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Processing apparatus, and manufacturing method of movable body

Abstract

A processing apparatus has: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of at least one of the object and an irradiation area that is formed on the surface of the object by the light irradiation apparatus; and a control apparatus that controls the first position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the irradiation area and the object to change a thickness of a part of the object.

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Background/Summary

TECHNICAL FIELD
(1) The present invention relates to a processing apparatus that is configured to process an object by irradiating it with a processing light and a manufacturing method of manufacturing a movable body.

BACKGROUND ART

(2) A Patent Literature 1 discloses, as a processing apparatus that is configured to process an object, a processing apparatus that forms a structure by irradiating a surface of an object with a laser beam to reduce a resistance of the surface. The processing apparatus is required to form the structure at the object properly.

CITATION LIST

Patent Literature

(3) Patent Literature 1: U.S. Pat. No. 4,994,639B

SUMMARY OF INVENTION

(4) A first aspect provide a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of at least one of the object and an irradiation area that is formed on the surface of the object by the light irradiation apparatus; and a control apparatus that controls the first position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the irradiation area and the object to change a thickness of a part of the object.

(5) A second aspect provides a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of at least one of the object and an irradiation area that is formed on the surface of the object by the light irradiation apparatus; and a control apparatus that controls the first position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the irradiation area and the object to remove a part of the object.

(6) A third aspect provides a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light while moving the light irradiation apparatus relative to the object to change a thickness of a part of the object.

(7) A fourth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light while moving the light irradiation apparatus relative to the object to remove a part of the object.

(8) A fifth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of the object to change a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light while moving the object relative to the light irradiation apparatus to change a thickness of a part of the object.

(9) A sixth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that irradiates a surface of an object with a processing light; a first position change apparatus that changes a position of the object to change a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus

to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light while moving the object relative to the light irradiation apparatus to remove a part of the object.

(10) A seventh aspect provides a processing apparatus that is provided with: a light irradiation apparatus that is provided to be movable in a direction along a surface of an object and that irradiates the surface of the object with a processing light; and a first position change apparatus that changes a position of at least one of the light irradiation apparatus and the object, a processing apparatus changes a thickness of a part of the object by irradiating the surface of the object with the processing light while changing the position of at least one of the light irradiation apparatus and the object.

(11) An eighth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that is provided to be movable in a direction along a surface of an object and that irradiates the surface of the object with a processing light; and a first position change apparatus that changes a position of at least one of the light irradiation apparatus and the object, a processing apparatus removes a part of the object by irradiating the surface of the object with the processing light while changing the position of at least one of the light irradiation apparatus and the object.

(12) A ninth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of at least one of the irradiation area and the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light to change a thickness of a part of the object.

(13) A tenth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of at least one of the irradiation area and the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light to remove a part of the object.

(14) An eleventh aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light to change a thickness of a part of the object.

(15) A twelfth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light to remove a part of the object.

(16) A thirteenth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of the object to change a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light to change a thickness of a part of the object.

(17) A fourteenth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that emits a processing light to form an irradiation area having an intensity distribution on a surface of an object; a first position change apparatus that changes a position of the object to change a position of the light irradiation apparatus on the surface of the object; and a control apparatus that controls the first position change apparatus to form a structure for reducing a resistance to a fluid at the surface of the object by irradiating the surface of the object with the processing light while moving the object relative to the light irradiation apparatus to remove a part of the object.
(18) A fifteenth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that is provided to be movable in a direction along a surface of an object and that irradiates the surface of the object with a processing light; and a first position change apparatus that changes a position of at least one of the light irradiation apparatus and the object, the processing apparatus changes a thickness of a part of the object by irradiating the surface of the object with the processing light.
(19) A sixteenth aspect provides a processing apparatus that is provided with: a light irradiation apparatus that is provided to be movable in a direction along a surface of an object and that irradiates the surface of the object with a processing light; and a first position change apparatus that changes a position of at least one of the light irradiation apparatus and the object, the processing apparatus removes a part of the object by irradiating the surface of the object with the processing light.
(20) A seventeenth aspect provides a manufacturing method of a movable body that moves in a fluid, the manufacturing method includes: irradiating a surface of an object with a processing light; and forming a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the object and an irradiation area that is formed on the surface of the object by an irradiation of the processing light to change a thickness of a part of the object.
(21) An eighteenth aspect provides a manufacturing method of a movable body that moves in a fluid, the manufacturing method includes: irradiating a surface of an object with a processing light; and forming a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the object and an irradiation area that is formed on the surface of the object by an irradiation of the processing light to remove a part of the object.
(22) A nineteenth aspect provides a manufacturing method of a movable body that moves in a fluid, the manufacturing method includes: irradiating a first area on a surface of an object with a processing light; changing a positional relationship between the object and the processing light; irradiating a second area that is different from the first area on the surface of the object with the processing light; and forming a structure for reducing a frictional resistance of the surface of the object to a fluid by changing a thickness of a part of the object at the first and second areas.
(23) A twentieth aspect provides a manufacturing method of a movable body that moves in a fluid, the manufacturing method includes: irradiating a first area on a surface of an object with a processing light; changing a positional relationship between the object and the processing light; irradiating a second area that is different from the first area on the surface of the object with the processing light; and forming a structure for reducing a frictional resistance of the surface of the object to a fluid by removing a part of the object at the first and second areas.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a cross-sectional view that schematically illustrates an entire structure of a processing

apparatus in the present embodiment.
(2) FIG. **2** Each of FIG. **2**A to FIG. **2**B is a cross-sectional view that schematically illustrates an aspect of a processing of a coat of paint formed on a surface of a processing target object.
(3) FIG. **3**A is a cross-sectional view that schematically illustrates a light irradiation apparatus of the processing apparatus in the present embodiment, each of FIG. **3**B and FIG. **3**C is a cross-sectional view that illustrates a structure of a light source system of the light irradiation apparatus and FIG. **3**D is a perspective view that schematically illustrates other example of an optical system of the light irradiation apparatus.
(4) FIG. **4** is a side view that illustrates a housing apparatus.
(5) FIG. **5**A is a cross-sectional view that illustrates a cross-sectional surface of a riblet structure formed by the processing apparatus in the present embodiment and FIG. **5**B is a perspective view that illustrates a cross-sectional surface of a riblet structure formed by the processing apparatus in the present embodiment.
(6) FIG. **6** Each of FIG. **6**A and FIG. **6**B is a front view that illustrates an airplane that is one example of the processing target object at which the riblet structure is formed and FIG. **6**C is a side view that illustrates the airplane that is one example of the processing target object at which the riblet structure is formed
(7) FIG. **7** is a plan view that illustrates a plurality of unit processing areas that are set on a surface of the coat SF of paint.
(8) FIG. **8** is a cross-sectional view that illustrates the processing apparatus that performs one step of a processing operation for forming the riblet structure.
(9) FIG. **9**A is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure and FIG. **9**B is a plane view that illustrates the surface of the coat of paint on which one step of the processing operation illustrated in FIG. **9**A is performing.
(10) FIG. **10** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(11) FIG. **11**A is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure and FIG. **11**B is a plane view that illustrates the surface of the coat of paint on which one step of the processing operation illustrated in FIG. **11**A is performing.
(12) FIG. **12** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(13) FIG. **13** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(14) FIG. **14** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(15) FIG. **15** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(16) FIG. **16** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(17) FIG. **17** is a cross-sectional view that illustrates the processing apparatus that performs one step of the processing operation for forming the riblet structure.
(18) FIG. **18** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(19) FIG. **19** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(20) FIG. **20** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(21) FIG. **21** is a cross-sectional view that schematically illustrates other example of the light

irradiation apparatus.
(22) FIG. **22** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(23) FIG. **23** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(24) FIG. **24** is a cross-sectional view that schematically illustrates other example of the light irradiation apparatus.
(25) FIG. **25** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a second modified example.
(26) FIG. **26**A is a cross-sectional view that illustrates an aspect in which the surface of the coat of paint is positioned within a range of a depth of focus of the optical system when the surface of the coat of paint is a flat surface, FIG. **26**B is a cross-sectional view that illustrates an aspect in which the surface of the coat of paint is positioned within the range of the depth of focus of the optical system when the surface of the coat of paint is a curved surface, FIG. **26**C is a cross-sectional view that illustrates an aspect in which the surface of the coat of paint is positioned within the range of the depth of focus of the optical system when there is a concavity and/or convexity at the surface of the coat of paint and FIG. **26**D is a cross-sectional view that illustrates an aspect in which the surface of the coat of paint is positioned within the range of the depth of focus of the optical system when the surface of the coat of paint is inclined with respect to an optical axis of the optical system.
(27) FIG. **27** is a cross-sectional view that schematically illustrates the light irradiation apparatus that is configured to adjust light concentration positions of a plurality of processing lights individually.
(28) FIG. **28** is a cross-sectional view that illustrates an aspect of an irradiation of the plurality of processing lights when the optical system is an optical system that is not telecentric at the coat of paint side.
(29) FIG. **29**A is a cross-sectional view that illustrates an aspect in which the light concentration positions of the plurality of processing lights are located at the surface of the coat of paint when the surface of the coat of paint is a flat surface, FIG. **29**B is a cross-sectional view that illustrates an aspect in which the light concentration positions of the plurality of processing lights are located at the surface of the coat of paint when the surface of the coat of paint is a curved surface, FIG. **29**C is a cross-sectional view that illustrates an aspect in which the light concentration positions of the plurality of processing lights are located at the surface of the coat of paint when there is a concavity and/or convexity at the surface of the coat of paint and FIG. **29**D is a cross-sectional view that illustrates an aspect in which the light concentration positions of the plurality of processing lights are located at the surface of the coat of paint when the surface of the coat of paint is inclined with respect to the optical axis of the optical system.
(30) FIG. **30**A is a cross-sectional view that illustrates the range of the depth of focus of the optical system that is set to include the surface of the coat of paint when the surface of the coat of paint is a flat surface, FIG. **30**B is a cross-sectional view that illustrates the range of the depth of focus of the optical system that is set to include the surface of the coat of paint when the surface of the coat of paint is a curved surface, FIG. **30**C is a cross-sectional view that illustrates the range of the depth of focus of the optical system that is set to include the surface of the coat of paint when there is a concavity and/or convexity at the surface of the coat of paint and FIG. **30**D is a cross-sectional view that illustrates the range of the depth of focus of the optical system that is set to include the surface of the coat of paint when the surface of the coat of paint is inclined with respect to the optical axis of the optical system.
(31) FIG. **31**A is a cross-sectional view that illustrates an image plane that is set to be coincident with the surface of the coat of paint when the surface of the coat of paint is a flat surface, FIG. **31**B is a cross-sectional view that illustrates an image plane that is set to be coincident with the surface of the coat SF of paint when the surface of the coat of paint is a curved surface, FIG. **31**C is a

cross-sectional view that illustrates an image plane that is set to be coincident with the surface of the coat SF of paint when there is a concavity and/or convexity at the surface of the coat of paint and FIG. **31**D is a cross-sectional view that illustrates an image plane that is set to be coincident with the surface of the coat SF of paint when the surface of the coat of paint is inclined with respect to the optical axis of the optical system.
(32) FIG. **32**A is a cross-sectional view that illustrates a non-processing area and FIG. **32**B is a plan view that illustrates the non-processing area.
(33) FIG. **33** Each of FIG. **33**A to FIG. **33**C is a graph that illustrates a relationship between a reflectance of the coat of paint to the processing light and an intensity of the processing light that is set by a control apparatus.
(34) FIG. **34** Each of FIG. **34**A to FIG. **33**C is a graph that illustrates a relationship between the reflectance of the coat of paint to the processing light and an irradiation time of the processing light that is set by a control apparatus.
(35) FIG. **35** is a graph that illustrates the reflectance of the coat of paint to a plurality of measurement light having different wavelengths, respectively.
(36) FIG. **36** is a cross-sectional view that schematically illustrates a light irradiation apparatus having a plurality of light source systems.
(37) FIG. **37** is a cross-sectional view that illustrates a range at which a surface characteristic measurement apparatus measures a shape of the surface of the coat of paint when the light irradiation apparatus moves relative to the coat SF of paint.
(38) FIG. **38** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a third modified example.
(39) FIG. **39** is a plan view that illustrates a positional relationship between a projection apparatus of a structure measurement apparatus and a detection apparatus.
(40) FIG. **40** is a plan view that illustrates a sample area at which the structure measurement apparatus measures a characteristic of the riblet structure.
(41) FIG. **41**A is a cross-sectional view that illustrates an ideal riblet structure which the processing apparatus should form, FIG. **41**B is a cross-sectional view that illustrates a riblet structure a size of which is same as a size of the ideal riblet structure, FIG. **41**C is a cross-sectional view that illustrates a riblet structure a size of which is smaller than the size of the ideal riblet structure and FIG. **41**D is a cross-sectional view that illustrates a riblet structure a size of which is larger than the size of the ideal riblet structure.
(42) FIG. **42**A is a cross-sectional view that illustrates a riblet structure a shape of which is same as a shape of the ideal riblet structure and FIG. **42**B is a cross-sectional view that illustrates a riblet structure a shape of which is different from the shape of the ideal riblet structure.
(43) The upper part of FIG. **43** is a cross-sectional view that illustrates a riblet structure including a concave structure at a position that is same as a position of the concave structure constituting the ideal riblet structure and the lower part of FIG. **43** is a cross-sectional view that illustrates a riblet structure including the concave structure at a position that is different from the position of the concave structure constituting the ideal riblet structure.
(44) FIG. **44**A is a cross-sectional view that illustrates the sample area in which the riblet structure is formed and FIG. **44**B is a cross-sectional view that illustrates the sample area in which the riblet structure is not formed.
(45) FIG. **45**A is a cross-sectional view that illustrates an aspect in which the riblet structure having a size smaller than an ideal size is irradiated with the processing light for modifying the riblet structure and FIG. **45**B is a cross-sectional view that illustrates the modified riblet structure.
(46) FIG. **46** is a cross-sectional view that schematically illustrates a structure of a light irradiation apparatus of a processing apparatus in a fourth modified example.
(47) FIG. **47**A and FIG. **47**B are plan views that illustrate plurality of irradiation areas having different arrangement pitches, respectively, and FIG. **47**C and FIG. **47**D are cross-sectional views

that illustrate the riblet structures formed by irradiating the plurality of irradiation areas illustrated in FIG. **47**A and FIG. **47**B with the plurality of processing lights, respectively.
(48) FIG. **48**A and FIG. **48**B are plan views that illustrate the plurality of processing lights having different relative angles, respectively, and FIG. **48**C and FIG. **48**D are plan views that illustrate the plurality of irradiation areas that are irradiated with the plurality of processing lights illustrated in FIG. **48**A and FIG. **48**B, respectively.
(49) FIG. **49**A and FIG. **49**B are plan views that illustrate the plurality of processing lights irradiated by the light irradiation apparatuses between which distances from the coat SF of paint are different, respectively, and FIG. **49**C and FIG. **49**D are plan views that illustrate the plurality of irradiation areas that are irradiated with the plurality of processing lights illustrated in FIG. **49**A and FIG. **49**B, respectively.
(50) FIG. **50**A and FIG. **50**C are plan views that illustrate the plurality of processing lights irradiated by the light irradiation apparatuses between which the number of the light source for irradiating with the processing light are different from each other, respectively, and FIG. **50**B and FIG. **50**D are plan views that illustrate the plurality of irradiation areas that are irradiated with the plurality of processing lights illustrated in FIG. **50**A and FIG. **50**C, respectively.
(51) FIG. **51**A and FIG. **51**C are plan views that illustrate first and second divided lights having different intersecting angles, respectively, and FIG. **51**B and FIG. **51**D are plan views that illustrate interference fringes formed on the surface of the coat of paint by an interference of the first and second divided lights illustrated in FIG. **51**A and FIG. **51**C, respectively.
(52) FIG. **52** is a cross-sectional views that illustrates a light irradiation apparatus that is configured to adjust the intersecting angle of the first and second divided light.
(53) FIG. **53** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a fifth modified example.
(54) FIG. **54** Each of FIG. **54**A and FIG. **54**C is a plan view that illustrates an intensity distribution on the surface of the coat of paint and FIG. **54**B and FIG. **54**D are cross-sectional views that illustrate the riblet structure formed by the irradiation of the plurality of processing lights having the intensity distributions illustrated in FIG. **54**A and FIG. **54**C, respectively.
(55) FIG. **55**A and FIG. **55**C are cross-sectional views that illustrate the plurality of irradiation areas having different shapes, respectively, and FIG. **55**B and FIG. **55**D are cross-sectional views that illustrate the riblet structures formed by irradiating the plurality of irradiation areas having shapes illustrated in FIG. **55**A and FIG. **55**C with the plurality of processing lights, respectively.
(56) FIG. **56**A and FIG. **56**C are cross-sectional views that illustrate the plurality of irradiation areas having different sizes, respectively, and FIG. **56**B and FIG. **56**D are cross-sectional views that illustrate the riblet structures formed by irradiating the plurality of irradiation areas having sizes illustrated in FIG. **56**A and FIG. **56**C with the plurality of processing lights, respectively.
(57) FIG. **57**A and FIG. **57**C are cross-sectional view that illustrate the plurality of processing lights having different intensities, respectively, and FIG. **57**B and FIG. **57**D are cross-sectional views that illustrate the riblet structure formed by the irradiation of the plurality of processing lights having the intensities illustrated in FIG. **57**A and FIG. **57**C, respectively.
(58) FIG. **58**A is a perspective view that illustrates the riblet structure in which a shape of the cross-sectional surface of the concave structure changes along an extending direction, FIG. **58**B is a I-I′ cross-sectional surface in FIG. **58**A and FIG. **58**C is a II-IF cross-sectional surface in FIG. **58**A.
(59) FIG. **59**A is a perspective view that illustrates the riblet structure in which a width of the concave structure changes along the extending direction, FIG. **59**B is a I-I′ cross-sectional surface in FIG. **54**A and FIG. **59**C is a II-IF cross-sectional surface in FIG. **59**A.
(60) FIG. **60** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a sixth modified example.
(61) FIG. **61** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a seventh modified example.

(62) FIG. **62** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in an eighth modified example.
(63) FIG. **63** is a cross-sectional view that illustrates one example of a structure of a suction part that allows the light irradiation apparatus to be disposed at the coat of paint.
(64) FIG. **64** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a ninth modified example.
(65) FIG. **65** is a cross-sectional view that schematically illustrates an entire structure of a processing apparatus in a tenth modified example.
(66) FIG. **66** is a plan view that illustrates a unit processing area that is partially overlapped with an adjacent another unit processing area.
(67) FIG. **67** is a cross-sectional view that illustrates an aspect of the irradiation of the processing light to the adjacent two unit processing areas.
(68) FIG. **68** is a cross-sectional view that illustrates an aspect of the irradiation of the processing light to the adjacent two unit processing areas.
(69) FIG. **69** is a cross-sectional view that illustrates the intensity of the processing light with which the adjacent two unit processing areas are irradiated.
(70) FIG. **70** is a cross-sectional view that illustrates the intensity of the processing light with which the adjacent two unit processing areas are irradiated.
(71) FIG. **71** Each of FIG. **71**A to FIG. **71**C is a plan view that illustrates an area at which the plurality of irradiation areas moves by a single scan operation.
(72) FIG. **72** Each of FIG. **72**A to FIG. **72**B is a cross-sectional view that illustrates a structural object in which a plurality of layers are laminated.

DESCRIPTION OF EMBODIMENTS

(73) Next, with reference to drawings, embodiments of the present invention will be described. However, the present invention is not limited to the below described embodiments.

(1) Structure of Processing Apparatus **1**

(74) Firstly, with reference to FIG. **1**, a structure of a processing apparatus **1** in the present embodiment will be described. FIG. **1** is a cross-sectional view that schematically illustrates the structure of the processing apparatus **1** in the present embodiment. Note that the structure of the processing apparatus **1** will be described in an XYZ rectangular coordinate system that is defined by a X axis, a Y axis and a Z axis that are perpendicular to one another in the below described description. An X axis and a Y axis are directions along a horizontal direction and a Z axis is a direction perpendicular to the X axis and the Y axis. Although the processing apparatus **1** is disposed on a processing target object S having a surface along the horizontal plane in FIG. **1**, the processing apparatus **1** is not necessarily disposed on the processing target object S having the surface along the horizontal plane. For example, as described later in detail with reference to FIG. **6** and so on, the processing apparatus **1** is sometimes disposed on a processing target object S having a surface intersecting with the horizontal plane and is sometimes suspended from the processing target object S. In this case, the X axis and the Y axis may be defined as directions along the surface of the processing target object S.
(75) As illustrated in FIG. **1**, the processing apparatus **1** processes a coat SF of paint that is formed on a surface of the processing target object S. The processing target object S may be a metal, may be an alloy (for example, a duralumin and the like), may be a resin (for example, CFRP (Carbon Fiber Reinforced Plastic) and the like), may be a glass or may be an object that is made from any other material, for example. The coat SF of paint is a film that covers the surface of the processing target object S. A thickness of the coat SF of paint is several microns to several hundred microns, for example, however, may be any other size. A painting material that constitutes the coat SF of paint may include a resin painting material (for example, at least one of a polyurethane type of painting material, a vinyl type of painting material, a silicon type of painting material and an epoxy type of painting material) or may include any other type of painting material, for example.

(76) The processing apparatus **1** irradiates the coat SF of paint with a processing light EL in order to process the coat SF of paint. The processing light EL may be any type of light, as long as the coat SF of paint is processed by irradiating the coat SF of paint with it. As one example, the processing light EL may be a laser light. Moreover, the processing light EL may be a light having any wavelength, as long as the coat SF of paint is processed by irradiating the coat SF of paint with it. The present embodiment will be described by using an example in which the processing light EL is an invisible light (for example, at least one of an infrared light, an ultraviolet light and the like). However, the processing light EL may be a visible light.
(77) The processing apparatus **1** irradiates an irradiation area EA set (in other words, formed) on the surface of the coat SF of paint with the processing light EL. As illustrated in FIG. **2**A, when the irradiation area EA is irradiated with the processing light EL, a part of the coat SF of paint that overlaps with the irradiation area EA (namely, the coat of paint that is located at an −Z side of the irradiation area EA) evaporates by the processing light EL. Here, all of the coat SF of paint that overlaps with the irradiation area EA does not evaporate along a thickness direction of the coat SF of paint. Namely, a part of the coat SF of paint that overlaps with the irradiation area EA (specifically, a part of the coat SF of paint that is relatively close to the irradiation area EA) evaporates and other part of the coat SF of paint that overlaps with the irradiation area EA (specifically, a part of the coat SF of paint that is relatively far away from the irradiation area EA) does not evaporate along the thickness direction of the coat SF of paint. In other words, the coat SF of paint evaporates so that the processing target object S is not exposed from the coat SF of paint. As a result, the coat SF of paint is removed at a part at which the coat SF of paint evaporates. On the other hand, the coat SF of paint remains as it is at a part at which the coat SF of paint does not evaporate. Namely, as illustrated in FIG. **2**B, the coat SF of paint is partially removed at a part that is irradiated with the processing light EL. As a result, as illustrated in FIG. **2**B, the thickness of the coat SF of paint is thinner in the part that is irradiated with the processing light EL, compared to a part that is not irradiated with the processing light EL. In other words, as illustrated in FIG. **2**B, there are the coat SF of paint that is relatively thick because it is not irradiated with the processing light EL and the coat SF of paint that is relatively thin because it is irradiated with the processing light EL on the surface of the processing target object S. Namely, the thickness of the coat SF of paint is adjusted at least partially by an irradiation of the processing light EL. As a result, a concave part (in other words, a groove part) C corresponding to the part at which the coat SF of paint is relatively thin is formed on the surface of the coat SF of paint. Therefore, “an operation for processing the coat SF of paint” in the present embodiment includes an operation for adjusting the thickness of the coat SF of paint, an operation for removing a part of the coat SF of paint and an operation for forming the concave part C at the coat SF of paint. Moreover, an energy of the processing light EL with which the coat SF of paint is irradiated is determined so that the irradiation of the processing light EL does not affect the processing target object S. In other words, the energy of the processing light EL is determined so that the irradiation of the processing light EL affects only the coat SF of paint.
(78) The coat SF of paint evaporate by absorbing the processing light EL. Namely, the coat SF of paint is decomposed photochemically, for example, and removed by means of the energy of the processing light EL being transmitted to the coat SF of paint. Incidentally, when the processing light EL is the laser light, a phenomenon in which the coat SF of paint is decomposed photochemically and removed by means of the energy of the processing light EL being transmitted to the coat SF of paint is sometimes referred to as a laser ablation. Thus, the coat SF of paint includes a material that is allowed to absorb the processing light EL. Specifically, the coat SF of paint may include a material in which an absorptance relating to the processing light EL (namely, an absorptance relating to a light having a wavelength that is different from a wavelength range of the visible light) is equal to or higher than a first absorption threshold value, for example. This material may be a coloring matter.

(79) When the coat SF of paint includes the coloring matter, the coloring matter may a coloring matter that takes on a predetermined color when it is irradiated with the visible light. As a result, the coat SF of paint including this coloring matter takes on the predetermined color. In this case, the coloring matter may have a characteristic that the absorptance of a first light component having a wavelength that is allowed to be recognized by a human as the predetermined colored light when it is reflected by the coat SF of paint among a wavelength range of the visible light is different from the absorptance of a second light component of the visible light other than the first light component so that the coat SF of paint takes on the predetermined color. For example, the coloring matter may have a characteristic that the absorptance of the first light component is lower than the absorptance of the second light component. For example, the coloring matter may have a characteristic that the absorptance of the first light component is equal to or lower than a predetermined second absorption threshold value (note that the second absorption threshold value is lower than the first absorption threshold value) and the absorptance of the second light component is equal to or higher than a predetermined third absorption threshold value (note that the third absorption threshold value is higher than the second absorption threshold value). As one example of the coloring matter that is allowed to absorb the processing light EL being the invisible light to a certain degree and that takes on the predetermined color, there is a near infrared absorption coloring matter manufactured by Spectrum Info Ltd located in Kiev in Ukraine (as one example, a tetrafluoro boronated 4-((E)-2-{(3E)-2-chloro-3-[2-(2,6-diphenyl-4H-thiopyran-4-ylidene) ethylidene] cyclohexa-1-yen-1-yl} vinyl)-2,6-diphenylthiopyrylium).
(80) Alternatively, when the coat SF of paint includes the coloring matter, the coloring matter may a coloring matter that is transparent to the visible light. As a result, the coat SF of paint including this coloring matter is a transparent film (what we call a clear coat). In this case, the coloring matter may have a characteristic that it does not absorb the visible light much (namely, reflects to a certain degree) so that the coat SF of paint is transparent. For example, the coloring matter may have a characteristic that the absorptance of the visible light is lower than a predetermined fourth absorption threshold value. As one example of the coloring matter that is allowed to absorb the processing light EL being the invisible light to a certain degree and that is transparent to the visible light, there is a near infrared absorption coloring matter manufactured by Spectrum Info Ltd located in Kiev in Ukraine (as one example, a tetrafluoro boronated 6-chloro-2-[(E)-2-(3-{(E)-2-[6-chloro-1-ethylbenzo [cd] indole-2(1H)-ylidene] ethylidene}-2-phenyl-1-cyclopentene-1-yl) ethenyl]-1-ethylbenzo [cd]-indolium).
(81) Again in FIG. **1**, in order to process the coat SF of paint, the processing apparatus **1** is provided with a light irradiation apparatus **11**, a driving system **12**, a housing apparatus **13**, a support apparatus **14**, a driving system **15**, an exhaust apparatus **16**, a gas supply apparatus **17** and a control apparatus **18**.
(82) The light irradiation apparatus **11** is configured to irradiate the coat SF of paint with the processing light EL under the control of the control apparatus **18**. In order to emit the processing light EL, the light irradiation apparatus **11** is provided with a light source system **111** that is configured to emit the processing light EL and an optical system **112** that guides the processing light EL emitted from the light source system **111** to the coat SF of paint as illustrated in FIG. **3**A.
(83) The light source system **111** emits a plurality of processing lights EL at the same time, for example. Thus, the light source system **111** is provided with a plurality of light sources **1111** as illustrated in FIG. **3**B. The plurality of light sources **1111** are arranged in a line at regular intervals. Each light source **1111** emits a pulsed light as the processing light EL. When a light emitting time width (hereinafter, it is referred to as a “pulse width”) of the pulsed light is shorter, a processing accuracy (for example, a forming accuracy of a riblet structure described later) improves. Therefore, each light source **1111** may emit the pulsed light having a relatively short pulse width as the processing light EL. For example, each light source **1111** may emit the pulsed light having the pulse width that is equal to or shorter than 1000 nanoseconds as the processing light EL.

Alternatively, the light source system **111** may be provided with single light source **1111** and a divide device **1112** that divides the light from the single light source **1111** into the plurality of processing lights EL, as illustrated in FIG. **3**C. A plurality of emitting ports from which the plurality of processing lights EL divided by the divide device **1112**, respectively, are arranged in a line at regular intervals. At least one of an optical fiber coupler and a waveguide splitter is one example of the divide device **1112**. Note that at least one of a lens-array, a diffractive optical element, a spatial light modulator and the like may be used as the divide device **1112**, as described later.

(84) The optical system **112** is provided with a focusing lens **1121**, a Galvano mirror **1122** and a fθ lens **1123**. The coat SF of paint is irradiated with the plurality of processing lights EL through the focusing lens **1121**, the Galvano mirror **1122** and the fθ lens **1123**.

(85) The focusing lens **1121** is an optical element that is constructed from one or more lens and that is for adjusting light concentration positions of the plurality of processing lights EL (namely, a focus position of the optical system **112**) by adjusting a position of at least one lens thereof along an optical axis direction. The Galvano mirror **1122** deflects the plurality of processing lights EL so that the surface of the coat SF of paint is swept with the plurality of processing lights EL (namely, the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, moves on the surface of the coat SF of paint). The Galvano mirror **1122** is provided with a X scanning mirror **1122**X and a Y scanning mirror **1122**Y. The X scanning mirror **1122**X reflects the plurality of processing lights EL to the Y scanning mirror **1122**Y. The X scanning mirror **1122**X is configured to swing or rotate in the θY direction (namely, in a rotational direction around the Y axis). Due to the swing or the rotation of the X scanning mirror **1122**X, the surface of the coat SF of paint is swept with the plurality of processing lights EL along the X axis direction. Due to the swing or the rotation of the X scanning mirror **1122**X, the plurality of irradiation areas EA moves on the coat SF of paint along the X axis direction. The X scanning mirror **1122**X changes a relative position relationship between the plurality of irradiation areas EA and the coat SF of paint along the X axis direction. The Y scanning mirror **1122**Y reflects the plurality of processing lights EL to the fθ lens **1123**. The Y scanning mirror **1122**Y is configured to swing or rotate in the θX direction (namely, in a rotational direction around the X axis). Due to the swing or the rotation of the Y scanning mirror **1122**Y, the surface of the coat SF of paint is swept with the plurality of processing lights EL along the Y axis direction. Due to the swing or the rotation of the Y scanning mirror **1122**X, the plurality of irradiation areas EA moves on the coat SF of paint along the Y axis direction. The Y scanning mirror **1122**Y changes a relative position relationship between the plurality of irradiation areas EA and the coat SF of paint along the Y axis direction. The fθ lens **1123** is an optical element for focuses the plurality of processing lights EL from the Galvano mirror **1122** on the coat SF of paint.

(86) The fθ lens **1123** is a terminal optical element that is disposed at the most light emitting side of the optical system **112** (in other word, that is closest to the coat SF of paint or that is disposed at an end of an optical path of the plurality of processing lights EL) among the optical element(s) of the optical system **112**. The fθ lens **1123** is configured to be attachable to and detachable from the optical system **112**. As a result, new fθ lens **1123** is allowed to be attached to the optical system **112** after old fθ lens **1123** is detached from the optical system **112**. However, when the optical system **112** is provided with an optical element (for example, a cover lens) that is disposed at more emitting side than the fθ lens **1123**, this optical element is the terminal optical element and this optical element is configured to be attachable to and detachable from the optical system **112**.

(87) Traveling directions of the plurality of processing lights EL from the optical system **112** is parallel to each other, for example. As a result, in the present embodiment, the coat SF of paint is irradiated with the plurality of processing lights EL traveling directions of which are parallel to each other at the same time. Namely, the plurality of irradiation areas EA are set on the coat SF of paint at the same time. Thus, a throughput relating to the processing of the coats SF of paint

improves compared to the case where the coat SF of paint is irradiated with the single processing light EL. Note that the optical system **112** may be configured so that all optical elements (for example, the focusing lens **1121**, the Galvano mirror **1122** and the fθ lens **1123**) are not on the same plane as illustrated in FIG. **3**D.
(88) Again in FIG. **1**, the driving system **12** moves the light irradiation apparatus **11** relative to the coat SF of paint (namely, relative to the processing target object S on the surface of which the coat SF of paint is formed) under the control of the control apparatus **18**. Namely, the driving system **12** moves the light irradiation apparatus **11** relative to the coat SF of paint so as to change a relative positional relationship between the light irradiation apparatus **11** and the coat SF of paint. When the relative positional relationship between the light irradiation apparatus **11** and the coat SF of paint is changed, a relative positional relationship between the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, and the coat SF of paint is also changed. Thus, it can be said that the driving system **12** moves the light irradiation apparatus **11** relative to the coat SF of paint so as to change the relative positional relationship between the plurality of irradiation areas EA and the coat SF of paint. The driving system **12** may move the light irradiation apparatus **11** along the surface of the coat SF of paint. In an example illustrated in FIG. **1**, the surface of the coat SF of paint is a plane that is parallel to at least one of the X axis and the Y axis, and thus, the driving system **12** may move the light irradiation apparatus **11** along at least one of the X axis and the Y axis. As a result, the irradiation areas EA moves on the coat SF of paint along at least one of the X axis and the Y axis. The driving system **12** may move the light irradiation apparatus **11** along the thickness direction of the coat SF of paint (namely, a direction that intersects with the surface of the coat SF of paint). In the example illustrated in FIG. **1**, the thickness direction of the coat SF of paint is a direction along the Z axis, and thus, the driving system **12** may move the light irradiation apparatus **11** along the Z axis. The driving system **12** may move the light irradiation apparatus **11** along the θX direction, the θY direction and the θZ direction in addition to at least one of the X axis, the Y axis and the Z axis.
(89) The driving system **12** supports the light irradiation apparatus **11** and moves the supporting light irradiation apparatus **11**. In which case, the driving system **12** is provided with a first supporting member that supports the light irradiation apparatus **11** and a first moving mechanism that moves the first supporting member, for example.
(90) The housing apparatus **13** is provided with a top member **131** and a partition member **132**. The top member **131** is disposed at the +Z side than the light irradiation apparatus **11**. The top member **131** is a plate-like member along the XY plane. The top member **131** supports the driving system **12** through a supporting member **133**. The partition member **132** is disposed at (or near) an outer rim of a surface at the −Z side of the top member **131**. The partition member **132** is a pipe-like (for example, a cylinder-like or rectangular pipe-like) member that extends from the top member **131** toward the −Z side. A space surrounded by the top member **131** and the partition member **132** is a containing space SP in which the light irradiation apparatus **11** and the driving system **12** are housed. Therefore, the above described driving system **12** moves the light irradiation apparatus **11** in the hosing space SP. Moreover, the containing space SP includes a space between the light irradiation apparatus **11** and the coat SF of paint (especially, a space including the optical path of the processing lights EL). More specifically, the containing space SP includes a space between the terminal optical element (for example, fθ lens **1123**) of the light irradiation apparatus **11** and the coat SF of paint (especially, the space including the optical path of the processing lights EL).
(91) Each of the top member **131** and the partition member **132** is a member that is configured to shield the processing light EL. Namely, each of the top member **131** and the partition member **132** is opaque to the wavelength of the processing light EL. As a result, the processing light EL propagating in the containing space SP does not leak outside the containing space SP (namely, outside the housing apparatus **13**). Note that each of the top member **131** and the partition member **132** may be a member that is configured to fade the processing light EL. Namely, each of the top

member **131** and the partition member **132** is translucent to the wavelength of the processing light EL. Moreover, each of the top member **131** and the partition member **132** is a member that does not allow unnecessary substance that is generated by the irradiation of the processing light EL to pass therethrough (namely, that is configured to shield). Fume of the coat SF of paint is one example of the unnecessary substance. As a result, the unnecessary substance that is generated in the containing space SP does not leak outside the containing space SP (namely, outside the housing apparatus **13**).
(92) An end part (specifically, an end part at the coat SF of paint side and an end part at the −Z side in the example illustrated in FIG. **1**) **134** of the partition member **132** is allowed to contact with the surface of the coat SF of paint. When the end part **134** contacts with the coat SF of paint, the housing apparatus **13** (namely, the top member **131** and the partition member **132**) maintains a sealability of the containing space SP with the coat SF of paint. The end part **134** is configured to change a shape thereof (especially, a shape of a contact surface (the surface at the −Z side in the example illustrated in FIG. **1**) of the end part **134** that contacts with the coat SF of paint, the same applies to the below described description) in accordance with a shape of the surface of the coat SF of paint when it contacts with the coat SF of paint. For example, when the end part **134** contacts with the coat SF of paint the surface of which is a planar shape, the shape of the end part **134** becomes a planar shape as with the coat SF of paint. For example, when the end part **134** contacts with the coat SF of paint the surface of which is a curved shape, the shape of the end part **134** becomes a curved shape as with the coat SF of paint. As a result, the sealability of the containing space SP improves, compared to the case where the end part **134** is not configured to change the shape thereof in accordance with the shape of the surface of the coat SF of paint. The end part **134** that is made from a member having an elasticity such as a gum (in other words, a flexible member) is one example of the end part **134** that is configured to change the shape. Note that a bellows-like end part **134***a* that is a structure having an elasticity as illustrated in FIG. **4** may be used as the end part **134** that is configured to change the shape, for example.
(93) Return to FIG. **1**, the end part **134** is configured to attach to the coat SF of paint in a state where it contacts with the coat SF of paint. For example, the end part **134** may be provided with a suction mechanism that is configured to suck the coat SF of paint. When the end part **134** attaches to the coat SF of paint, the sealability of the containing space SP improves more, compared to the case where the end part **134** does not attach to the coat SF of paint. However, the end part **134** may not be configured to adhere to the coat SF of paint. Even in this case, the sealability of the containing space SP is maintained to a certain degree as long as the end part **134** contacts with the coat SF of paint.
(94) The partition member **132** is a member that is configured to extend and contract along the Z axis by a non-illustrated driving system (for example, an actuator) that operates under the control of the control apparatus **18**. For example, the partition member **132** may be a bellows-like member (what we call a bellows). In this case, the partition member **132** is configured to extend and contract due to the expansion and the contraction of the bellows-like part. Alternatively, the partition member **132** may be provided with a telescopic pipe in which a plurality of hollow cylindrical members having different diameters, respectively, are combined, for example. In this case, the partition member **132** is configured to extend and contract due to a relative movement of the plurality of cylindrical members. A state of the partition member **132** is allowed to be set to at least a first expansion state in which the partition member **132** extends along the Z axis and a size thereof in the Z axis direction is relatively long and a first contraction state in which the partition member **132** contracts along the Z axis and the size thereof in the Z axis direction is relatively short. When the partition member **132** is in the first expansion state, the end part **134** is allowed to contact with the coat SF of paint. On the other hand, when the partition member **132** is in the first contraction state, the end part **134** does not contact with the coat SF of paint. Namely, when the partition member **132** is in the first contraction state, the end part **134** is away from the coat SF of

paint toward the +Z side. Note that a configuration for switching the state of the partition member **132** between the first expansion state in which the end part **134** of the partition member **132** is allowed to contact with the coat SF of paint and the first contraction state in which the end part **134** is away from the coat SF of paint is not limited to a configuration that allows the partition member **132** to extend and contract. For example, the state of the partition member **132** may be switched between the first expansion state and the first contraction state by means of the housing apparatus **13** itself being configured to move along the ±Z direction.
(95) The housing apparatus **13** is further provided with the detection apparatus **135**. The detection apparatus **135** detects the unnecessary substance (namely, the substance that is generated by the irradiation of the processing light EL) in the containing space SP. A detected result of the detection apparatus **135** is used by the control apparatus **18** when the state of the partition member **132** is changed from the first expansion state to the first contraction state, as described later in detail.
(96) The support apparatus **14** supports the housing apparatus **13**. Since the housing apparatus **13** supports the driving system **12** and the light irradiation apparatus **11**, the support apparatus **14** substantially supports the driving system **12** and the light irradiation apparatus **11** through the housing apparatus **13**. In order to support the housing apparatus **13**, the support apparatus **14** is provided with a beam member **141** and a plurality of leg members **142**. The beam member **141** is disposed at the +Z side than the housing apparatus **13**. The beam member **141** is a beam-like member that extends along the XY plane. The beam member **141** supports the housing member **13** through supporting members **143**. The plurality of leg members **142** are disposed at the beam member **141**. The leg member **142** is a bar-like member that extends from the beam member **141** toward the −Z side.
(97) An end part (specifically, an end part at the coat SF of paint side and an end part at the −Z side in the example illustrated in FIG. **1**) **144** of the leg member **142** is allowed to contact with the surface of the coat SF of paint. As a result, the support apparatus **14** is supported by the coat SF of paint (namely, by the processing target object S). Namely, the support apparatus **14** supports the housing apparatus **13** in a state where the end part **144** contacts with the coat SF of paint (in other words, in a state where the support apparatus **14** is supported by the coat SF of paint). The end part **144** is configured to change a shape thereof (especially, a shape of a contact surface (the surface at the −Z side in the example illustrated in FIG. **1**) of the end part **144** that contacts with the coat SF of paint, the same applies to the below described description) in accordance with the shape of the surface of the coat SF of paint when the it contacts with the coat SF of paint, as with the end part **134** of the housing apparatus **13**. The end part **144** is configured to adhere to the coat SF of paint in a state where it contacts with the coat SF of paint. For example, the end part **144** may be provided with a suction mechanism that is configured to suck the coat SF of paint. When the end part **144** adheres to the coat SF of paint, a stability of the support apparatus **14** improves more, compared to the case where the end part **144** does not adhere to the coat SF of paint. However, the end part **144** may not be configured to adhere to the coat SF of paint.
(98) The beam member **141** is a member that is configured to extend and contract along at least one of the X axis and the Y axis (alternatively, along any direction along the XY plane) by the driving system **15** that operates under the control of the control apparatus **18**. For example, the beam member **141** may be provided with a telescopic pipe in which a plurality of hollow cylindrical members having different diameters, respectively, are combined, for example. In this case, the beam member **141** is configured to extend and contract due to a relative movement of the plurality of cylindrical members.
(99) The leg member **142** is a member that is configured to extend and contract along the Z axis by the driving system **15** that operates under the control of the control apparatus **18**. For example, the leg member **142** may be provided with a telescopic pipe in which a plurality of hollow cylindrical members having different diameters, respectively, are combined, for example. In this case, the leg member **142** is configured to extend and contract due to a relative movement of the plurality of

cylindrical members. A state of the leg member **142** is allowed to be set to at least a second expansion state in which the leg member **142** extends along the Z axis and a size thereof in the Z axis direction is relatively long and a second contraction state in which the leg member **142** contracts along the Z axis and the size thereof in the Z axis direction is relatively short. When the leg member **142** is in the second expansion state, the end part **144** is allowed to contact with the coat SF of paint. On the other hand, when the leg member **142** is in the second contraction state, the end part **144** does not contact with the coat SF of paint. Namely, when the leg member **142** is in the second contraction state, the end part **144** is away from the coat SF of paint toward the +Z side.
(100) The driving system **15** moves the support apparatus **14** relative to the coat SF of paint (namely, relative to the processing target object S on the surface of which the coat SF of paint is formed) under the control of the control apparatus **18**. Namely, the driving system **15** moves the support apparatus **14** relative to the coat SF of paint so as to change a relative positional relationship between the support apparatus **14** and the coat SF of paint. Since the support apparatus **14** supports the housing apparatus **13**, the driving system **15** substantially moves the housing apparatus **13** relative to the coat SF of paint by moving the support apparatus **14**. Namely, the driving system **15** moves the support apparatus **14** relative to the coat SF of paint so as to substantially change a relative positional relationship between the housing apparatus **13** and the coat SF of paint. Moreover, the housing apparatus **13** supports the light irradiation apparatus **11** through the driving system **12**. Thus, the driving system **15** is allowed to substantially move the light irradiation apparatus **11** relative to the coat SF of paint by moving the support apparatus **14**. Namely, the driving system **15** is allowed to move the support apparatus **14** relative to the coat SF of paint so as to substantially change the relative positional relationship between the light irradiation apparatus **14** and the coat SF of paint. In other words, the driving system **15** is allowed to move the support apparatus **14** relative to the coat SF of paint so as to substantially change the relative positional relationship between the plurality of irradiation areas EA and the coat SF of paint.
(101) The driving system **15** extends and contracts the beam member **141** in order to move the support apparatus **14** under the control of the control apparatus **18**. Moreover, the driving system **15** extends and contracts the plurality of leg members **142** in order to move the support apparatus **14** under the control of the control apparatus **18**. Note that a moving aspect of the support apparatus **14** by the driving system **15** will be described later in detail with reference to FIG. **7** to FIG. **17**.
(102) The exhaust apparatus **16** is coupled to the containing space SP through an exhaust pipe **161**. The exhaust apparatus **16** is configured to exhaust gas in the containing space SP. Especially, the exhaust apparatus **16** is configured to suck the unnecessary substance that is generated by the irradiation of the processing light EL outside the containing space SP from the containing space SP by exhausting the gas in the containing space SP. Especially, when the unnecessary substance is on the optical path of the processing lights EL, there is a possibility that the irradiation of the processing lights EL to the coat SF of paint is affected. Thus, the exhaust apparatus **16** especially sucks, from a space including the optical path of the processing lights EL between the terminal optical element of the optical system **112** and the coat SF of paint, the unnecessary substance with the gas in this space. The unnecessary substance sucked by the exhaust apparatus **16** from the containing space SP is discharged outside the processing apparatus **1** through a filter **162**. The filter **162** sorbs the unnecessary substance. Note that the filter **162** may be attachable and detachable and may be replaceable.
(103) The gas supply apparatus **17** is coupled to the containing space SP through an intake pipe **171**. The gas supply apparatus **17** is configured to supply gas to the containing space SP. The gas that is supplied to the containing space SP includes at least one of an air, a CDA (Clean Dry Air) and an inert gas. The inert gas includes a nitrogen gas. In the present example, the gas supply apparatus **17** supplies the CDA. Thus, the containing space SP is a space that is purged by the CDA. At least a part of the CDA supplied to the containing space SP is sucked by the exhaust

apparatus **16**. The CDA sucked by the exhaust apparatus **16** from the containing space SP is discharged outside the processing apparatus **1** through the filter **162**.

(104) The gas supply apparatus **17** especially supplies the gas such as the CDA to an optical surface **1124** at the containing space SP side of the fθ lens **1123** (namely, an optical surface at the containing space SP side of the terminal optical element of the optical system **112**) illustrated in FIG. **3**. There is a possibility that the optical surface **1124** is exposed to the unnecessary substance that is generated by the irradiation of the processing light EL, because the optical surface **1124** faces the containing space SP. As a result, there is a possibility that the unnecessary substance adheres to the optical surface **1124**. Moreover, there is a possibility that the unnecessary substance adhered to the optical surface **1124** is backed (namely, is firmly fixed) by the processing light EL passing through the optical surface **1124**, because the processing lights EL pass through the optical surface **1124**. The unnecessary substance adhered (moreover, firmly fixed) to the optical surface **1124** becomes a dust to be likely to affect a characteristic of the processing lights EL. However, when the gas such as the CDA is supplied to the optical surface **1124**, a contact between the optical surface **1124** and the unnecessary substance is prevented. Thus, an adherence of the dust to the optical surface **1124** is prevented. Therefore, the gas supply apparatus **17** also serves as an adherence prevention apparatus that prevents the adherence of the dust to the optical surface **1124**. Moreover, even when the dust is adhered (moreover, firmly fixed) to the optical surface **1124**, there is a possibility that the dust is removed (for example, is blown) by the CDA supplied to the optical surface **1124**. Therefore, the gas supply apparatus **17** also serves as an adherence prevention apparatus that removes the dust adhered to the optical surface **1124**.

(105) The control apparatus **18** controls an entire operation of the processing apparatus **1**. Especially, the control apparatus **18** controls the light irradiation apparatus **11**, the driving system **12**, the housing apparatus **13** and the driving system **15** so that the concave part C having a desired shape is formed at a desired position, as described later in detail.

(2) Specific Example of Processing Operation by Processing Apparatus **1**

(2-1) Specific Example of Structure Formed by Processing Operation

(106) As described above by using FIG. **2**, the processing apparatus **1** forms the concave part C at the coat SF of paint in the present embodiment. The concave part C is formed at a part of the coat SF of paint that is actually irradiated with the processing light EL (namely, a part at which the irradiation area EA that is actually irradiated with the processing light EL is set). Thus, the concave part C is formable at a desired position of the coat SF of paint by properly setting a position on the coat SF of paint that is actually irradiated with the processing light EL (namely, a position at which the irradiation area EA that is actually irradiated with the processing light EL is set). Namely, a structure of the coat SF of paint is formable on the processing target object S.

(107) In the present embodiment, the processing apparatus **1** forms a riblet structure that is one example of the structure of the coat SF of paint on the processing target object S under the control of the control apparatus **15**. The riblet structure is a structure by which a resistance (especially, a frictional resistance, a turbulent frictional resistance) of the surface of the coat SF of paint to a fluid is reducible. A resistance of the processing target object S on which the riblet structure is formed to the fluid is smaller than a resistance of the processing target object S on which the riblet structure is not formed to the fluid. Thus, it can be said that the riblet structure is a structure by which the resistance of the surface of the processing target object S to the fluid is reducible. Note that the fluid here may be any medium (gas, liquid) that flows relative to the surface of the coat SF of paint, and the medium may be referred to as the fluid when the surface of the coat SF of paint moves although the medium itself is static.

(108) One example of the riblet structure is illustrated in FIG. **5**A and FIG. **5**B. As illustrated in FIG. **5**A and FIG. **5**B, the riblet structure is a structure in which a plurality of concave structures CP**1** each of which is formed by sequentially forming the concave part C along a first direction (the Y axis direction in an example illustrated in FIG. **5**A and FIG. **5**B) (namely, a plurality of concave

structures CP**1** each of which is linearly formed to extend along the first direction) are arranged along a second direction (the X axis direction in the example illustrated in FIG. **5**A and FIG. **5**B) that intersects with the first direction, for example. A convex structure CP**2** that protrudes from a surrounding area substantially exists between two adjacent concave structures CP**1**. Therefore, it can be said that the riblet structure is a structure in which a plurality of convex structures CP**2** each of which linearly extends along the first direction (for example, the Y axis direction) are arranged along the second direction (for example, the X axis direction) that intersects with the first direction, for example. The riblet structure illustrated in FIG. **5**A and FIG. **5**B is a periodical structure.

(109) An interval between the two adjacent concave structures CP**1** (namely, an arrangement pitch P**1** of the concave structure CP**1**) is several microns to several hundred microns, for example, however, may be different size. Moreover, a depth (namely, a depth in the Z axis direction) D of each concave structure CP**1** is several microns to several hundred microns, for example, however, may be different size. The depth D of each concave structure CP**1** may be equal to or smaller than the arrangement pitch P**1** of the concave structure CP**1**. The depth D of each concave structure CP**1** may be equal to or smaller than a half of the arrangement pitch P**1** of the concave structure CP**1**. A shape of a cross-sectional surface including the Z axis (specifically, a cross-sectional surface along the XZ plane) of each concave structure CP**1** is a bowl-shaped curved shape, however, may be a triangle shape, may be a quadrangular shape, may be a polygonal shape more than a pentagonal shape. Similarly, an interval between the two adjacent convex structures CP**2** (namely, an arrangement pitch P**2** of the convex structure CP**2**) is several microns to several hundred microns, for example, however, may be different size. Moreover, a height (namely, a height in the Z axis direction) H of each convex structure CP**2** is several microns to several hundred microns, for example, however, may be different size. The height H of each convex structure CP**2** may be equal to or smaller than the arrangement pitch P**2** of the convex structure CP**2**. The height H of each convex structure CP**2** may be equal to or smaller than a half of the arrangement pitch P**2** of the convex structure CP**2**. A shape of a cross-sectional surface including the Z axis (specifically, a cross-sectional surface along the XZ plane) of each convex structure CP**2** is a chevron shape having a curved slope, however, may be a triangle shape, may be a quadrangular shape, may be a polygonal shape more than a pentagonal shape. Note that the riblet structure itself formed by the processing apparatus **1** may be an existing riblet structure disclosed in “Mechanical Engineers' Handbook, Basic Edition, α4 Fluids Engineering”, Chapter 5, edited by The Japan Society of Mechanical Engineers, for example, and a detailed description of the riblet structure itself is omitted.

(110) As described above, the resistance of the surface of the processing target object S to the fluid is reducible by the riblet structure like this, as described above. Thus, the processing target object S may be an object an object (for example, a structural object) the resistance of which to the fluid is desired to be reduced. For example, the processing target object S may be an object (namely, a movable body) that is movable so that at least a part thereof travels in the fluid (for example, at least one of the gas and the liquid). Specifically, for example, the processing target object S may include an airframe (for example, at least one of a body PL**1**, a main wing PL**2**, a vertical tail PL**3** and a horizontal tail PL**4**) of an airplane PL as illustrated in FIG. **6**A to FIG. **6**C. In this case, as illustrated in FIG. **6**A to FIG. **6**C, the processing apparatus **1** may self-stands on the airframe of the airplane PL by the support apparatus **14**. Alternatively, the processing apparatus **1** may be attached to the airframe of the airplane PL to suspend (namely, hang) from the airframe of the airplane PL by the support apparatus **14** as illustrated in FIG. **6**B, because the end part **144** of the leg member **142** of the support apparatus **14** is configured to attach to the coat SF of paint. Moreover, the processing apparatus **1** is capable of self-standing on the coat SF of paint even when the surface of the coat SF of paint is inclined with respect to the horizontal plane in a state where the surface of the coat SF of paint faces upwardly, because the end part **144** of the leg member **142** of the support apparatus **14** is configured to attach to the coat SF of paint and the end part **134** of the partition

member **132** of the housing apparatus **13** is configured to adhere to the coat SF of paint. Moreover, the processing apparatus **1** is capable of attaching to the coat SF of paint to suspend from the coat SF of paint even when the surface of the coat SF of paint is inclined with respect to the horizontal plane in a state where the surface of the coat SF of paint faces downwardly. Even in both cases, the light irradiation apparatus **11** is movable along the surface of the airplane PL by the driving system **12** and/or the movement of the support apparatus **14**. Therefore, the processing apparatus **1** is capable of forming the riblet structure of the coat SF of paint at the processing target object S such as the airframe of the airplane (namely, the processing target object S the surface of which is a curved surface, the surface of which is inclined with respect to the horizontal plane or the surface of which faces downwardly).

(111) Beyond that, for example, the processing target object S may include a vehicle body of a vehicle. For example, the processing target object S may include a ship hull of a ship. For example, the processing target object S may include a body of a rocket. For example, the processing target object S may include a turbine (for example, at least one of a hydraulic turbine, a wind turbine and the like, especially a turbine blade thereof). Alternatively, for example, the processing target object S may include a component that constitutes the object at least a part of which travels in the fluid. Alternatively, for example, the processing target object S may include an object at least a part of which is fixed in the flowing fluid. Specifically, for example, the processing target object S may include a bridge column built in a river or a sea.

(112) Note that one example of the processing target object S described here is a relatively large object (for example, an object having a size of an order of several meters to several hundred meters). In this case, as illustrated in FIG. **6**A to FIG. **6**C, a size of the light irradiation apparatus **11** is smaller than a size of the processing target object S. However, the processing target object S may be an object having any size. For example, the processing target object S may be an object having a size of an order of kilometer, centimeter, millimeter or micrometer.

(113) A size of the above described riblet structure (for example, at least one of the arrangement pitch P**1** of the concave structure CP**1**, the depth D of each concave structure CP**1**, the arrangement pitch P**2** of the convex structure CP**2**, the height H of each convex structure CP**2** and the like) may be set to a proper size by which an effect of a reduction of the resistance is properly achieved based on what object the processing target object S is. More specifically, the size of the riblet structure may be set to a proper size by which the effect of the reduction of the resistance is properly achieved based on a type of the fluid that distributes around the used (namely, operated) processing target object S, a relative velocity of the processing target object S relative to the fluid, a shape of the processing target object S and the like. For example, when the processing target object S is the airframe of the airplane that flies at a 1000 kilometer per hour at an altitude of 10 kilometer in cruising, the arrangement pitch P**1** of the concave structure CP**1** (namely, the arrangement pitch P**2** of the convex structure CP**2**) may be set to about 78 micrometers, for example.

(114) Moreover, the size of the above described riblet structure may be set to a proper size by which an effect of a reduction of the resistance is properly achieved based on what object the processing target object S is and where the riblet structure is formed at the object. For example, when the processing target object S is the airframe of the airplane PL, the size of the riblet structure formed at the body PL**1** may be different from the size of the riblet structure formed at the main wing PL**2**.

(2-2) Flow of Processing Operation

(115) Next, with reference to FIG. **7** to FIG. **17**, a flow of a processing operation for forming the riblet structure will be described.

(116) Firstly, as described above, the plurality of processing lights EL are deflected by the Galvano mirror **1122**. In order to form the riblet structure, the Galvano mirror **1122** deflects the plurality of processing lights EL to alternately repeat a scan operation for sweeping the surface of the coat SF of paint with the plurality of processing lights EL along the Y axis (namely, for moving the

plurality of irradiation areas EA along the Y axis on the surface of the coat SF of paint) and a step operation for moving the plurality of irradiation areas EA along the X axis on the surface of the coat SF of paint by a predetermined amount. In this case, a size of an area on the surface of the coat SF of paint that is swept with the plurality of processing lights EL by controlling the Galvano mirror **1122** without moving the light irradiation apparatus **11** relative to the coat SF of paint is limited. Therefore, in the present embodiment, as illustrated in FIG. **7**, the control apparatus **18** sets a plurality of unit processing areas SA on the surface of the coat SF of paint (especially, an area of the coat SF of paint at which the riblet structure should be formed). Each unit processing area SA corresponds to an area that is sweepable with the plurality of processing lights EL by controlling the Galvano mirror **1122** without moving the light irradiation apparatus **11** relative to the coat SF of paint. A shape of each unit processing area SA is a quadrangular shape, however, may be any shape.
(117) The control apparatus **18** forms the riblet structure at one unit processing area SA (for example, SA**1**) by controlling the light irradiation apparatus **11** to irradiate the one unit processing area SA (SA**1**) with the plurality of processing lights EL deflected by the Galvano mirror **1122**. Then, the control apparatus **18** disposes the light irradiation apparatus **11** on a position from which another unit processing area SA (for example, SA**2**) is irradiated with the plurality of processing lights EL by controlling at least one of the driving systems **12** and **15** to move the light irradiation apparatus **11** relative to the coat SF of paint. Then, the control apparatus **18** forms the riblet structure at the another unit processing area SA (SA**2**) by controlling the light irradiation apparatus **11** to irradiate the another unit processing area SA (SA**2**) with the plurality of processing lights EL deflected by the Galvano mirror **1122**. The control apparatus **18** repeats forms the riblet structure by repeating the following operation at all unit processing areas SA**1** to SA**16**.
(118) Next, an operation for forming the riblet structure at the unit processing areas SA**1** to SA**4** illustrated in FIG. **7** will be described as one example. Incidentally, in the below described description, an example in which two unit processing areas SA that are adjacent to each other along the X axis are located in the containing space SP will be described. However, the fact remains that same operation is performed even when any number of unit processing area SA is located in the containing space SP.
(119) As illustrated in FIG. **8**, firstly, the control apparatus **18** controls the driving system **15** to move the support apparatus **14** relative to the coat SF of paint so that the housing apparatus **13** is disposed at a first housing position at which the unit processing areas SA**1** and SA**2** are located in the containing space SP. Namely, the control apparatus **18** moves the housing apparatus **13** supported by the support apparatus **14** so that the unit processing areas SA**1** and SA**2** are covered by the housing apparatus **13**. Moreover, the control apparatus **18** controls the driving system **12** to move the light irradiation apparatus **11** relative to the coat SF of paint so that the light irradiation apparatus **11** is disposed at a first irradiation position from which the unit processing area SA**1** is irradiated with the plurality of processing lights EL. After the housing apparatus **13** is disposed at the first housing position and the light irradiation apparatus **11** is disposed at the first irradiation position, the partition member **132** becomes to be the first expansion state. Therefore, the end part **134** of the partition member **132** contacts with and adheres to the coat SF of paint. Similarly, the plurality of leg members **142** becomes to be the second expansion state. Therefore, the end parts **144** of the plurality of leg members **142** contact with and adhere to the coat SF of paint.
(120) Then, as illustrated in FIG. **9**A and FIG. **9**B, the control apparatus **18** controls the light irradiation apparatus **11** (especially, the Galvano mirror **1122**) to sweep the unit processing area SA**1** with the plurality of processing lights EL. Specifically, the control apparatus **18** controls the Y scanning mirror **1122**Y of the Galvano mirror **1122** to sweep a certain area in the unit processing area SA**1** with the plurality of processing lights EL along the Y axis direction, in order to perform the above described scan operation. During a period when the scan operation is performed, the light source system **111** emits the plurality of processing lights EL. Then, the control apparatus **18**

rotates the X scanning mirror **1122**X of the Galvano mirror **1122** by a unit step amount, in order to perform the above described step operation. During a period when the step operation is performed, the light source system **111** does not emit the plurality of processing lights EL. Then, the control apparatus **18** controls the Y scanning mirror **1122**Y of the Galvano mirror **1122** to sweep a certain area in the unit processing area SA**1** with the plurality of processing lights EL along the Y axis direction, in order to perform the above described scan operation. In this manner, the control apparatus **18** controls the Galvano mirror **1122** to sweep whole of the unit processing area SA**1** (alternatively, a partial area at which the riblet structure should be formed in the unit processing area SA**1**) with the plurality of processing lights EL by alternately repeating the scan operation and the step operation. As a result, the riblet structure is formed in the unit processing area SA**1**. Note that a width of an area that is swept by the processing lights EL (namely, a width of the unit processing area SA, especially, a width in the X axis direction) is wider than a width (especially, a width in the X axis direction) of the light irradiation apparatus **11**, as illustrated in FIG. **9**A and FIG. **9**B.

(121) The control apparatus **18** controls the driving system **15** so that the plurality of leg members **142** continue to be in the second expansion state during a period when the light irradiation apparatus **11** emits the processing lights EL. As a result, the end parts **144** of the plurality of leg members **142** continue to adhere to the coat SF of paint. As a result, the stability of the support apparatus **14** improves, and thus, there is a low possibility that the irradiation areas EA of the processing lights EL are shifted on the coat SF of paint accidentally due to an instability of the support apparatus **14**. However, a part of the plurality of leg members **142** may be in the second contraction state as long as the support apparatus **14** is capable of self-standing on the coat SF of paint (alternatively, is capable of adhering to the coat SF of paint to suspend from the coat SF of paint) during at least a part of the period when the light irradiation apparatus **11** emits the lights EL.

(122) The control apparatus **18** controls the non-illustrated driving system that extends and contracts the partition member **132** so that the partition member **132** continues to be in the first expansion state during the period when the light irradiation apparatus **11** emits the processing lights EL. As a result, the end part **134** of the partition member **132** continues to attach to the coat SF of paint. As a result, the sealability of the containing space SP is maintained, and thus, the processing light EL propagating in the containing space SP does not leak outside the containing space SP (namely, outside the housing apparatus **13**). Moreover, the unnecessary substance that is generated in the containing space SP does not leak outside the containing space SP (namely, outside the housing apparatus **13**).

(123) Note that there is a possibility that at least a part of the end part **134** that should attach to the coat SF of paint is away from the coat SF of paint due to any factor. If the light irradiation apparatus **11** continues to emit the processing lights EL in this situation, there is a possibility that at least one of the processing light EL and the unnecessary substance leaks outside the housing apparatus **13**. Thus, the control apparatus **18** may control the light irradiation apparatus **11** to stop the irradiation of the processing lights EL when it is detected that at least a part of the end part **134** is away from the coat SF of paint during the period when the light irradiation apparatus **11** emits the processing lights EL.

(124) Then, as illustrated in FIG. **10**, the control apparatus **18** controls the driving system **12** so that the light irradiation apparatus **11** moves from the first irradiation position to a second irradiation position at which the light irradiation apparatus **11** irradiates the unit processing area SA**2** with the plurality of processing lights EL. During a period when the light irradiation apparatus **11** moves, the control apparatus **18** controls the light irradiation apparatus **11** so that the light irradiation apparatus **11** does not emit the processing lights EL.

(125) Then, as illustrated in FIG. **11**A and FIG. **9**B, the control apparatus **18** controls the light irradiation apparatus **11** (especially, the Galvano mirror **1122**) to sweep the unit processing area SA**2** with the plurality of processing lights EL. Specifically, the control apparatus **18** controls the

light irradiation apparatus **11** (especially, the Galvano mirror **1122**) to sweep whole of the unit processing area SA**2** (alternatively, a partial area at which the riblet structure should be formed in the unit processing area SA**2**) with the plurality of processing lights EL by alternately repeating the above described scan operation and the above described step operation. As a result, the riblet structure is formed in the unit processing area SA**2**. Note that the concave parts CP**1** constituting the riblet structure in the unit processing area SA**1** may be sequentially connected to or may not be connected to the concave parts CP**1** constituting the riblet structure in the unit processing area SA**2** (alternatively, other unit processing area SA) one by one. Because the size of about 10 centimeter or more can be secured as the size of the unit processing size SA, and thus, a sequential length of one concave part CP**1** formed by sweeping the unit processing area SA with the processing lights EL is about 10 centimeter or more, and this size is sufficiently longer than a sequential length (about several millimeters) that is calculated on the basis of an air speed and a frequency of turbulence phenomenon when the airplane is used (namely, cruises) to fulfill a function of the riblet structure.
(126) After the riblet structure is formed in the unit processing area SA**2**, there is no unit processing area SA in which the riblet structure is not formed yet in the containing space SP. Thus, it is difficult for the light irradiation apparatus **11** to irradiate the unit processing area SA in which the riblet structure is not formed yet with the plurality of processing lights EL to form therein only by moving the light irradiation apparatus **11** in the containing space SP by the driving system **12**. Thus, when there is no unit processing area SA in which the riblet structure is not formed yet in the containing space SP, the control apparatus **18** controls the driving system **15** to move the support apparatus **14** (namely, to move the housing apparatus **13**) so that the unit processing area SA in which the riblet structure is not formed yet is located in the containing space SP.
(127) Specifically, firstly, as illustrated in FIG. **12**, the control apparatus **18** controls the non-illustrated driving system that extends and contracts the partition member **132** so that the state of the partition member **132** is switched from the first expansion state to the first contraction state. As a result, the end part **134** of the partition member **132** is away from the coat SF of paint. Note that the control apparatus **18** controls the light irradiation apparatus **11** so that the light irradiation apparatus **11** does not emit the processing lights EL during a period when the support apparatus **14** moves. Thus, even when the end part **134** is away from the coat SF of paint, at least one of the processing light EL and the unnecessary substance does not leak outside the housing apparatus **13**.
(128) However, although the unnecessary substance existing in the containing space SP is sucked outside the containing space SP by the above described exhaust apparatus **16**, there is a possibility that all of the unnecessary substance existing in the containing space SP is not sucked by the exhaust apparatus **16** (namely, the unnecessary substance remains in the containing space SP) due to any factor. In this, if the end part **134** is away from the coat SF of paint, there is a possibility that the unnecessary substance leaks outside the housing apparatus **13**. Thus, the control apparatus **18** determines on the basis of the detected result of the detection apparatus **135** that detects the unnecessary substance in the containing space SP whether or not the partition member **132** is switched from the first expansion state to the first contraction state. When the unnecessary substance remains in the containing space SP, the control apparatus **18** does not switch the partition member **132** from the first expansion state to the first contraction state. In this case, the exhaust apparatus **16** continues to suck the unnecessary substance remaining in the containing space SP. On the other hand, when the unnecessary substance does not remain in the containing space SP, the control apparatus **18** switches the partition member **132** from the first expansion state to the first contraction state.
(129) Moreover, the control apparatus **18** controls the driving system **15** so that the state of at least one leg member **142** that moves relative to the coat SF of paint due to the movement of the support apparatus **14** (especially, the expansion of the contracted beam member **141** described later) among the plurality of leg members **142** is switched from the second expansion state to the second

contraction state. The leg member **142** that moves relative to coat SF of paint due to the expansion of the contracted beam member **141** is typically the leg member **142** that is disposed at a front side along a moving direction of the support apparatus **14** (namely, a moving direction of the housing apparatus **13**) among the plurality of leg members **142**. In an example illustrated in FIG. **12**, the support apparatus **14** moves toward the +X side and the leg member **142** that is disposed at the front side along the moving direction of the support apparatus **14** is the leg member **142** at the +X side. Hereinafter, the leg member **142** that is disposed at the front side along the moving direction of the support apparatus **14** is referred to as a “front leg member **142**”. As a result, the end part **144** of the front leg member **142** is away from the coat SF of paint.
(130) Then, as illustrated in FIG. **13**, the control apparatus **18** controls the driving system **15** so that the housing apparatus **13** moves from the first housing position to a second housing position at which the unit processing areas SA**3** and SA**4** are located in the containing space SP. Specifically, the control apparatus **18** controls the driving system **15** so that the beam member **141** extends along the moving direction of the support apparatus **14**. As a result, the beam member **141** extends while supporting the housing apparatus **13** (moreover, while supporting the light irradiation apparatus **11** supported by the housing apparatus **13**). In parallel with the movement of the support apparatus **14**, the control apparatus **18** controls the driving system **12** so that the light irradiation apparatus **11** moves from the second irradiation position to a third irradiation position at which the light irradiation apparatus **11** irradiates the unit processing area SA**3** with the plurality of processing lights EL.
(131) The control apparatus **18** controls the non-illustrated driving system that extends and contracts the partition member **132** so that the partition member **132** continues to be in the first contraction state during the period when the support apparatus **14** moves (namely, the contracted beam member **141** extends). As a result, the movement of the support apparatus **14** (namely, the movement of the housing apparatus **13**) is not prevented by a contact between the end part **134** of the partition member **132** and the coat SF of paint. Moreover, the coat SF of paint is not scratched by the contact between the end part **134** and the coat SF of paint when the support apparatus **14** moves. However, when the contact between the end part **134** and the coat SF of paint does not prevent movement of the support apparatus **14**, at least a part of the end part **134** may contact with the coat SF of paint during at least a part of the period when the support apparatus **14** moves. When the contact between the end part **134** and the coat SF of paint does not scratch the coat SF of paint during the period when the support apparatus **14** moves, at least a part of the end part **134** may contact with the coat SF of paint during at least a part of the period when the support apparatus **14** moves.
(132) Moreover, the control apparatus **18** controls the driving system **15** so that the front leg member **142** continues to be in the second contraction state during the period when the support apparatus **14** moves. As a result, the movement of the support apparatus **14** (namely, the movement of the housing apparatus **13**) is not prevented by a contact between the end part **144** of the front leg member **142** and the coat SF of paint. Moreover, the coat SF of paint is not scratched by the contact between the end part **144** and the coat SF of paint when the support apparatus **14** moves. However, when the contact between the end part **144** and the coat SF of paint does not prevent movement of the support apparatus **14**, at least a part of the end part **144** may contact with the coat SF of paint during at least a part of the period when the support apparatus **14** moves. When the contact between the end part **144** and the coat SF of paint does not scratch the coat SF of paint during the period when the support apparatus **14** moves, at least a part of the end part **144** may contact with the coat SF of paint during at least a part of the period when the support apparatus **14** moves.
(133) Moreover, the control apparatus **18** controls the driving system **15** so that the other leg member **142** of the plurality of leg members **142** other than the front leg member **142** continues to be in the first expansion state during the period when the support apparatus **14** moves. As a result, the movement of the support apparatus **14** (namely, the movement of the housing apparatus **14**) is

not prevented by the contact between the end part **144** of the front leg member **142** and the coat SF of paint. Moreover, the coat SF of paint is not scratched by the contact between the end part **144** and the coat SF of paint when the support apparatus **14** moves. Even when the end part **144** of the front leg member **142** is away from the coat SF of paint, the end part **144** of the other leg member other than the front leg member **142** contacts with the coat SF of paint. Thus, the fact remains that the processing apparatus **1** is capable of self-standing on the coat SF of paint (alternatively, is capable of adhering to the coat SF of paint to suspend from the coat SF of paint), as with the case where all end parts **144** of the plurality of leg members **142** contact with the coat SF of paint.
(134) Moreover, during the period when the support apparatus **14** moves, the control apparatus **18** controls the light irradiation apparatus **11** so that the light irradiation apparatus **11** does not emit the processing lights EL.
(135) After the housing apparatus **13** is disposed at the second housing position, as illustrated in FIG. **14**, the control apparatus **18** controls the non-illustrated driving system that extends and contracts the partition member **132** so that the partition member **132** is switched from the first contraction state to the first expansion state. As a result, the end part **134** of the partition member **132** contacts with and adheres to the coat SF of paint. Moreover, the control apparatus **18** controls the driving system **15** so that the front leg member **142** is switched from the second contraction state to the second expansion state. As a result, the end part **144** of the front leg member **142** contacts with and adheres to the coat SF of paint. Here, an operation for extending the partition member **132** and an operation for extending the front leg member **142** may be performed at the same time or may be performed at different times.
(136) Then, as illustrated in FIG. **15**, the control apparatus **18** controls the driving system **15** so that the state of at least one leg member **142** that moves relative to the coat SF of paint due to the movement of the support apparatus **14** (especially, the contraction of the extended beam member **141** described later) among the plurality of leg members **142** is switched from the second expansion state to the second contraction state. The leg member **142** that moves relative to coat SF of paint due to the contraction of the extended beam member **141** is typically the leg member **142** that is disposed at a rear side along the moving direction of the support apparatus **14** among the plurality of leg members **142**. In an example illustrated in FIG. **15**, the leg member **142** that is disposed at the rear side along the moving direction of the support apparatus **14** is the leg member **142** at the −X side. Hereinafter, the leg member **142** that is disposed at the rear side along the moving direction of the support apparatus **14** is referred to as a “rear leg member **142**”. As a result, the end part **144** of the rear leg member **142** is away from the coat SF of paint.
(137) Then, as illustrated in FIG. **16**, the control apparatus **18** controls the driving system **15** to contract the beam member **141** extending along the moving direction of the support apparatus **14**.
(138) After the beam member **141** finishes contracting, as illustrated in FIG. **17**, the control apparatus **18** controls the driving system **15** so that the second leg member **142** is switched from the second contraction state to the second expansion state. As a result, the end part **144** of the rear leg member **142** contacts with and adheres to the coat SF of paint.
(139) Then, the control apparatus **18** controls the light irradiation apparatus **11** to sweep the unit processing areas SA**3** and SA**4** with the plurality of processing lights EL, as with the case where the unit processing areas SA**1** and SA**2** are swept with the plurality of processing lights EL. Then, same operation is repeated, and thus, the surface of the coat SF of paint (especially, the area of the coat SF of paint at which the riblet structure should be formed) is irradiated with the plurality of processing lights EL. As a result, the riblet structure of the coat SF of paint is formed on the processing target object S.
(3) Technical Effect of Processing Apparatus **1**
(140) As described above, the processing apparatus **1** in the present embodiment forms the riblet structure of the coat SF of paint on the surface of the processing target object S by irradiating the processing target object S (especially, the coat SF of paint formed on the surface thereof) with the

processing lights EL. Thus, the processing apparatus **1** forms the riblet structure relatively easily in a relatively short time, compared to a processing apparatus that forms the riblet structure by cutting the surface of the processing target object S by a cutting tool such as an end mill.
(141) Moreover, the processing apparatus **1** forms the plurality of concave structures CP**1** at the same time by emitting the plurality of processing lights EL at the same time. Thus, the throughput relating to the formation of the riblet structure improves, compared to a processing apparatus that forms only single concave structure CP**1** at a time by emitting the single processing light EL.
(142) Moreover, the processing apparatus **1** sweeps the coat SF of paint relatively fast by deflecting the plurality of processing lights EL by the Galvano mirror **1122**. Thus, the throughput relating to the formation of the riblet structure improves.
(143) Moreover, the processing apparatus **1** forms the riblet structure on the surface of the processing target object S by processing the coat SF of paint formed on the surface of the processing target object S instead of directly processing the processing target object S. Thus, an increase of a weight of the processing target object S duet to the formation of the riblet structure is prevented, compared to a processing apparatus that forms the riblet structure by newly adding (for example, pasting), on the surface of the processing target object S (namely, the surface of the coat SF of paint), a special material for forming the riblet structure.
(144) Moreover, the riblet structure is formable again relatively easily, because the processing apparatus **1** does not directly process the processing target object S. Specifically, when the riblet structure is formed again, firstly, the riblet structure of the coat SF of paint is removed and then new coat SF of paint is coated. Then, the processing apparatus **1** forms new riblet structure by processing the newly coated coat SF of paint. Therefore, a deterioration (for example, a breakage) of the riblet structure is handled relatively easily by forming the riblet structure again.
(145) Moreover, the processing apparatus **1** is allowed to form the riblet structure on the surface of the processing target object S that is difficult to be directly processed or at which the riblet structure is not formed from the beginning, because the processing apparatus **1** does not directly process the processing target object S. Namely, the riblet structure is formable relatively easily by processing the coat SF of paint by the processing apparatus **1** after coating the coat SF of paint on the surface of the processing target object.
(146) Moreover, the processing apparatus **1** forms the riblet structure of the coat SF of paint. The coat SF of paint usually has relatively strong durability to an external environment (for example, at least one of heat, light, wind and the like). Thus, the processing apparatus **1** is capable of forming the riblet structure relatively having the strong durability relatively easily.
(147) Moreover, in the present embodiment, the optical path of the processing lights EL between the terminal optical element of the optical system **112** and the coat SF of paint is included in the containing space SP. Thus, it is possible to properly prevent the processing light EL with which the coat SF of paint is irradiated (alternatively, scattered light, reflected light or the like of the processing light EL from the coat SF of paint) from propagating (in other words, scattering) toward the surrounding environment of the processing apparatus **1**, compared to a processing apparatus in which the optical path of the processing lights EL is not included in the containing space SP (namely, is exposed to an opened space). Moreover, it is possible to properly prevent the unnecessary substance generated by the irradiation of the processing light EL from flying (in other words, scattering) toward the surrounding environment of the processing apparatus **1**.
(148) Moreover, in the present embodiment, the light irradiation apparatus **11** is supported by the support apparatus **14** that is movable on the coat SF of paint. Thus, the processing apparatus is capable of relatively easily processing the coat SF of paint that relatively widely spreads. Namely, the processing apparatus **1** is capable of forming the riblet structure of the coat SF of paint in a relatively wide area on the surface of the processing target object S. Moreover, the processing apparatus **1** is capable of forming the riblet structure on the surface of the relatively large or heavy processing target object S relatively easily, because it does necessarily move the processing target

object S.

(149) Moreover, the processing apparatus **1** sucks the unnecessary substance generated by the irradiation of the processing light EL outside the containing space SP by using the exhaust apparatus **16**. Thus, the unnecessary substance rarely prevents the irradiation of the processing lights EL to the coat SF of paint. Thus, an irradiation accuracy of the processing lights EL improves, compared to a processing apparatus that is not provided with the exhaust apparatus **16** (namely, in which there is a possibility that the unnecessary substance prevents the irradiation of the processing lights EL to the coat SF of paint).

(150) Moreover, the processing apparatus **1** prevents the adherence of the dust to the optical surface **1124** (namely, the optical surface at the containing space SP side of the terminal optical element of the optical system **112**) by using the gas supply apparatus **17**. Thus, there is lower possibility that the irradiation of the processing lights EL to the coat SF of paint is prevented by the dust that adheres to the optical surface **1124**, compared to a processing apparatus that is not provided with the gas supply apparatus **17**. Thus, the irradiation accuracy of the processing lights EL improves. As a result, the forming accuracy of a riblet structure improves.

(4) Modified Example

(151) Next, modified examples of the processing apparatus **1** will be described.

(4-1) First Modified Example

(152) The above described structure of the light irradiation apparatus **11** illustrated in FIG. **3** is one example, and the processing apparatus **1** may be provided with another light irradiation apparatus having a structure that is different from the light irradiation apparatus **11** illustrated in FIG. **3**. Next, as one example of another light irradiation apparatus having the structure that is different from the light irradiation apparatus **11**, a light irradiation apparatus **21***a*, a light irradiation apparatus **22***a*, a light irradiation apparatus **23***a*, a light irradiation apparatus **24***a*, a light irradiation apparatus **25***a*, a light irradiation apparatus **26***a* and a light irradiation apparatus **27***a* will be described.

(4-1-1) Structure of Light Irradiation Apparatus **21***a*

(153) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **21***a* is provided with a light source system **211***a* that is configured to emit the processing light EL and an optical system **212***a* that guides the processing light EL emitted from the light source system **211***a* to the coat SF of paint as illustrated in FIG. **18**.

(154) The light source system **211***a* is provided with a single light source **2111***a*. The light source **2111***a* may be same as the above described light source **1111**, and thus, the detailed description thereof is omitted.

(155) The optical system **212***a* divides the processing light EL emitted from the light source **2111***a* into a plurality of (typically, two) lights and forms interference fringes that are formed by an interference of two divided processing lights EL on the surface of the coat SF of paint. In order to form the interference fringes, the optical system **212***a* is provided with an optical divide device **2121***a*, a light emitting port **2123***a*, a light emitting port **2124***a*, a collecting optical system **2125***a* and a collecting optical system **2126***a*. The light divide device **2121***a* divides the processing light EL emitted from the light source **2111***a* into a first divided light EL**1** and a second divided light EL**2**. The first divided light EL**1** is emitted from the light emitting port **2123***a* through a non-illustrated light guiding path (for example, an optical fiber and the like). The second divided light EL**2** is emitted from the light emitting port **2124***a* through a non-illustrated light guiding path (for example, an optical fiber and the like). The first divided light EL**1** emitted from the light emitting port **2123***a* is converted into parallel light by the collecting optical system **2125***a* and the surface of the coat SF of paint is irradiated with it. The second divided light EL**2** emitted from the light emitting port **2124***a* is converted into parallel light by the collecting optical system **2126***a* and the surface of the coat SF of paint is irradiated with it. The first divided light EL**1** emitted from the collecting optical system **2125***a* and the second divided light EL**2** emitted from the collecting optical system **2126***a* interfere with each other and form, on the surface of the coat SF of paint,

interference fringes having an interference pattern that is a fringe pattern in a periodical direction along the X direction in the drawing and that corresponds to the above described riblet structure (alternatively, the concave structure CP**1**). Namely, the coat SF of paint is irradiated with, as the processing light for forming the riblet structure, interference light having an intensity distribution on the surface of the coat SF of paint. As a result, a part of the coat SF of paint evaporates in accordance with the interference fringes, and thus, the riblet structure of the coat SF of paint is formed on the surface of the surface of the processing target object S.

(156) The irradiation area EA that is irradiated with the first divided light EL**1** and the second divided light EL**2** by the light irradiation apparatus **21***a* (namely, the irradiation area EA in which the interference fringes are formed) is an area that spread two-dimensionally along the surface of the coat SF of paint. Therefore, the processing apparatus **1***a* having the light irradiation apparatus **21***a* forms the riblet structure of the coat SF of paint by alternately repeating an operation for forming the interference fringes on the surface of the coat SF of paint and the step operation for moving the irradiation area EA in which the interference fringes are formed along at least one of the X axis and the Y axis on the surface of the coat SF of paint by a predetermined amount. Namely, the processing apparatus **1***a* having the light irradiation apparatus **21***a* repeats an operation for forming the interference fringes on a certain area on the surface of the coat SF of paint, then moving the light irradiation apparatus **21***a* relative to the coat SF of paint and then forming the interference fringes on another area on the surface of the coat SF of paint. Note that the light irradiation apparatus **21***a* is not capable of moving the irradiation area EA by deflecting the first divided light EL**1** and the second divided light EL**2**. Thus, the processing apparatus **1***a* having the light irradiation apparatus **21***a* moves the irradiation area EA relative to the coat SF of paint by moving the light irradiation apparatus **21***a* by the driving system **12**. Note that the irradiation area EA may be moved by disposing a Galvano mirror between the collecting optical systems **2125***a* and **2126***a* and the coat SF of paint in the light irradiation apparatus **21***a*. Moreover, a pitch of the fringe pattern of the interference fringes may be changed by changing an angle at which the first divided light EL**1** from the collecting optical system **2125***a* and the second divided light EL**2** from the collecting optical system **2126***a* are intercrossed. In this case, the angle at which the first divided light EL**1** and the second divided light EL**2** reaching the irradiation area EA are intercrossed may be changed by configuring the light emitting port **2123***a* and the collecting optical system **2125***a* to be movable as an integrated one and configuring the light emitting port **2124***a* and the collecting optical system **2126***a* to be movable as an integrated one.

(4-1-2) Structure of Light Irradiation Apparatus **22***a*

(157) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **22***a* is provided with a light source system **221***a* that is configured to emit the processing light EL and an optical system **222***a* that guides the processing light EL emitted from the light source system **221***a* to the coat SF of paint as illustrated in FIG. **19**.

(158) The light source system **221***a* is provided with a single light source **2211***a*. The light source **2211***a* may be same as the above described light source **1111**, and thus, the detailed description thereof is omitted.

(159) The optical system **222***a* converts the processing light EL emitted from the light source **2211***a* into a plurality of processing lights EL**0** and projects the plurality of processing lights EL**0** on the coat SF of paint. The optical system **222***a* is provided with a mirror array **2221***a*. The mirror array **2221***a* is provided with a plurality of mirrors M that are arranged in a matrix. Each mirror M is configured to change an inclination angle thereof. As one example of an operation, it is switched between a state where the processing light EL entering each mirror M is reflected to the coat SF of paint and a state where the processing light EL entering each mirror M is not reflected to the coat SF of paint. Note that the inclination angle of each mirror M may be controlled to change a position of the processing light EL from each mirror M on the coat SF of paint. The control apparatus **18** controls a digital mirror device **2221***a* so that the plurality of processing lights EL**0** that forms the

above described riblet structure (especially, the plurality of concave structures CP**1** that are a part of the riblet structure) are emitted from the mirror array **2221***a*. As a result, the light irradiation apparatus **22***a* irradiates the surface of the coat SF of paint with the plurality of processing lights EL at the same time, as with the above described light irradiation apparatus **11**. Namely, the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL**0**, respectively, are set on the surface of the coat SF of paint at the same time. As a result, the light irradiation apparatus **22***a* is capable of forming the riblet structure of the coat SF of paint on the surface of the processing target object S, as with the above described light irradiation apparatus **11**.
(160) The optical system **222***a* of the light irradiation apparatus **22***a* may be provided with the Galvano mirror **1122** and the fθ lens **1123**, as with the light irradiation apparatus **11**. In this case, the light irradiation apparatus **22***a* may sweep the surface of the coat SF of paint with the plurality of processing lights EL by controlling the Galvano mirror **1122**. Alternatively, when the optical system **222***a* is not provided with the Galvano mirror **1122** and the fθ lens **1123**, the surface of the coat SF of paint may be swept with the plurality of processing lights EL by moving the light irradiation apparatus **22***a* by the driving system **12**. Note that the surface of the coat SF of paint may be swept with the plurality of processing lights EL by controlling the inclination angle of each mirror M of the mirror array **2221***a* to change a position of a reflected surface of each mirror M.
(4-1-3) Structure of Light Irradiation Apparatus **23***a*
(161) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **23***a* is provided with a light source system **231***a* that is configured to emit the processing light EL and an optical system **232***a* that guides the processing light EL emitted from the light source system **231***a* to the coat SF of paint as illustrated in FIG. **20**.
(162) The light source system **231***a* may be same as the above described light source system **111**, and thus, the detailed description thereof is omitted. Note that the light source system **231***a* having the plurality of light sources **1111** (namely, the light source system **231***a* having the structure illustrated in FIG. **3**B) is used for the description in FIG. **20**.
(163) The optical system **232***a* reduces the plurality of processing lights EL emitted from the plurality of light sources **1111**, respectively, and projects them on the coat SF of paint. The optical system **232***a* is provided with a plurality of collimator lenses **2321***a* and a projection optical system **2322***a*. The plurality of collimator lenses **2321***a* convert the plurality of processing lights EL emitted from the plurality of light sources **1111**, respectively, into parallel lights, respectively. The projection optical system **2322***a* projects the plurality of processing lights EL each of which is converted to the parallel light on the coat SF of paint by a predetermined reduction magnification (for example, a projection magnification of 1/10). Note that the projection optical system **2322***a* may be configured to form a light source image on the coat SF of paint or may be configured to the light source image at a position that is away from the coat SF of paint along the optical axis direction. As a result, the light irradiation apparatus **23***a* irradiates the surface of the coat SF of paint with the plurality of processing lights EL at the same time, as with the above described light irradiation apparatus **11**. Namely, the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, are set on the surface of the coat SF of paint at the same time. As a result, the light irradiation apparatus **23***a* is capable of forming the riblet structure of the coat SF of paint on the surface of the processing target object S, as with the above described light irradiation apparatus **11**. Here, the projection magnification of the projection optical system **2322***a* is not limited to the reduction magnification, and may be an equal magnification or may be an enlargement magnification. Moreover, one or more optical element of the projection optical system **2322***a* may be configured to be movable (typically, movable along the optical axis direction) to change the projection magnification. In this case, intervals at which the plurality of irradiation areas EA are formed is changeable, and thus, the pitch of the riblet structure is changeable. Note that each of the plurality of collimator lenses **2321***a* may be disposed on the light source **1111**. Moreover, the traveling directions of the plurality of processing lights EL emitted

from the projection optical system **2322***a* are not limited to be parallel to each other, and intervals therebetween may be configured to increase or decrease as the plurality of processing lights EL propagates more.

(164) The optical system **232***a* of the light irradiation apparatus **23***a* may be provided with the Galvano mirror **1122**, as with the light irradiation apparatus **11**. In this case, the light irradiation apparatus **23***a* may sweep the surface of the coat SF of paint with the plurality of processing lights EL by controlling the Galvano mirror **1122**. Alternatively, when the optical system **232***a* is not provided with the Galvano mirror **1122**, the surface of the coat SF of paint may be swept with the plurality of processing lights EL by moving the light irradiation apparatus **23***a* by the driving system **12**. Moreover, it may be configured that the surface of the coat SF of paint may be swept with the plurality of processing lights EL by moving the light sources **1111**.

(4-1-4) Structure of Light Irradiation Apparatus **24***a*

(165) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **24***a* is provided with a light source system **241***a* that is configured to emit the processing light EL and an optical system **242***a* that guides the processing light EL emitted from the light source system **241***a* to the coat SF of paint as illustrated in FIG. **21**.

(166) The light source system **241***a* is provided with a single light source **2411***a* and an illumination optical system **2412***a*. The light source **2411***a* may be same as the above described light source **1111**, and thus, the detailed description thereof is omitted. The illumination optical system **2412***a* uniforms a light amount of the processing light EL from the light source **2411***a* in a cross-sectional surface of a flux of the processing light EL.

(167) The optical system **242***a* is provided with a mask **2421***a* and a projection optical system **2422***a*. The mask **242***a* is a photo mask (in other words, a reticle) at which a mask pattern having a light transmittance distribution corresponding to the riblet structure (alternatively, the structure that should be formed) (for example, a pattern in which a transmittance pattern through which the processing light EL is allowed to pass and a light shield pattern that shields the processing light EL are arranged in the X axis direction in a periodical manner) is formed. The processing light EL passing through the illumination optical system **2412***a* passes through the mask **2421***a* to be the processing light EL having an intensity distribution the corresponds to the riblet structure and that changes in a periodical manner. The projection optical system **2422***a* projects the processing light EL passing through the mask **2421***a* on the coat SF of paint by a predetermined reduction magnification (for example, a projection magnification of 1/10). In other words, the projection optical system forms a reduction image of the mask **2421***a* on the coat SF of paint. As a result, the light irradiation apparatus **24***a* irradiates the surface of the coat SF of paint with the processing light EL having the intensity distribution corresponding to the above described riblet structure (alternatively, the concave structure CP**1**). Namely, the surface of the coat SF of paint is irradiated with the processing light EL having the intensity distribution corresponding to the riblet structure on the surface of the coat SF of paint. As a result, a part of the coat SF of paint evaporates based on the intensity distribution of the processing light EL and thus the riblet structure of the coat SF of paint is formed on the surface of the processing target object S. Here, the projection magnification of the projection optical system **2322***a* is not limited to the reduction magnification, and may be an equal magnification or may be an enlargement magnification. Moreover, one or more optical element of the projection optical system **2322***a* may be configured to be movable (typically, movable along the optical axis direction) to change the projection magnification. In this case, period of the intensity distribution in periodical manner is changeable, and thus, the pitch of the riblet structure is changeable.

(168) The irradiation area EA that is irradiated with the processing light EL by the light irradiation apparatus **24***a* is an area that spreads two-dimensionally along the surface of the coat SF of paint. Therefore, the processing apparatus **1***a* having the light irradiation apparatus **24***a* forms the riblet structure of the coat SF of paint by alternately repeating an operation for irradiating the surface of

the coat SF of paint with the processing light EL through the mask **2421***a* and the step operation for moving the irradiation area EA along at least one of the X axis and the Y axis on the surface of the coat SF of paint by a predetermined amount. Note that the light irradiation apparatus **24***a* is not capable of moving the irradiation area EA by deflecting the processing light EL. Thus, the processing apparatus **1***a* having the light irradiation apparatus **24***a* moves the irradiation area EA relative to the coat SF of paint by moving the light irradiation apparatus **24***a* by the driving system **12**.

(169) The optical system **242***a* of the light irradiation apparatus **24***a* may be provided with the Galvano mirror **1122**, as with the light irradiation apparatus **11**. In this case, the light irradiation apparatus **24***a* may sweep the surface of the coat SF of paint with the plurality of processing lights EL by controlling the Galvano mirror **1122**. Moreover, the mask **2421***a* and the light source system **241***a* may be moved relative to the projection optical system **2422***a*.

(170) Note that the light irradiation apparatus **24***a* may be provided with a spatial light modulator that is configured to spatial-modulate the processing light EL by a modulation pattern based on the riblet structure. "Spatially-modulating the processing light EL" means changing a characteristic of the light that is at least one of an amplitude (an intensity) of the processing light EL in a cross-sectional surface of the processing light EL that intersects with the traveling direction, a phase of the light, a polarization state of the light, the wavelength of the light and the traveling direction (in other words, a deflected state). The spatial light modulator may be a transmission type of spatial light modulator that is transparent to the processing light EL to space-modulate it, or may be a reflection type of spatial light modulator that reflect the processing light EL to spatially-modulate it.

(4-1-5) Structure of Light Irradiation Apparatus **25***a*

(171) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **25***a* is provided with a light source system **251***a* that is configured to emit the processing light EL, a lens array **2513***a* that divides the processing light EL emitted from the light source system **251***a* into a plurality of beams and an optical system **252***a* that guides the plurality of beams from the lens array **2513***a* to the coat SF of paint as illustrated in FIG. **22**.

(172) The light source system **245***a* is provided with a single light source **2511***a* and a beam expander **2512***a* that shapes, typically expands and emits an entering beam from the light source **2511***a*. The beam expander **2512***a* may have an optical member for uniforms the intensity distribution in a beam cross-sectional surface of the entering beam from the light source **2511***a*.

(173) The lens array **2513***a* is provided with a plurality of lens elements that are arranged in a direction intersecting the entering beam, typically in the YZ plane in the drawing and each of which focuses the entering beam. The light source image that are arranged two-dimensionally is formed at an emitting side of the lens array **2513***a*.

(174) The optical system **252***a* is provided with an aforcal zoom lens **2522***a* for setting an interval between a plurality of entering beams to a predetermined interval, a condensing optical system **2523***a* that condenses the plurality of beams from the aforcal zoom lens **2522***a* on a predetermined position and a fθ lens **2524***a* that focuses the plurality of beams from the condensing optical system **2523***a* on the coat SF of paint as the plurality of processing lights EL**0**.

(175) The plurality of processing lights EL**0** from the optical system **252***a* (the plurality of processing lights EL**0** from the fθ lens **2524***a*) forms the plurality of irradiation areas EA on the coat SF of paint. In other words, the coat SF of paint is irradiated with the plurality of processing lights EL**0**.

(176) Here, the aforcal zoom lens **2522***a* may be regarded as a zoom lens that is telecentric on both sides. In this case, a position at which the plurality of light source images are formed by the lens array **2513***a*, an optical path between the aforcal zoom lens **2522***a* and the condensing optical system **2523***a* and the coat SF of paint are optically conjugate to one another. Since the optical path between the aforcal zoom lens **2522***a* and the condensing optical system **2523***a*, namely, the optical

path at an emitting side of the aforcal zoom lens **2522***a* and the coat SF of paint are optically conjugate to each other, it is clear that the interval between the processing lights EL**0** reaching the coat SF of paint is changed when the interval between the plurality of beams emitted from the aforcal zoom lens **2522***a* is changed. Therefore, the interval between the processing lights EL**0** reaching the coat SF of paint may be changed by changing a magnification (an angular magnification) of the aforcal zoom lens **2522***a* by a non-illustrated driving part.

(177) Moreover, a part of a plurality of lenses of the condensing optical system **2523***a* may be used as a focusing lens by configuring it to be movable along the optical axis direction.

(178) Note that the lens array **2513***a* may be referred to as a light divide element in the above described description. A reflection type of mirror array may be used instead of the lens array **2513***a*.

(4-1-6) Structure of Light Irradiation Apparatus **26***a*

(179) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **26***a* is provided with a light source system **261***a* that is configured to emit the processing light EL, a lens array **2613***a* that divides the processing light EL emitted from the light source system **261***a* into a plurality of beams and an optical system **262***a* that guides the plurality of beams from the lens array **2613***a* to the coat SF of paint as illustrated in FIG. **23**.

(180) The light irradiation apparatus **26***a* illustrated in FIG. **23** is different from the light irradiation apparatus **25***a* illustrated in FIG. **22** in that a position of a Galvano mirror **2624***a* is disposed between a condensing optical system **2623***a* (a focusing lens) and a fθ lens **2625***a*. Another structure of the light irradiation apparatus **26***a* may be same as another structure of the light irradiation apparatus **25***a*. Even when the arrangement of the Galvano mirror **2624***a* is different as described above, the light irradiation apparatus **26***a* illustrated in FIG. **23** achieves an effect that is same as the light irradiation apparatus **25***a* illustrated in FIG. **22**.

(181) Note that the fθ lens **2625***a* may be an optical system that is telecentric on the coat SF of paint side, or may be an optical system that is non-telecentric on the coat SF of paint side. When the fθ lens **2625***a* is the optical system that is non-telecentric on the coat SF of paint side, an area that is larger than a size of the fθ lens **2625***a* is allowed to be irradiated with the processing light EL.

(182) Moreover, when at least one partial lens of the condensing optical system **2523***a* or **2623***a* is used as the focusing lens to move it along the optical axis direction in each of the above described light irradiation apparatuses **26***a* and **26***b* illustrated in FIG. **22** and FIG. **23**, respectively, there is a possibility that the magnification of the optical system **252***a* or **262***a* is changed due to a movement of the focusing lens. In this case, a fluctuation of the magnification due to the movement of the focusing lens may be modified by changing the magnification of the aforcal zoom lens **2522***a* or **2622***a*.

(183) Note that the Galvano mirror **2624***a* may be a biaxial Galvano mirror that is movable around two axis that are perpendicular to each other, however, it is not limited to this and a mirror having two combined single-axial mirrors may be used.

(4-1-7) Structure of Light Irradiation Apparatus **27***a*

(184) In order to irradiate the coat SF of paint with the processing light EL, the light irradiation apparatus **27***a* is provided with a light source system **271***a* that is configured to emit the processing light EL, a light divide part having a light divide member **2713***a* that divides the processing light EL emitted from the light source system **271***a* into a plurality of beams and an optical system **272***a* that guides the plurality of beams from the light divide part to the coat SF of paint as illustrated in FIG. **24**. Here, the structures of the light source system **271***a* and the optical system **272***a* are same as the structure of the light source system **251***a* and the optical system **252***a* illustrated in FIG. **22**, and thus the description about them is omitted here.

(185) A reflective type of diffractive optical element may be used as the light divide member **2713***a*. An entering beam entering the light divide member **2713***a* is divided into a plurality of diffracted beams that travel toward directions that are different from each other by a diffraction

action, for example. A collimator optical system **2714***a* having a front focal point located at a position of the light divide member **2713***a* is disposed at an emitting side of the light divide member **2713***a*, and directions of the plurality of beams traveling toward directions that are different from each other are changed to be parallel to each other and they travel to the optical system **272***a* as the plurality of beams that are parallel to each other.
(186) Note that the light divide member **2713***a* is not limited to the reflective type of diffractive optical element, and a reflective type of spatial light modulator may be used. Various spatial light modulator such as a mirror array having a plurality of mirrors positions and/or attitudes of which are changeable each other, a LCOS (Liquid Crystal On Silicon) type of spatial light modulator or the like may be used as the reflective type of spatial light modulator. Here, when the spatial light modulator that is configured to actively change a state of a reflected light is used as the light divide member **2713***a*, at least one of the position, a shape, a distribution and the like of the irradiation area EA on the coat SF of paint is adjustable by changing a state (the intensity distribution, the traveling direction and the like) of the light from the spatial light modulator. Moreover, at least one of a transmission type of diffractive optical element and a transmission type of spatial light modulator may be used as the light divide member **2713***a*.
(187) Note that the optical system **262***a* illustrated in FIG. **25** may be used as the optical system **272***a* illustrated in FIG. **24**.
(4-1-8) Modified Example of Light Irradiation Apparatus **11** Illustrated in FIG. **3**
(188) In the light source system **111** illustrated in FIG. **3**B, the plurality of light sources **1111** are arranged in a line at regular intervals. However, the plurality of light sources **1111** may not be arranged at regular intervals and may not be arranged in a line. Namely, the plurality of light sources **1111** may be arranged in another arrangement pattern that is different from the arrangement pattern illustrated in FIG. **3**B. For example, the plurality of light sources **1111** may be arranged in a matrix at regular intervals. For example, the plurality of light sources **1111** may be arranged in a staggered arrangement pattern. For example, the plurality of light sources **1111** may be arranged in a line or in rows at random intervals.
(189) In the light source system **111** illustrated in FIG. **3**C, the plurality of emitting ports from which the plurality of processing lights EL divided by the divide device **1112**, respectively, are arranged in a line at regular intervals. However, the plurality of emitting ports may not be arranged at regular intervals and may not be arranged in a line. Namely, the plurality of emitting ports may be arranged in another arrangement pattern that is different from the arrangement pattern illustrated in FIG. **3**C. For example, the plurality of emitting ports may be arranged in a matrix at regular intervals. For example, the plurality of emitting ports may be arranged in a staggered arrangement pattern. For example, the plurality of emitting ports may be arranged in a line or in rows at random intervals. Alternatively, the light source system **111** may be provided with single emitting port. Namely, the light source system **111** may emit single processing light EL. In this case, the light source system **111** may not be provided with the divide device **1112**.
(190) The coat SF of paint is irradiated with the plurality of processing lights EL at the same time by the light irradiation apparatus **11** illustrated in FIG. **3**. The coat SF of paint may not be irradiated with the plurality of processing lights EL at the same time. For example, the coat SF of paint may not be irradiated with other part of the plurality of processing lights EL during a period when the coat SF of paint is irradiated with a part of the plurality of processing lights EL. For example, the coat SF of paint may be irradiated with a part of the plurality of processing lights EL at a first timing and then the coat SF of paint may be irradiated with other part of the plurality of processing lights EL at a second timing that is different from the first timing. For example, the coat SF of paint may be irradiated with the plurality of processing lights EL in order.
(191) In the light irradiation apparatus **11** illustrated in FIG. **3**, the Galvano mirror **1122** is the biaxial Galvano mirror having both of the X scanning mirror **1122**X and the Y scanning mirror **1122**Y. However, the Galvano mirror **1122** may be a single-axial Galvano mirror having at least

one of the X scanning mirror **1122**X and the Y scanning mirror **1122**Y. The processing apparatus having the single-axial Galvano mirror may sweep the surface of the coat SF of paint with the plurality of processing lights EL along either one of the X axis direction and the Y axis direction by controlling the Galvano mirror and may sweep the surface of the coat SF of paint with the plurality of processing lights EL along the other one of the X axis direction and the Y axis direction by moving the light irradiation apparatus having the single-axial Galvano mirror along the other one of the X axis direction and the Y axis direction by using the driving system **12**. Note that a Galvano mirror having one mirror that is rotatable around two perpendicular axes may be used as the Galvano mirror **1122**.

(4-2) Second Modified Example

(192) Next, with reference to FIG. **25**, a processing apparatus **1***b* in a second modified example will be described. As illustrated in FIG. **25**, the processing apparatus **1***b* in the second modified example is different from the above described processing apparatus **1** in that it is further provided with a surface characteristic measurement apparatus **19***b*. The surface characteristic measurement apparatus **19***b* measures a characteristic of the surface of the coat SF of paint (especially, a partial surface part of the surface of the coat SF of paint that will be irradiated with the plurality of processing lights EL by the light irradiation apparatus **11**) before the surface of the coat SF of paint is irradiated with the plurality of processing lights EL by the light irradiation apparatus **11**. The surface characteristic measurement apparatus **19***b* is supported by the housing apparatus **13** through a supporting member **136***b*. Therefore, a positional relationship between the light irradiation apparatus **11** and the surface characteristic measurement apparatus **19***b* is fixed in the containing space SP. Moreover, the processing apparatus **1***b* in the second modified example is different from the above described processing apparatus **1** in that it controls the light irradiation apparatus **11** on the basis of a measured result of the surface characteristic measurement apparatus **19***b*. Another feature of the processing apparatus **1***b* may be same as another feature of the processing apparatus **1**.

(193) Next, specific examples of an advance measurement control operation for controlling the light irradiation apparatus **11** on the basis of the measured result of the surface characteristic measurement apparatus **19***b* will be described.

(4-2-1) First Specific Example of Advance Measurement Control Operation

(194) In the first specific example, the surface characteristic measurement apparatus **19***b* measures a shape of the surface of the coat SF of paint as the characteristic of the surface of the coat SF of paint. The surface characteristic measurement apparatus **19***b* irradiates the coat SF of paint with a measurement light MLb (hereinafter, the measurement light MLb used in the first modified example is referred to as a “measurement light MLb**1**”). Thus, the surface characteristic measurement apparatus **19***b* is provided with a projection apparatus **191***b* that emits the measurement light MLb**1**. Moreover, the surface characteristic measurement apparatus **19***b* measures a reflected light of the measurement light MLb**1** from the coat SF of paint. Thus, the surface characteristic measurement apparatus **19***b* is provided with a detection apparatus **192***b* that detects the reflected light of the measurement light MLb**1**. The reflected light is the measurement light EL reflected by the surface of the coat SF of paint, and thus, the measured result of the reflected light (namely, an output of the surface characteristic measurement apparatus **19***b*) includes an information relating to the shape of the surface of the coat SF of paint. Thus, the control apparatus **18** is capable of determining the shape of the surface of the coat SF of paint on the basis of the measured result of the surface characteristic measurement apparatus **19***b*. Note that an measurement apparatus that emits the measurement light MLb**1** having a predetermined light pattern (for example, a liner light pattern or a grid-like light pattern) on the surface of the coat SF of paint and that measures the shape of the surface by measuring a pattern image from a direction that is different from an irradiation direction of the measurement light MLb**1** (for example, a measurement apparatus using an optical cutting method and the like) is one example of the surface

characteristic measurement apparatus **19***b* that measures the shape of the surface of the coat SF of paint. Moreover, an optical measurement apparatus using various methods such as a moire topography method using a grid irradiation method or a grid projection method, a holography interference method, an auto collimation method, a stereo method, an astigmatism method, a critical angle method or a knife edge method may be used as one example of the surface characteristic measurement apparatus **19***b*

(195) In the first specific example, the control apparatus **18** sets an irradiation condition (namely, an irradiation state) of the plurality of processing lights EL on the basis of the shape of the surface of the coat SF of paint. In the first specific example, the irradiation condition of the plurality of processing lights EL is light concentration positions FP of the plurality of processing lights EL. Specifically, the control apparatus **18** sets the light concentration positions FP of the plurality of processing lights EL to positions that allow the coat SF of paint to be processed by the irradiation of the plurality of processing lights EL, for example. Here, as described above, the coat SF of paint is processed so that a part of the coat SF of paint evaporates by the irradiation of the processing lights EL. The coat SF of paint evaporates by the energy that is transmitted from the processing lights EL to the coat SF of paint by the irradiation of the processing lights EL (namely, the energy of the processing lights EL absorbed by the coat SF of paint). The energy that is transmitted from the processing light EL to the coat SF of paint becomes larger as the intensity of the processing light EL on the surface of the coat SF of paint becomes higher. Thus, when the intensity of the processing light EL on the surface of the coat SF of paint is equal to or higher than an intensity that allows the coat SF of paint to evaporate, the coat SF of paint evaporates by the irradiation of the processing light EL. Therefore, the control apparatus **18** sets the light concentration positions FP of the plurality of processing lights EL to the positions that allow the coat SF of paint to be processed by the irradiation of the plurality of processing lights EL on the basis of a relationship between a relative position of the light concentration positions FP of the processing lights EL relative to the surface of the coat SF of paint and the intensity of the processing lights EL on the surface of the coat SF of paint. Moreover, although a part of the coat SF of paint in the irradiation area EL that is irradiated with the processing light EL is processed to evaporate, there is a possibility that the irradiation area EA that is irradiated with the processing light EL becomes large and a desired riblet structure is not formed when the light concentration position of the processing light EL is away from (namely, away along the Z axis direction) surface of the coat SF of paint too much. Therefore, the control apparatus **18** sets the light concentration positions FP of the plurality of processing lights EL so that the sizes of the irradiation areas EA of the processing lights EL become desired sizes.

(196) Considering this premise, when the surface of the coat SF of paint is located within a range of a depth of focus (namely, DOF: Depth Of Focus, and an area that extends from the light concentration positions FP of the plurality of processing lights EL toward an object plane side and an image plane side) of the optical system **112**, the intensity of the processing lights EL becomes high to some extent (namely, becomes equal to or higher than an intensity that allows the coat SF of paint to evaporate) on the surface of the coat SF of paint. Moreover, when the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112**, the sizes of the irradiation areas of the processing lights EL on the surface of the coat SF of paint become desired sizes. A state where the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112** may mean a state where the size of the irradiation area EA of the processing light EL formed on the surface of the coat SF of paint is within a desired range. Therefore, as illustrated in FIG. **26**A to FIG. **26**D, the control apparatus **18** may set the light concentration positions FP of the plurality of processing lights EL so that the surface of the coat SF of paint (especially, a partial surface part of the surface of the coat SF of paint that is irradiated with the plurality of processing lights EL) is located within the range of the depth of focus of the optical system **112**. FIG. **26**A is a cross-sectional view that illustrates an aspect in which the surface of the

coat SF of paint is positioned within the range of the depth of focus of the optical system **112** when the surface of the coat SF of paint is a flat surface. FIG. **26**B is a cross-sectional view that illustrates an aspect in which the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112** when the surface of the coat SF of paint is a curved surface. FIG. **26**C is a cross-sectional view that illustrates an aspect in which the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112** when there is a concavity and/or convexity at the surface of the coat SF of paint. FIG. **26**D is a cross-sectional view that illustrates an aspect in which the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112** when the surface of the coat SF of paint is inclined with respect to the optical axis AX (namely, the optical axis AX along the Z axis) of the optical system **112**.

(197) When the light concentration positions FP of the plurality of processing lights EL moves relative to the coat SF of paint along the Z axis, a relative positional relationship (especially, a positional relationship along the Z axis direction) between the coat SF of paint and the range of the depth of focus of the optical system **112** changes. Thus, it can be said that the control apparatus **18** substantially sets the relative positional relationship between the coat SF of paint and the range of the depth of focus of the optical system **112** by setting the light concentration positions FP of the plurality of processing lights EL.

(198) After setting the light concentration positions FP like this, the control apparatus **18** controls the focusing lens **1121** of the light irradiation apparatus **11** so that the plurality of processing lights EL are focused on the set light concentration positions FP. Namely, the control apparatus **18** controls the focusing lens **1121** to collectively control (namely, adjust) the light concentration positions FP of the plurality of processing lights EL so that the plurality of processing lights EL are focused on the set light concentration positions FP. In other words, the control apparatus **18** controls the focusing lens **1121** to control at the same time (change at the same time) the light concentration positions FP of the plurality of processing lights EL so that the plurality of processing lights EL are focused on the set light concentration positions FP. Incidentally, even in the light irradiation apparatuses **21***a* to **24***a* described in the first modified example, if the optical systems **212***a* to **242***a* are provided with the focusing lens **1121**, the light irradiation apparatuses **21***a* to **24***a* are controllable by the control apparatus **18** so that the plurality of processing lights EL are focused on the set light concentration positions FP. As a result, the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112**. Therefore, the surface of the coat SF of paint is irradiated with the processing lights EL the intensity of which is equal to or higher than the intensity that allows the coat SF of paint to evaporate. Thus, the coat SF of paint is properly processed by the plurality of processing lights EL.

(199) According to the first specific example of the advance measurement control operation, the processing apparatus **1***b* is capable of processing the coat SF of paint without being subjected to a restraint of the shape of the surface of the coat SF of paint while achieving an effect that is same as an effect achievable by the above described processing apparatus **1**.

(200) Note that the relative positions on the surface of the coat SF of paint (especially, the positions in a direction along the surface of the coat SF of paint) of the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, change due to the sweep with the plurality of the processing lights EL. Namely, the plurality of processing lights moves relative to the coat SF of paint along the surface of the coat SF of paint. When the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change, there is a possibility that shapes of parts of the surface of the coat of paint at which the plurality of irradiation areas EA are formed also change during a period when the plurality of processing lights EL are emitted. Thus, the control apparatus **18** may set the light concentration positions FP appropriately on the basis of the shapes of the parts of the surface of the coat of paint at which the plurality of irradiation areas EA are formed and control the focusing lens **1121** so that the plurality of

processing lights EL are focused on the set light concentration positions FP during the period when the plurality of processing lights EL are emitted (namely, the plurality of processing lights EL relatively moves relative to the coat SF of paint).

(201) Moreover, depending on the shape of the surface of the coat SF of paint, a part of the surface of the coat SF of paint (especially, a partial surface part of the surface of the coat SF of paint that is irradiated with the plurality of processing lights EL) is not positioned within the range of the depth of focus of the optical system **112** in some cases even when the light concentration positions FP of the plurality of processing lights EL are set. Namely, a part of the surface of the coat SF of paint is positioned within the range of the depth of focus of the optical system **112** and other part of the surface of the coat SF of paint is not positioned within the range of the depth of focus of the optical system **112** in some cases. In this case, the processing apparatus **1***b* may irradiate the coat SF of paint with only a part of the plurality of processing lights EL selectively so that a part of the coat SF of paint the surface of which is positioned within the range of the depth of focus of the optical system **112** is irradiated with the processing light EL and other part of the coat SF of paint the surface of which is not positioned within the range of the depth of focus of the optical system **112** is not irradiated with the processing light EL.

(202) Moreover, a control of the light concentration positions FP of the plurality of processing lights EL by the focusing lens **1121** is equivalent to a control of a relative positional relationship between the surface of the coat SF of paint and the light concentration positions FP of the plurality of processing lights EL along the Z axis direction. Thus, the control apparatus **18** may control the driving system **12** to control the relative position of the light irradiation apparatus **11** relative to the coat SF of paint in the Z axis direction, in addition to or instead of controlling the focusing lens **1121** to control the light concentration positions FP of the plurality of processing lights EL. Even in this case, the processing apparatus **1***b* is capable of processing the coat SF of paint without being subjected to the restraint of the shape of the surface of the coat SF of paint.

(203) Moreover, when the light concentration positions FP change, the intensity distribution of the plurality of processing lights EL in a plane (for example, the XZ plane in examples illustrated in FIG. **26**A to FIG. **26**D) including an axis that intersects with the surface of the coat SF of paint change. Thus, the control of the light concentration positions FP of the plurality of processing lights EL by the focusing lens **1121** is equivalent to a control of the intensity distribution of the plurality of processing lights EL in the plane including the axis that intersects with the surface of the coat SF of paint. In other words, the control apparatus **18** may control the intensity distribution of the plurality of processing lights EL in the plane including the axis that intersects with the surface of the coat SF of paint so that the coat SF of paint is processed by the irradiation of the plurality of processing lights EL. In this case, the optical system **112** may be provided with an intensity distribution adjusting element for adjusting the intensity distribution of the plurality of processing lights EL under the control of the control apparatus **18**. A filter having a desired density distribution in a plane intersecting the optical path, an aspherical (refractive or reflective) optical member having a desired surface shape in the plane intersecting the optical path, a diffractive optical element, a spatial light modulator and the like may be used as the intensity distribution adjusting element, for example. Alternatively, when the shapes of the plurality of processing lights EL in the plane including the axis that intersects with the surface of the coat SF of paint change, the intensity distribution of the plurality of processing lights EL also change. Thus, the control apparatus **18***b* may control the shapes of the plurality of processing lights EL in the plane including the axis that intersects with the surface of the coat SF of paint so that the coat SF of paint is processed by the irradiation of the plurality of processing lights EL. In this case, the optical system **112** may be provided with an optical shape adjusting element for adjusting the shapes of the plurality of processing lights EL under the control of the control apparatus **18**. A diaphragm having a predetermined shape of an aperture, a filter having a desired density distribution in the plane intersecting the optical path, an aspherical (refractive or reflective) optical member having a

desired surface shape in the plane intersecting the optical path, a diffractive optical element, a spatial light modulator and the like may be used as the optical shape adjusting element as the intensity distribution adjusting element, for example. Note that the control apparatus **18** may control or may not control the light concentration positions of the plurality of processing lights EL when controlling at least one of the intensity distribution and the shapes of the plurality of processing lights EL.

(204) Moreover, when the light concentration positions FP change, sizes of the irradiation areas EA on the surface of the coat SF of paint change. Specifically, the size of the irradiation area EA becomes smaller as the light concentration position FP is closer to the surface of the coat SF of paint in a direction along the surface of the coat SF of paint. The size of the irradiation area EA becomes larger as the light concentration position FP is farther from the surface of the coat SF of paint in a direction along the surface of the coat SF of paint. Thus, the control of the light concentration positions FP of the plurality of processing lights EL by the focusing lens **1121** is equivalent to a control of the sizes of the plurality of irradiation areas EA on the coat SF of paint. Therefore, it can be said that the control apparatus **18** substantially controls the sizes of the plurality of irradiation areas EA on the coat SF of paint on the basis of the positional relationship between the coat SF of paint and the plurality of irradiation areas EA. For example, in the example illustrated in FIG. **26**C, it can be said that the control apparatus **18** controls the sizes of the plurality of irradiation areas EA so that (i) the size of the irradiation area EA formed at a first part (a part that is located at the left side illustrated in FIG. **26**C) on the coat SF of paint becomes relatively small and (ii) the sizes of the irradiation areas EA formed at a second part (a part that is located at a center illustrated in FIG. **26**C) and a third part (a part that is located at a right side illustrated in FIG. **26**C) on the coat SF of paint becomes relatively large. Namely, it can be said that the control apparatus **18** sets the size of the irradiation area EA formed at the first part on the coat SF of paint to a desired first size, sets the size of the irradiation area EA formed at the second part on the coat SF of paint to a desired second size and sets the size of the irradiation area EA formed at the third part on the coat SF of paint to a desired third size,

(205) Moreover, in the above described description, the control apparatus **18** is allowed to collectively control (control at the same time) the light concentration positions FP of the plurality of processing lights EL by controlling the focusing lens **1121**. However, the control apparatus **18** may control the light concentration positions FP of the plurality of processing lights EL individually or independently. However, when the light concentration positions FP of the plurality of processing lights EL are controlled individually or independently, the processing apparatus **1***b* is provided with a light irradiation apparatus **11***b***-1** having a plurality of focusing lenses **1121** for adjusting the light concentration positions FP of the plurality of processing lights EL, respectively, instead of the light irradiation apparatus **11**. One example of the light irradiation apparatus **11***b***-1** having the plurality of focusing lenses **1121** is illustrated in FIG. **27**. As illustrated in FIG. **27***b*, the light irradiation apparatus **11***b***-1** is provided with a plurality of irradiation units **110***b***-1**. Each irradiation unit **110***b***-1** is provided with a light source system **111***b***-1** and the above described optical system **112**. The light source system **111***b***-1** is provided with the single light source **1111**. According to the light irradiation apparatus **110***b***-1**, the light concentration positions FP of the plurality of processing lights EL are controllable individually or independently, because the plurality of irradiation units **110***b***-1** that emit the plurality of processing lights EL, respectively, are provided with the plurality of focusing lenses **1121**, respectively. Note that each irradiation unit **110***b***-1** is not limited to the unit that irradiates the coat SF of paint with the plurality of processing lights EL and may be a unit that irradiates the coat SF of paint with the single processing light EL.

(206) Incidentally, in the case where each irradiation unit **110***b***-1** emits the single processing light EL, when the optical system **112** of each irradiation unit **110***b***-1** is the non-telecentric on the coat SF of paint side, a distance between the optical system **112** and the light concentration position FP changes depending on the position on the coat of paint even when the surface of the coat SF of

paint is the flat surface, as illustrated in FIG. **28**. In this case, the focusing lens **1121** may be controlled on the basis of the position of the processing light EL on the coat SF of paint.
(207) Even when the light concentration positions FP of the plurality of processing lights EL are controlled individually or independently, the control apparatus **18** may set the light concentration positions FP of the plurality of processing lights EL so that the surface of the coat SF of paint is located within the range of the depth of focus of the optical system **112**. Alternatively, as illustrated in FIG. **29**A to FIG. **29**D, the control apparatus **18** may set the light concentration positions FP of the plurality of processing lights EL so that the light concentration positions FP of the plurality of processing lights EL are positioned at the surface of the coat SF of paint. FIG. **29**A is a cross-sectional view that illustrates an aspect in which the light concentration positions FP of the plurality of processing lights EL are positioned at the surface of the coat SF of paint when the surface of the coat SF of paint is a flat surface. FIG. **29**B is a cross-sectional view that illustrates an aspect in which the light concentration positions FP of the plurality of processing lights EL are positioned at the surface of the coat SF of paint when the surface of the coat SF of paint is a curved surface. FIG. **29**C is a cross-sectional view that illustrates an aspect in which the light concentration positions FP of the plurality of processing lights EL are positioned at the surface of the coat SF of paint when there is a concavity and/or convexity at the surface of the coat SF of paint. FIG. **29**D is a cross-sectional view that illustrates an aspect in which the light concentration positions FP of the plurality of processing lights EL are positioned at the surface of the coat SF of paint when the surface of the coat SF of paint is inclined with respect to the optical axis AX of the optical system **112**.
(208) Moreover, depending on the shape of the surface of the coat SF of paint, the light concentration position FP of a part of the plurality of processing lights EL is not positioned at the surface of the coat SF of paint in some cases even when the light concentration positions FP of the plurality of processing lights EL are set individually or independently. Namely, the light concentration position FP of a part of the plurality of processing lights EL is located at the surface of the coat SF of paint and the light concentration position FP of other part of the plurality of processing lights EL is not positioned at the surface of the coat SF of paint in some cases. In this case, the processing apparatus **1***b* may irradiate the coat SF of paint with only a part of the plurality of processing lights EL selectively so that the coat SF of paint is irradiated with the processing light EL the light concentration position FP of which is positioned at the surface of the coat SF of paint and the coat SF of paint is not irradiated with the processing light EL the light concentration position FP of which is not positioned at the surface of the coat SF of paint. Alternatively, the surface of the painted fil SF is not located within the range of the depth of focus of the optical system **112** for emitting the processing light EL that is a part of the plurality of processing lights EL in some cases even when the light concentration positions FP of the plurality of processing lights EL are set individually or independently. Namely, the surface of the coat SF of paint is positioned within the range of the depth of focus of one optical system **112** for emitting one processing light EL of the plurality of processing lights EL and the surface of the coat SF of paint is not positioned within the range of the depth of focus of other one optical system **112** for emitting other one processing light EL of the plurality of processing lights EL in some cases. In this case, the processing apparatus **1***b* may irradiate the coat SF of paint with only a part of the plurality of processing lights EL selectively so that the processing light EL is emitted through the optical system **112** having the depth of focus within which the surface of the coat SF of paint is included and the processing light EL is not emitted through the optical system **112** having the depth of focus within which the surface of the coat SF of paint is not included
(209) Note that an individual control of the light concentration positions FP of the plurality of processing lights EL is substantially equivalent to a change of the relative positional relationship between the coat SF of paint and the light concentration positions FP of the plurality of processing lights EL in the Z axis direction (alternatively, a direction intersecting with the surface of the coat SF of paint). Thus, the control apparatus **18** may control a non-illustrated driving system by which

the plurality of irradiation units **110**_b_**-1** are movable individually to control the relative position of each of the plurality of irradiation units **110**_b_**-1** relative to the coat SF of paint in the Z axis direction, in addition to or instead of controlling the plurality of focusing lenses **1121** to control the light concentration positions FP of the plurality of processing lights EL. Controlling the relative position of each of the plurality of irradiation units **110**_b_**-1** in the Z axis direction results in the change of the relative positional relationship between the surface of the coat SF of paint and the light concentration positions FP of the plurality of processing lights EL in the Z axis direction. Thus, the processing apparatus **1**_b_ is capable of processing the coat SF of paint without being subjected to the restraint of the shape of the surface of the coat SF of paint even when controlling the relative position of each of the plurality of irradiation units **110**_b_**-1** in the Z axis direction.
(210) Alternatively, when an attitude (for example, an tilt amount, and relative position in at least one of the θX direction and the θY direction) of each of the plurality of irradiation units **110**_b_**-1** relative to the coat SF of paint changes, the relative positional relationship between the light concentration positions FP of the plurality of processing lights EL emitted from the plurality of irradiation units **110**_b_**-1**, respectively, changes. Thus, the control apparatus **18** may control a non-illustrated driving system by which the plurality of irradiation units **110**_b_**-1** are movable individually to control the attitude of each of the plurality of irradiation units **110**_b_**-1** relative to the coat SF of paint. Even in this case, the processing apparatus **1**_b_ is capable of processing the coat SF of paint without being subjected to the restraint of the shape of the surface of the coat SF of paint. Note that the control apparatus **18** may control the attitude of the light irradiation apparatus **11** relative to the coat SF of paint even when the processing apparatus **1**_b_ is provided with the light irradiation apparatus **11** that is not provided with the plurality of irradiation units **110**_b_**-1**. Even in this case, the relative position of the light concentration positions FP of the plurality of processing lights EL relative to the coat SF of paint is controllable.
(4-2-2) Second Specific Example of Advance Measurement Control Operation
(211) A second specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that a condition relating to the depth of focus of the optical system **112** (in the below described description, the range of the depth of focus is used) is used as the irradiation condition of the plurality of processing lights EL instead of the light concentration positions FP of the plurality of processing lights EL. Another feature of the second specific example of the advance measurement control operation may be same as the first specific example of the advance measurement control operation.
(212) In the second specific example, the control apparatus **18** sets the light concentration positions FP of the plurality of processing lights EL to positions that allow the coat SF of paint to be processed by the irradiation of the plurality of processing lights EL, as with the first specific example. For example, as illustrated in FIG. **30**A to FIG. **30**D, the control apparatus **18** may set the range of the depth of focus of the optical system **112** so that the surface of the coat SF of paint (especially, a partial surface part of the surface of the coat SF of paint that is irradiated with the plurality of processing lights EL) is positioned within the range of the depth of focus of the optical system **112**. In other words, control apparatus **18** may set the range of the depth of focus of the optical system **112** so that the sizes of the irradiation areas EA of the processing lights EL formed on the surface of the coat SF of paint is within the desired range. FIG. **30**A is a cross-sectional view that illustrates the range of the depth of focus of the optical system **112** that is set to include the surface of the coat SF of paint when the surface of the coat SF of paint is a flat surface. FIG. **30**B is a cross-sectional view that illustrates the range of the depth of focus of the optical system **112** that is set to include the surface of the coat SF of paint when the surface of the coat SF of paint is a curved surface. FIG. **30**C is a cross-sectional view that illustrates the range of the depth of focus of the optical system **112** that is set to include the surface of the coat SF of paint when there is a concavity and/or convexity at the surface of the coat SF of paint. FIG. **30**D is a cross-sectional

view that illustrates the range of the depth of focus of the optical system **112** that is set to include the surface of the coat SF of paint when the surface of the coat SF of paint is inclined with respect to the optical axis AX of the optical system **112**.

(213) In the second specific example, the optical system **112** is provided with an optical element for adjusting the range of the depth of focus of the optical system **112** (hereinafter, this optical element is referred to as a "focus depth adjusting element"). For example, the focusing lens **1121** may be used as the focus depth adjusting element. The range of the depth of focus may be positions of a lower limit and an upper limit of the range of the depth of focus in the traveling direction of the light. The control apparatus **18** controls the focus depth adjusting element so that the range of the depth of focus of the optical system **112** becomes the set range of the depth of focus. As a result, the surface of the coat SF of paint is located within the range of the depth of focus of the optical system **112**. Therefore, the surface of the coat SF of paint is irradiated with the processing lights EL the intensity of which is equal to or higher than the intensity that allows the coat SF of paint to evaporate and the coat SF of paint is removed in a desired range. Thus, the coat SF of paint is properly processed by the plurality of processing lights EL. Incidentally, although a size of the range of the depth of focus is fixed in the second specific example, the size of the range of the depth of focus may be changed. When the size of the range of the depth of focus is changed, numerical apertures of the optical system **112** at the coat SF of paint side may be changed.

(214) According to the second specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation.

(215) Incidentally, depending on the shape of the surface of the coat SF of paint, a part of the surface of the coat SF of paint (especially, a partial surface part of the surface of the coat SF of paint that is irradiated with the plurality of processing lights EL) is not located within the range of the depth of focus of the optical system **112** even when the range of the depth of focus of the optical system **112** is set in the second specific example, as with the first specific example. In this case, the processing apparatus **1***b* may irradiate the coat SF of paint with only a part of the plurality of processing lights EL selectively so that a part of the coat SF of paint the surface of which is located within the range of the depth of focus of the optical system **112** is irradiated with the processing light EL and other part of the coat SF of paint the surface of which is not located within the range of the depth of focus of the optical system **112** is not irradiated with the processing light EL.

(4-2-3) Third Specific Example of Advance Measurement Control Operation

(216) A third specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that the control apparatus **18** sets a state of an image plane of the optical system **112** (namely, an optical plane on which the processing lights EL form an image through the optical system **112**) on the basis of the shape of the surface of the coat SF of paint. Moreover, the third specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that the control apparatus **18** controls the optical system **112** so that the state of the image plane of the optical system **112** becomes the set state. Another feature of the third specific example of the advance measurement control operation may be same as the first specific example of the advance measurement control operation. Here, a virtual plane that fits the plurality of light concentration positions FP may be used as the image plane of the optical system **112**. Moreover, in the modified example illustrated in FIG. **21**, a plane on which the image of the mask **2421***a* is formed may be used.

(217) The control apparatus **18** may set a size of the image plane on the basis of the shape of the surface of the coat SF of paint. For example, the control apparatus **18** may set the size of the image plane to a predetermined size based on the shape of the surface of the coat SF of paint. The control apparatus **18** may set a relative position (for example, a relative position along at least one of the X

axis direction, the Y axis direction and the Z axis direction) of the image plane relative to the coat SF of paint (especially, the surface of the coat SF of paint) on the basis of the shape of the surface of the coat SF of paint. For example, the control apparatus **18** may set the position of the image plane to a predetermined position based on the shape of the surface of the coat SF of paint. The control apparatus **18** may set a shape of the image plane on the basis of the shape of the surface of the coat SF of paint. For example, the control apparatus **18** may set the shape of the image plane to a predetermined shape based on the shape of the surface of the coat SF of paint.
(218) When the state of the image plane is set, the control apparatus **18** may set the state of the image plane so that the image plane is coincident with the surface of the coat SF of paint as illustrated in FIG. **31**A to FIG. **31**D. FIG. **31**A is a cross-sectional view that illustrates the image plane that is set to be coincident with the surface of the coat SF of paint when the surface of the coat SF of paint is a flat surface. FIG. **31**B is a cross-sectional view that illustrates the image plane that is set to be coincident with the surface of the coat SF of paint when the surface of the coat SF of paint is a curved surface. As illustrated in FIG. **31**B, when the surface of the coat SF of paint is the curved surface (namely, is bent), the image plane is set so that the set image plane is also the curved plane (namely, is bent). FIG. **31**C is a cross-sectional view that illustrates the image plane that is set to be coincident with the surface of the coat SF of paint when there is a concavity and/or convexity at the surface of the coat SF of paint. As illustrated in FIG. **31**C, depending on the shape of the surface of the coat SF of paint, it is difficult to make the single image plane be coincident with the surface of the coat SF of paint in some cases. In this case, the surface of the coat of paint may be divided into a plurality of divided areas (in an example illustrated in FIG. **31**C, three divided areas #1 to #3) and the state (especially, at least one of the size and the position) of the image plane may be set so that the image planes (in the example illustrated in FIG. **31**C, three image plane #1 to #3) that are coincident with the divided areas, respectively, are obtained. Moreover, in this case, the plurality of divided areas are irradiated with the processing lights EL in order. Namely, the processing apparatus **1***b* processes the divided area #1 by emitting the processing light EL when the image plane of the optical system **12** is set to the image plane #1, then, processes the divided area #2 by emitting the processing light EL when the image plane of the optical system **12** is set to the image plane #2, and then, processes the divided area #3 by emitting the processing light EL when the image plane of the optical system **12** is set to the image plane #3. FIG. **31**D is a cross-sectional view that illustrates the image plane that is set to be coincident with the surface of the coat SF of paint when the surface of the coat SF of paint is inclined with respect to the optical axis AX of the optical system **112**. As illustrated in FIG. **31**D, when the surface of the coat SF of paint is inclined, the state of the image plane is set so that the set image plane is also inclined.
(219) In the third specific example, the optical system **112** that guides the processing lights EL to the coat SF of paint is provided with an optical element for adjusting the state of the image plane (hereinafter, this optical element is referred to as a “image plane adjusting element”). The control apparatus **18** controls the image plane adjusting element so that the image plane on which the processing lights EL actually form the image becomes the set image plane. Alternatively, the control apparatus **18** may control at least one of the relative position and the attitude of the light irradiation apparatus **11** relative to the coat SF of paint so that the image plane on which the processing lights EL actually form the image becomes the set image plane. As a result, the image plane on which the processing lights EL form the image is coincident with the surface of the coat SF of paint. Therefore, the coat SF of paint is properly processed by the plurality of processing lights EL. Note that a movable or deformable optical member among the optical member(s) constituting the optical system **112** may be used as the image plane adjusting element, for example. For example, a pair of wedge-shaped prisms that are rotatable around an optical axis may be disposed and the image plane may be inclined by changing a vertex angle of whole of the pair of the wedge-shaped prisms. Moreover, as the image plane adjusting element, the image plane may be

inclined by decentering or inclining at least one of the optical member(s) constituting the optical system **112** with respect to the optical axis. Moreover, a pair of cylindrical lenses that are rotatable around an optical axis may be disposed as the image plane adjusting element and a degree of curvature of the image plane may be adjusted by changing their relative angle around the optical axis. Moreover, a deformable optical member may be disposed as the image plane adjusting element and the degree of the curvature of the image plane of the optical system **112** may be adjusted by a deformation of this optical member. Note that the focusing lens **1121** may be the image plane adjusting element when the processing light EL is the single processing light.
(220) According to the third specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation.
(4-2-4) Fourth Specific Example of Advance Measurement Control Operation
(221) A fourth specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that the control apparatus **18** sets, on the surface of the coat SF of paint, a non-processing area at which the coat SF of paint should not be processed by the irradiation of the processing light EL on the basis of the shape of the surface of the coat SF of paint. Moreover, the fourth specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that the control apparatus **18** controls the light irradiation apparatus **11** so that the non-processing area is not irradiated with the processing light EL. Another feature of the fourth specific example of the advance measurement control operation may be same as the first specific example of the advance measurement control operation.
(222) The control apparatus **18** sets an area at which a structural object having a size that is equal to or larger than an allowable size exists on the surface of the coat SF of paint to the non-processing area, as illustrated in FIG. **32**A. Specifically, for example, the control apparatus **18** sets an area at which a convex structural object exists on the surface of the coat SF of paint to the non-processing area, wherein the convex structural object protrudes from a surrounding area and a protruding amount T**1** of the convex structural object from the surrounding area is larger than a predetermined protruding threshold value (for example, several millimeters, several centimeters and the like) based on the allowable size. For example, the control apparatus **18** sets an area at which a concave structural object exists on the surface of the coat SF of paint to the non-processing area in addition to or instead of the area at which the convex structural object exists, wherein the concave structural object hollows from a surrounding area and a hollowing amount T**2** of the concave structural object from the surrounding area is larger than a predetermined hollowing threshold value (for example, several millimeters, several centimeters and the like) based on the allowable size. The convex structural object or the concave structural object typically exists at a part at which the processing target object S itself protrudes or hollows, as illustrated in FIG. **32**A.
(223) As described above, the airframe of the airplane PL is one example of the processing target object S. In this case, the structural object having the size that is equal to or larger than the allowable size includes an operational structural object that is formed at a surface of the airframe for an operation of the airplane PL, for example. An antenna structural object relating to an antenna is one example of the operational structural object. The antenna structural object includes at least one of the antenna itself and an accessory that is provided with the antenna, for example. At least one of an ELT (Emergency Locator Transmitter) antenna, a VHF (Very High Frequency) antenna, an ADF (Automatic Direction Finder) antenna, an ATC (Air Traffic Control) transponder antenna, a TCAS (Traffic alert and Collision Avoidance System) antenna, a meteorological radar antenna and the like is one example of the antenna. A sensor structural object relating to a sensor is one example of the operational structural object. The sensor structural object includes at least one of the sensor itself and an accessory that is disposed with the sensor, for example. An ice detection sensor, a pitot tube, an AOA (Angle Of Attack) sensor, an altitude sensor and the like is one example of the

sensor. A flow structural object relating to an inflow and an outflow of the fluid (typically, the gas) is one example of the operational structural object. At least one of an inflow port into which the fluid flows (for example, at least one of an air intake, a cooling port and the like) and an outflow port from which the fluid flows (for example, at least one of a drain discharge port, an exhaust port and the like). Beyond that, at least one of a window of a monitoring camera, a wiper, a retract door and the like is one example of the operational structural object.

(224) After setting the non-processing area, the control apparatus **18** controls the light control apparatus **11** to sweep the surface of the coat of paint with the plurality of processing lights EL. In this period, the control apparatus **18** controls the light irradiation apparatus **11** not to irradiate the non-processing area with the processing light EL as illustrated in FIG. **32**A and FIG. **32**B. Namely, the control apparatus **18** may turn off the processing light EL with which a certain irradiation area EA is irradiated when this certain irradiation area EA overlaps with the non-processing area. Turning off the processing light EL is realizable by at least one of turning off the light source **1111**, inserting a light shielding member into the optical path of the processing light EL and the like. On the other hand, the control apparatus **18** controls the light irradiation apparatus **11** to irradiate an area that is not set as the non-processing area with the processing light EL. Note that a control of setting a sweeping area of the processing light EL to only a processing area other than the non-processing area may be performed when the processing light EL is single.

(225) According to the fourth specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation. Moreover, in the fourth specific example, the processing apparatus **1***b* does not irradiate the part at which the coat SF of paint should not be processed with the processing light EL. Thus, the processing apparatus **1***b* is capable of processing the coat SF of paint while preventing the irradiation of the processing light EL from adversely affecting any structural object such as the operational structural object.

(226) Note that the area at which the structural object having the size that is equal to or larger than the allowable size exists on the surface of the coat SF of paint is set to the non-processing area in the above described description. However, the riblet structural may be desired to be formed at the area at which the structural object having the size that is equal to or larger than the allowable size exists in some cases. For example, there is a possibility that the area at which the structural object having the size that is equal to or larger than the allowable size exists arises on the surface of the coat SF of paint due to at least one of a distortion of the processing target object S and unevenness of the thickness of the coat SF of paint, although the above described operational structural object does not exist. In this case, there is a possibility that the area at which the structural object having the size that is equal to or larger than the allowable size exists is the area at which the riblet structure should be formed, because it is not the area at which the operational structural object does not exist. Thus, the control apparatus **18** may not set, to the non-processing area, an area (hereinafter, this area is referred to as a “processing desired area” for the purpose of description) at which the riblet structure is desired to be formed although the structural object having the size that is equal to or larger than the allowable size exists and may irradiate the processing desired area with the processing light EL. Alternatively, the control apparatus **18** may temporarily set the processing desired area to the non-processing area and may irradiate the processing desired area with the processing light EL after or before irradiating the area on the surface of the coat SF of paint other than the processing desired area with the processing light EL. However, the area at which the structural object having the size that is equal to or larger than the allowable size exists corresponds to an area that protrudes from an area at which the structural object having the size that is equal to or larger than the allowable size does not exist (namely, the area at which there is the concavity and/or convexity). Thus, in order to irradiate the area at which the structural object having the size that is equal to or larger than the allowable size exists with the processing light EL, the control apparatus **18** may adjust the light concentration positions FP of the plurality of

processing lights EL (see the above described first specific example), may control the driving system **12** to move the light irradiation apparatus **11** along the Z axis (see the above described first specific example) and may adjust the depth of focus of the optical system **112** (see the above described second specific example).

(227) Moreover, the control apparatus **18** may set, to the non-processing area, an area at which the riblet structure is already formed (namely, the concave structure CP**1** and/or the convex structure CP**2** is already formed) in addition to or instead of the area at which the structural object having the size that is equal to or larger than the allowable size exists on the surface of the coat SF of paint. In this case, the riblet structure that is already formed is not processed so that a characteristic deteriorates (for example, the shape becomes an undesired shape) due to the second irradiation of the processing light EL.

(228) Moreover, the control apparatus **18** may control the light irradiation apparatus **11** so that the irradiation areas EA do not overlap with the non-processing area (namely, the irradiation areas EA move to avoid the non-processing area on the surface of the coat SF of paint. For example, the control apparatus **18** may control the driving system **12** to move the light irradiation apparatus **11** relative to the coat SF of paint so that the irradiation areas EA do not overlap with the non-processing area during the period when the light irradiation apparatus **11** emits the processing lights EL. Even in this case, the processing apparatus **1***b* is capable of processing the coat SF of paint while preventing the irradiation of the processing light EL from adversely affecting any structural object such as the operational structural object, because it does not irradiate the part at which the coat SF of paint should not be processed with the processing light EL.

(4-2-5) Fifth Specific Example of Advance Measurement Control Operation

(229) In the fifth specific example, the surface characteristic measurement apparatus **19***b* measures, as the characteristic of the surface of the coat SF of paint, a reflectance R of the coat SF of paint to the processing light EL. In order to measure the reflectance R, the projection apparatus **191***b* of the surface characteristic measurement apparatus **19***b* irradiates the coat SF of paint with the measurement light MLb (hereinafter, the measurement light MLb used in the fifth modified example is referred to as a "measurement light MLb**2**"). The measurement light MLb**2** is a light having a wavelength that is same as the wavelength of the processing light EL. Alternatively, the measurement light MLb**2** may be a light including a light component a wavelength of which is same as the wavelength of the processing light EL. In this case, if an intensity of the measurement light MLb**2** is equal to or higher than the intensity allows the coat SF of paint to evaporate, there is a possibility that the coat SF of paint evaporates due to the irradiation of the measurement light MLb**2**. Thus, the projection apparatus **191***b* emits the measurement light MLb**2** having the intensity lower than the intensity that allows the coat SF of paint to evaporate. Namely, the projection apparatus **191***b* emits the measurement light MLb**2** having the intensity that is too low to evaporate the coat SF of paint.

(230) The detection apparatus **192***b* of the surface characteristic measurement apparatus **19***b* measures a reflected light (especially, an intensity thereof) of the measurement light MLb**2** from the coat SF of paint. Since the measurement light MLb**2** is the light having the wavelength that is same as the wavelength of the processing light EL, the intensity of the reflected light of the measurement light MLb**2** becomes larger as the reflectance R of the coat SF of paint to the processing light EL becomes higher. Therefore, a measured result of the reflected light (namely, the output of the surface characteristic measurement apparatus **19***b*) includes an information relating to the reflectance R. Thus, the reflectance R is determined on the basis of the measured result of the surface characteristic measurement apparatus **19***b* by the control apparatus **18**.

(231) In the fifth specific example, the control apparatus **18** sets the intensity of the plurality of processing lights EL on the basis of the reflectance R. Specifically, as illustrated in FIG. **33**A, the control apparatus **18** sets the intensity of the plurality of processing lights EL so that the intensity of the plurality of processing lights EL becomes higher as the reflectance R becomes higher. After

setting the intensity of the plurality of processing lights EL in this manner, the control apparatus **18** controls the light irradiation apparatus **11** to emit the plurality of processing lights EL having the set intensity. Note that a relationship between the reflectance R and the intensity of the processing lights EL is not limited to a liner relationship illustrated in FIG. **33**A, and may be a non-liner relationship illustrated in FIG. **33**B and FIG. **33**C.

(232) According to the fifth specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation. Moreover, in the fifth specific example, the processing apparatus **1***b* irradiates the coat SF of paint with the processing lights EL the intensity of which becomes higher as the reflectance R of the coat SF of paint to the processing light EL becomes higher. Thus, the processing apparatus **1***b* is capable of properly processing the coat SF of paint without being affected by a difference of the reflectance R of the coat SF of paint. Namely, the processing apparatus **1***b* is capable of processing the coat SF of paint having the relatively high reflectance R and the coat SF of paint having the relatively low reflectance R to form the same riblet structure. The reason will be described below.

(233) Firstly, as described above, the coat SF of paint evaporates by the energy that is transmitted from the processing lights EL to the coat SF of paint by the irradiation of the processing lights EL. Thus, if the intensity of the processing lights EL with which the coat SF of paint having the relatively high reflectance R is same as the intensity of the processing lights EL with which the coat SF of paint having the relatively low reflectance R, the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively high reflectance R is smaller than the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively low reflectance R. The reason is that the coat SF of paint having the relatively high reflectance R reflects a larger amount of the processing lights EL than the coat SF of paint having the relatively low reflectance R and thus a ratio of the processing lights EL absorbed by the coat SF of paint as the energy becomes smaller. Namely, the reason is that a degree of an absorption of the processing lights EL by the coat SF of paint having the relatively high reflectance R (namely, the absorptance of the coat SF of paint to the processing light EL) is lower than a degree of an absorption of the processing lights EL by the coat SF of paint having the relatively low reflectance R (namely, the absorptance of the coat SF of paint to the processing light EL). As a result, there is a possibility that the coat SF of paint having the relatively high reflectance R is not processed in a same manner as the coat SF of paint having the relatively low reflectance R is processed. Namely, there is a possibility that the riblet structure formed by processing the coat SF of paint having the relatively high reflectance R is different from the riblet structure formed by processing the coat SF of paint having the relatively low reflectance R.

(234) However, in the fifth specific example, the intensity of the processing lights EL with which the coat SF of paint having the relatively high reflectance R is irradiated is higher than the intensity of the processing lights EL with which the coat SF of paint having the relatively low reflectance R is irradiated, and thus, the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively high reflectance R is likely to be same as the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively low reflectance R. In other words, the control apparatus **18** sets the intensity of the plurality of processing lights EL on the basis of the reflectance R so that the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively high reflectance R is same as the energy that is transmitted from the processing lights EL to the coat SF of paint having the relatively low reflectance R. As a result, the coat SF of paint having the relatively high reflectance R is processed in a same manner as the coat SF of paint having the relatively low reflectance R is processed. Namely, the riblet structure formed by processing the coat SF of paint having the relatively high reflectance R is same as the riblet structure formed by processing the coat SF of paint having the relatively low reflectance R. Therefore, the processing apparatus **1***b* is capable of preventing a

fluctuation of the forming accuracy of the riblet structure caused by the difference of the reflectance R of the coat SF of paint. Note that there is a possibility that a processing range of the riblet go beyond the coat SF of paint and thereby the processing target object S is affected when the coat SF of paint having the relatively low reflectance R is irradiated with the processing lights EL having the high intensity. In the present example, since the intensity of the plurality of processing lights EL is set on the basis of the reflectance R, there is small possibility that the processing target object S is adversely affected.

(235) Note that the relative positions on the surface of the coat SF of paint (especially, the positions in the direction along the surface of the coat SF of paint) of the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, change due to the sweep with the plurality of the processing lights EL, as described above. When the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change, there is a possibility that the reflectance R at a part of the surface of the coat SF of paint at which the plurality of irradiation areas EA are set also changes during the period when the plurality of processing lights EL are emitted. Thus, the control apparatus **18** may set the intensity of the plurality of processing lights EL on the basis of the reflectance R at the part of the surface of the coat SF of paint at which the plurality of irradiation areas EA are set and may control the light irradiation apparatus **11** to emit the plurality of processing lights EL having the set intensity during the period when the plurality of processing lights EL are emitted (namely, when the plurality of processing lights EL relatively moves relative to the coat SF of paint). Incidentally, depending on the shape of the surface of the coat SF of paint, there is a possibility that an incident angle of the processing light EL relative to the coat SF of paint changes when the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change. Alternatively, there is a possibility that the incident angle of the processing light EL relative to the coat SF of paint changes due to any factor although the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA do not change. When the incident angle of the processing light EL relative to the coat SF of paint changes, there is a possibility that the reflectance R changes. Even in this case, the control apparatus **18** may set the intensity of the processing lights EL to a proper intensity by using an information of the shape of the surface of the coat SF of paint that is measured or that is prepared in advance.

(236) Moreover, the energy that is transmitted from the processing lights EL to the coat SF of paint changes depending on not only the intensity of the processing lights EL but also an irradiation time of the processing lights EL. Specifically, the energy that is transmitted from the processing lights EL to the coat SF of paint becomes larger as the irradiation time of the processing lights EL becomes longer. The "irradiation time of the processing light EL" here means a time during which same area on the surface of the coat SF of paint is irradiated with the processing light EL. Thus, the control apparatus **18** may set the irradiation time of the plurality of processing lights EL on the basis of the reflectance R in addition to or instead of the intensity of the plurality of processing lights EL. Specifically, as illustrated in FIG. **34**A to FIG. **34**C, the control apparatus **18** sets the irradiation time of the plurality of processing lights EL so that the irradiation time of the plurality of processing lights EL becomes longer as the reflectance R becomes higher. Not that FIG. **34**A illustrates a case where a relationship between the reflectance R and the irradiation time of the processing lights EL changes linearly and FIG. **34**B and FIG. **34**C illustrate a case where a relationship between the reflectance R and the irradiation time of the processing lights EL changes non-linearly. After setting the irradiation time of the plurality of processing lights EL in this manner, the control apparatus **18** controls the light irradiation apparatus **11** to emit the plurality of processing lights EL on the basis of the set irradiation time. Specifically, the control apparatus **18** controls a scanning speed of the plurality of processing lights EL (namely, a relative moving speed of the plurality of irradiation areas EA relative to the coat SF of paint) on the basis of the set irradiation time. More specifically, the control apparatus **18** controls the scanning speed so that the

scanning speed of the processing lights EL becomes slower as the irradiation time becomes longer. In order to control the scanning speed, the control apparatus **18** may control a rotational frequency or a swinging frequency of the Galvano mirror **1122**. Specifically, the control apparatus **18** may control a rotational frequency or a swinging frequency of the Galvano mirror **1122** so that so that the control a rotational frequency or a swinging frequency of the Galvano mirror **1122** becomes lower as the irradiation time becomes longer. As a result, the scanning speed of the processing lights EL becomes slower as the irradiation time becomes longer. Even in the case where the irradiation time of the plurality of processing lights EL is set on the basis of the reflectance R in this manner, an effect that is same as an effect achievable in the case where the intensity of the plurality of processing lights EL is set on the basis of the reflectance R is achievable. Incidentally, depending on the shape of the surface of the coat SF of paint, there is a possibility that the incident angle of the processing light EL relative to the coat SF of paint changes when the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change. Alternatively, there is a possibility that the incident angle of the processing light EL relative to the coat SF of paint changes due to any factor although the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA do not change. When the incident angle of the processing light EL relative to the coat SF of paint changes, there is a possibility that the reflectance R changes. Even in this case, the control apparatus **18** may set the irradiation time of the processing lights EL to a proper time by using the information of the shape of the surface of the coat SF of paint that is measured or that is prepared in advance.

(237) Note that the processing apparatus **1***b* is provided with the surface characteristic measurement apparatus **19***b***-1** that measures the shape of the surface of the coat SF of paint and the surface characteristic measurement apparatus **19***b***-2** that measures the reflectance of the coat SF of paint individually when the processing apparatus **1***b* performs not only the fifth specific example of the advance measurement control operation but also at least one of the first specific example to the fourth specific example of the advance measurement control operation. In this case, the surface characteristic measurement apparatuses **19***b***-1** and **19***b***-2** emit the measurement lights MLb**1** and MLb**2**, respectively, and they may share a light source of the measurement lights MLb**1** and MLb**2**. Namely, the surface characteristic measurement apparatuses **19***b***-1** and **19***b***-2** may share a single light source that emits the measurement light MLb that is usable as the measurement lights MLb**1** and MLb**2**.

(238) In the above described description, the measurement light MLb**2** for measuring the reflectance R is the light having the wavelength that is same as the wavelength of the processing light EL (alternatively, the light including the light component the wavelength of which is same as the wavelength of the processing light EL). However, the measurement light MLb**2** may be a light having the wavelength that is different from the wavelength of the processing light EL (alternatively, a light that does not includes the light component the wavelength of which is same as the wavelength of the processing light EL). Even in this case, the reflectance R is determined on the basis of the measured result of the surface characteristic measurement apparatus **19***b* by the control apparatus **18**, as long as the measurement light MLb that has any correlation between the reflectance of the coat SF of paint to the measurement light MLb and the reflectance R of the coat SF of paint to the processing light EL is used.

(239) In the above described description, the surface characteristic measurement apparatus **19***b* measures the reflectance R of the coat SF of paint to the processing light EL. However, the absorptance of the coat SF of paint to the processing light EL becomes lower as the reflectance R of the coat SF of paint to the processing light EL becomes higher. Thus, it can be said that the surface characteristic measurement apparatus **19***b* substantially measures the absorptance of the coat SF of paint to the processing light EL. In this case, it can be said that the control apparatus **18** sets the intensity of the plurality of processing lights EL so that the intensity of the plurality of processing lights EL becomes lower as the absorptance of the coat SF of paint to the processing

light EL becomes higher. Moreover, it can be said that the control apparatus **18** sets the irradiation time of the plurality of processing lights EL so that the irradiation time of the plurality of processing lights EL becomes shorter as the absorptance of the coat SF of paint to the processing light EL becomes higher.

(4-2-6) Sixth Specific Example of Advance Measurement Control Operation

(240) In the sixth specific example, the surface characteristic measurement apparatus **19***b* measures, as the characteristic of the surface of the coat SF of paint, reflectances Ra of the coat SF of paint to the plurality of measurement lights MLb having different wavelengths, respectively (hereinafter, the measurement light MLb used in the sixth modified example is referred to as a "measurement light MLb**3**"). In order to measure the reflectances Ra, the projection apparatus **191***b* of the surface characteristic measurement apparatus **19***b* irradiates the coat SF of paint with the plurality of measurement lights MLb**3** having the different wavelengths, respectively. The plurality of measurement lights MLb**3** may include or may not include the light having the wavelength that is same as the wavelength of the processing light EL. The plurality of measurement lights MLb**3** may include or may not include the light including the light component the wavelength of which is same as the wavelength of the processing light EL. The intensity of the plurality of measurement lights MLb**3** are set to the intensity lower than the intensity that allows the coat SF of paint to evaporate, as with the fifth specific example. Moreover, the detection apparatus **192***b* of the surface characteristic measurement apparatus **19***b* measures reflected lights (especially, an intensity thereof) of the plurality of measurement lights MLb**3** from the coat SF of paint. Thus, the reflectance Ra of the coat SF of paint to each of the plurality of measurement lights MLb**3** is determined on the basis of the measured result of the surface characteristic measurement apparatus **19***b* by the control apparatus **18**. Note that FIG. **35** is a graph that illustrates an example of the plurality of determined reflectances Ra.

(241) Then, the control apparatus **18** sets the wavelength of at least one of the plurality of measurement lights MLb**3** to the wavelength of the processing light EL. Specifically, the control apparatus **18** sets the wavelength of one measurement light MLb**3** to which the reflectance Ra is minimum among the plurality of measurement lights MLb**3** to the wavelength of the processing light EL. Namely, the control apparatus **18** sets the wavelength of one measurement light MLb**3** to which the absorptance of the coat SF of paint is maximum among the plurality of measurement lights MLb**3** to the wavelength of the processing light EL. In an example illustrated in FIG. **35**, the reflectance Ra corresponding to a measurement light MLb**3**(#3) is minimum among five measurement lights MLb**3** (namely, a measurement light MLb**3**(#1) to a measurement light MLb**3**(#5)). Thus, the control apparatus **18** sets the wavelength of the measurement lights MLb**3**(#3) to the wavelength of the processing light EL

(242) Then, the control apparatus **18** controls the light irradiation apparatus **11** to irradiate the coat SF of paint with the processing light EL having the set wavelength. Specifically, the processing apparatus **1***b* that performs the sixth specific example of the advance measurement control operation is provided with a light irradiation apparatus **11***b***-6** having the plurality of light source systems **111** that emit the processing lights EL having different wavelengths, respectively, instead of the above described light irradiation apparatus **11**, as illustrated in FIG. **36**. The wavelengths of the plurality of processing lights EL emitted from the plurality of light source systems **111** are same as the wavelengths of the plurality of measurement lights MLb**3**, respectively. The control apparatus **18** controls one optical system **111** that is configured to emit the processing light EL having the set wavelength among the plurality of light source systems **111** so that the one light source system **111** emits the plurality of processing lights EL having the set wavelength. On the other hand, the control apparatus **18** controls the other optical system **111** other than the one optical system **111** among the plurality of light source systems **111** so that the other light source system **111** does not emit the processing lights EL. As a result, the light irradiation apparatus **111** irradiates the coat SF of paint with the processing lights EL having the set wavelength.

(243) Note that the light irradiation apparatus **11***b***-6** is provided with the plurality of light source systems **111** that emit the processing lights EL having different wavelengths, respectively, in the above described example, however, may be provided with the light source system **111** including a wavelength changeable light source that is configured to sequentially change the emitting wavelength in addition to or instead of this.
(244) According to the sixth specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation. Moreover, in the sixth specific example, the processing apparatus **1***b* irradiates the coat SF of paint with the processing lights EL having the wavelength that is same as the one measurement light MLb**3** corresponding to the minimum reflectance Ra among the plurality of measurement lights MLb**3**. Thus, the processing apparatus **1***b* is capable of irradiating the coat SF of paint with the processing light EL to which the reflectance R of the coat of paint is relatively high (namely, to which the absorptance of the coat SF of paint is relatively low). Thus, the processing apparatus **1***b* is capable of properly processing the coat SF of paint without being affected by the difference of the characteristic of the coat SF of paint.
(245) Note that there is a possibility that the reflectance Ra at the part of the surface of the coat SF of paint at which the plurality of irradiation areas EA are set also changes during the period when the plurality of processing lights EL are emitted, as described in the fifth specific example. Thus, the control apparatus **18** may set the wavelength of the processing lights EL on the basis of the reflectance Ra at the part of the surface of the coat SF of paint at which the plurality of irradiation areas EA are set and may control the light irradiation apparatus **11** to emit the plurality of processing lights EL having the set wavelength during the period when the plurality of processing lights EL are emitted (namely, when the plurality of processing lights EL relatively moves relative to the coat SF of paint). Note that there is a possibility that the reflectance R changes when the incident angle of the processing light EL relative to the coat SF of paint changes, as described in the fifth specific example. In this case, the control apparatus **18** may set the wavelength of the processing lights EL to a proper wavelength by using the information of the shape of the surface of the coat SF of paint that is measured or that is prepared in advance.
(246) Moreover, the control apparatus **18** may set the wavelength of one measurement light MLb**3** to which the reflectance Ra is equal to or lower than a predetermined reflection threshold value (namely, to which the absorptance of the coat SF of paint is equal to or higher than a predetermined absorption threshold value) among the plurality of measurement lights MLb**3** to the wavelength of the processing light EL. The reflection threshold value is set to satisfy a condition that the coat SF of paint evaporates by the processing lights EL even when a part of the processing lights EL with which the coat SF of paint is irradiated is reflected by the coat SF of paint having the reflectance R that is equal to or higher than the reflection threshold value. The absorpotion threshold value is also set from a same viewpoint. Even in this case, the processing apparatus **1***b* is capable of properly processing the coat SF of paint without being affected by the difference of the characteristic of the coat SF of paint.
(4-2-7) Seventh Specific Example of Advance Measurement Control Operation
(247) A seventh specific example of the advance measurement control operation is different from the above described first specific example of the advance measurement control operation in that control apparatus **18** controls the relative positional relationship between the coat SF of paint and the plurality of irradiation areas EA on the basis of the shape of the surface of the coat SF of paint. Another feature of the seventh specific example of the advance measurement control operation may be same as the first specific example of the advance measurement control operation.
(248) Specifically, in the seventh specific example, the surface characteristic measurement apparatus **19***b* measures the shape of the surface of the coat SF of paint before the light irradiation apparatus **11** moves and measures the shape of the surface of the coat SF of paint after the light

irradiation apparatus **11** moves (alternatively, when the light irradiation apparatus **11** moves), in a situation where the light irradiation apparatus **11** relatively moves relative to the coat SF of paint (moreover, the surface characteristic measurement apparatus **19***b* a relative position of which is fixed to the light irradiation apparatus **11** also relatively moves). In this case, the surface characteristic measurement apparatus **19***b* measures the shape of the coat SF of paint so that an area **31***b* on the surface of the coat SF of paint that is a measurement target of the surface characteristic measurement apparatus **19***b* before the light irradiation apparatus **11** moves is partially overlapped with an area **32***b* on the surface of the coat SF of paint that is the measurement target of the surface characteristic measurement apparatus **19***b* after the light irradiation apparatus **11** moves, as illustrated in FIG. **37**. Namely, the surface characteristic measurement apparatus **19***b* performs the measurement in accordance with the movement of the light irradiation apparatus **11** to measure the shape of the surface of an overlapped area **33***b* that is included in both of the areas **31***b* and **32***b*. As a result, the measured result of the overlapped area **33***b* that is included in both of the areas **31***b* and **32***b* is included in both of the measured result of the area **31***b* and the measured result of the area **32***b*.

(249) The control apparatus **18** determines on the basis of the measured result of the area **31***b* and the measured result of the area **32***b* how the overlapped area **33***b* moves. Specifically, the control apparatus **18** determines a specific area at which the shape of the surface is some sort of shape that is uniquely distinguishable in the area **31***b* on the basis of the measured result of the area **31***b*. Moreover, the control apparatus **18** determines on the basis of the measured result of the area **32***b* by a pattern matching using the shape of the surface of the specific area as a template whether or not the specific area exists in the area **32***b*. When the specific area does not exist in the area **32***b*, the control apparatus **18** determines new specific area in the area **31***b* and determines whether or not the new specific area exists in the area **32***b*. When the specific area exists in the area **32***b*, the specific area corresponds to the overlapped area **33***b*. The control apparatus **18** determines how a relative position of the surface characteristic measurement apparatus **19***b* relative to the overlapped area **33***b* changes in accordance with the movement of the light irradiation apparatus **11** by comparing the position of the overlapped area **33***b* in the area **31***b* and the position of the overlapped area **33***b* in the area **32***b*. Specifically, the control apparatus **18** determines how long the surface characteristic measurement apparatus **19***b* moves relative to the overlapped area **33***b* along each of the X axis direction and the Y axis direction. Note that the light irradiation apparatus **11** may irradiate the surface of the coat SF of paint with the processing light EL to form the specific area at which the shape of the surface is some sort of shape that is uniquely distinguishable in the area **31***b*. For example, the processing is performed so that the riblet structure has a shape in which a part of the convex structure or the concave structure linearly extending along a predetermined direction is cut, and the riblet structure in which the shape of the cross-sectional surface changes in an extending direction of the riblet as illustrated in FIG. **58** and FIG. **59** described later.

(250) A relative moving distance of the surface characteristic measurement apparatus **19***b* relative to the overlapped area **33***b* is same as a relative moving distance of the light irradiation apparatus **11** relative to the overlapped area **33***b*. A relative moving direction of the surface characteristic measurement apparatus **19***b* relative to the overlapped area **33***b* is same as a relative moving direction of the light irradiation apparatus **11** relative to the overlapped area **33***b*. Therefore, the control apparatus **18** is capable of determining how long the light irradiation apparatus **11** moves relative to the coat SF of paint along each of the X axis direction and the Y axis direction. Namely, the control apparatus **18** is capable of determining the relative position of the light irradiation apparatus **11** relative to the coat SF of paint by determining the relative position of the surface characteristic measurement apparatus **19***b* relative to the overlapped area **33***b*

(251) Since the light irradiation apparatus **11** irradiates the coat SF of paint with the processing lights EL, determining the relative position of the light irradiation apparatus **11** relative to the coat SF of paint is substantially equivalent to determining the relative positions of the plurality of

irradiation areas EA relative to the coat SF of paint. Therefore, the control apparatus **18** is capable of determining the relative positions (especially, the positions along each of the X axis direction and the Y axis direction) of the plurality of irradiation areas EA relative to the coat SF of paint on the basis of the shape of the surface of the coat SF of paint. Then, when the determined positions of the plurality of irradiation areas EA are away from positions of the plurality of irradiation areas EA that are required to form the riblet structure (alternatively, the structure to be formed by processing the coat SF of paint), the control apparatus **18** controls the light irradiation apparatus **11** so that the plurality of irradiation areas EA relatively move relative to the coat SF of paint. Namely, the control apparatus **18** controls the positional relationship between the coat SF of paint and the plurality of irradiation areas EA. For example, the control apparatus **18** may relatively move the plurality of irradiation areas EA by controlling the driving system **12** to move the light irradiation apparatus **11** relative to the coat SF of paint.

(252) According to the seventh specific example of the advance measurement control operation, the processing apparatus **1***b* achieves an effect that is same as the effect achievable by the above described first specific example of the advance measurement control operation. Moreover, in the seventh specific example, the processing apparatus **1***b* is capable of properly adjusting the relative positions of the plurality of irradiation areas EA on the surface of the coat SF of paint and thus is capable of forming the riblet structure more properly (for example, with higher accuracy).

(4-2-8) Eighth Specific Example of Advance Measurement Control Operation

(253) In the above described description, the processing apparatus **1***b* is provided with the surface characteristic measurement apparatus **19***b*. However, the processing apparatus **1***b* may not be provided with the surface characteristic measurement apparatus **19***b*. Even in this case, the processing apparatus **1***b* is allowed to perform the above described advance measurement control operation, as long as the information relating to the shape of the surface of the coat SF of paint is available by the control apparatus **18**. For example, the shape of the surface of the coat SF of paint is allowed to be estimated from a design data such as a three-dimensional model of the processing target object S. Thus, the control apparatus **18** may collect the design data of the processing target object S, may estimate the shape of the surface of the coat SF of paint from the design data and may perform the first specific example to the fourth specific example of the above described advance measurement control operation on the basis of the estimated shape of the surface of the coat SF of paint. Alternatively, the control apparatus **18** may collect a data in which an information of a processing area and the non-processing area is added to the design data. Alternatively, for example, the reflectance R of the coat SF of paint is allowed to be estimated from a specification of the coat SF of paint. Thus, the control apparatus **18** may collect an information relating to the specification of the coat SF of paint, may estimate the reflectance R of the coat SF of paint from the information relating to the specification and may perform the fifth specific example to the sixth specific example of the above described advance measurement control operation on the basis of the estimated reflectance R of the coat SF of paint. Alternatively, the control apparatus **18** may collect a data in which a reflectance information of a painting (generally, an information relating to a color) is added to the design data. As a result, the measurement by the surface characteristic measurement apparatus **19***b* is not necessary, and thus, a time required to process the coat SF of paint is reducible. Note that the operation performed in this case may not be referred to as the advance measurement control operation, because it does not need the measurement by the surface characteristic measurement apparatus **19***b*. Note that the non-processing area may be masked by a masking tape.

(254) In the above described description, the control apparatus **18** controls at least one of the light concentration positions FP of the processing lights EL, the intensity distribution of the processing lights EL, the shapes of the processing lights EL and the depth of focus of the optical system **112** on the basis of the shape of the surface of the coat SF of paint. The control apparatus **18** controls at least one of the intensity of the plurality of processing lights EL, the irradiation time of the plurality

of processing lights EL and the wavelength of the plurality of processing lights EL on the basis of the reflectance of the coat SF of paint. However, the control apparatus **18** may control any characteristic of the processing lights EL on the basis of any characteristic of the coat SF of paint so that the coat SF of paint is processed by the irradiation of the plurality of processing lights EL. At least one of the shapes of the plurality of irradiation areas EA, the sizes of the plurality of irradiation areas EA, the positions of the plurality of irradiation areas EA, the relative position between the plurality of processing lights EL, the relative angle between the plurality of processing lights EL, the polarization state of the plurality of processing lights EL, the intensity of the plurality of processing lights EL, the irradiation time of the plurality of processing lights EL and the wavelengths of the plurality of processing lights EL is one example of any characteristic of the processing lights EL.

(255) In the above described description, the surface characteristic measurement apparatus **19***b* measures the characteristic of the surface of the coat SF of paint before the light irradiation apparatus **11** irradiates the surface of the coat SF of paint with the plurality of processing lights EL. Namely, the light irradiation apparatus **11** does not emit the plurality of processing lights EL during a period when the surface characteristic measurement apparatus **19***b* measures the characteristic of the surface of the coat SF of paint, and the surface characteristic measurement apparatus **19***b* does not measure the characteristic of the surface of the coat SF of paint during the period when the light irradiation apparatus **11** emits the plurality of processing lights EL. However, the surface characteristic measurement apparatus **19***b* may measure the characteristic of the surface of the coat SF of paint in at least a part of the period when the light irradiation apparatus **11** irradiates the surface of the coat SF of paint with the plurality of processing lights EL. The light irradiation apparatus **11** may irradiate the surface of the coat SF of paint with the plurality of processing lights EL in at least a part of the period when the surface characteristic measurement apparatus **19***b* measures the characteristic of the surface of the coat SF of paint. Namely, an operation for measuring the characteristic of the surface of the coat SF of paint by the surface characteristic measurement apparatus **19***b* and an operation for irradiating the surface of the coat SF of paint with the plurality of processing lights EL (namely, an operation for processing the coat SF of paint) by the light irradiation apparatus **11** may be performed in parallel. For example, the surface characteristic measurement apparatus **19***b* may measure the characteristic of other area of the coat SF of paint that is different from one area in at least a part of the period when the light irradiation apparatus **11** irradiates the one area of the coat SF of paint the characteristic of which is already measured by the surface characteristic measurement apparatus **19***b* with the plurality of processing lights EL. For example, the light irradiation apparatus **11** may irradiate the one area of the coat SF of paint the characteristic of which is already measured by the surface characteristic measurement apparatus **19***b* with the plurality of processing lights EL in at least a part of the period when the surface characteristic measurement apparatus **19***b* measures other area of the coat SF of paint. In this case, it is expected that a throughput relating to the formation of the riblet structure improves.

(4-3) Third Modified Example

(256) Next, with reference to FIG. **38**, a processing apparatus **1***c* in a third modified example will be described. As illustrated in FIG. **38**A, the processing apparatus **1***c* in the third modified example is different from the above described processing apparatus **1** in that it is further provided with a structure measurement apparatus **19***c*. Another feature of the processing apparatus **1***c* may be same as another feature of the processing apparatus **1**.

(257) The structure measurement apparatus **19***c* measures a characteristic of the riblet structure (alternatively, any structure, the same applies to this modified example) formed by the irradiation of the processing lights EL from the light irradiation apparatus **11**. A presence or absence of the riblet structure, a shape of the riblet structure (for example, at least one of a shape of the cross-sectional surface of the concave structure CP**1**, a shape of the cross-sectional surface of the convex structure CP**2** and the like), a size of the riblet structure (for example, at least one of the depth D of

the concave structure CP**1**, a width of the concave structure CP**1**, the arrangement pitch P**1** of the concave structure CP**1**, the height H of the convex structure CP**2**, the width of the convex structure CP**2**, the arrangement pitch P**2** of the convex structure CP**2**, and the like) and a position of the riblet structure (for example, the position of at least one of the concave structure CP**1** and the convex structure CP**2**) is one example of the characteristic of the riblet structure.
(258) In order to measure the characteristic of the riblet structure, the structure measurement apparatus **19***c* is provided with a lighting apparatus **191***c* and a detection apparatus **192***c*. The lighting apparatus **191***c* and the detection apparatus **192***c* are supported by the housing apparatus **13** through a supporting member **136***c*. The lighting apparatus **191***c* irradiates the riblet structure (namely, the coat SF of paint) with a measurement light MLc**1**. When the riblet is irradiate with the measurement light MLc**1**, the measurement light MLc**1** is reflected or scattered by the riblet structure. As a result, a measurement light MLc**2** including at least one of a reflected light or a scattered light of the measurement light MLc**1** is emitted from the riblet structure. The detection apparatus **192***c* detects the measurement light MLc**2**.
(259) When the part at which the riblet structure is formed is irradiated with the measurement light MLc**1**, the measurement light MLc**2** includes at least one of the reflected light and the scattered light that propagate in a traveling direction that intersects with a traveling direction of the measurement light MLc**1**. On the other hand, when the part at which the riblet structure is not formed is irradiated with the measurement light MLc**1**, the measurement light MLc**2** does not include at least one of the reflected light and the scattered light that propagate in the traveling direction that intersects with the traveling direction of the measurement light MLc**1**. Namely, the traveling direction of the measurement light MLc**2** is nearly parallel with the traveling direction of the measurement light MLc**1**. Thus, as illustrated in FIG. **39**, when the lighting apparatus **191***c* and the detection apparatus **192***c* are disposed to detect the measurement light MLc**2** traveling in the direction that intersects with the traveling direction of the measurement light MLc**1**, the control apparatus **18** is capable of determining the presence or absence of the riblet structure at a part that is irradiated with the measurement light MLc**1** on the basis of a detected result of the detection apparatus **192***c*. Moreover, the characteristic (for example, the intensity and the like) of the measurement light MLc**2** changes depending on at least one of the shape and the size of the riblet structure. Therefore, the control apparatus **18** is capable of determining at least one of the shape of the riblet structure, the size of the riblet structure, a position of the concave structure CP**1** that constitutes the riblet structure and a position of the convex structure CP**2** that constitutes the riblet structure on the basis of the detected result of the detection apparatus **192***c*.
(260) The structure measurement apparatus **19***c* is configured to change the traveling direction of the measurement light MLc**1**. For example, when the lighting apparatus **191***c* is provided with an optical element that optically changes the traveling direction of the measurement light MLc**1**, the traveling direction of the measurement light MLc**1** may be changed by this optical element. For example, when the lighting apparatus **191***c* is relatively movable relative to the coat SF of paint, the traveling direction of the measurement light MLc**1** may be changed by a relative movement of the lighting apparatus **191***c*. Here, if the measurement light MLc**1** is allowed to be emitted to the riblet structure from only one direction, there is a possibility that the measurement light MLc**2** is not generated even if the riblet structure is irradiated with the measurement light MLc**1**, depending on the extending direction of the riblet structure. However, when the traveling direction of the measurement light MLc**1** is changeable, the lighting apparatus **191***c* is allowed to emit the measurement light MLc**1** from various directions to the riblet structure extending in a certain direction. Thus, the structure measurement apparatus **19***c* is capable of measuring the characteristic of the riblet structure without being affected by the difference of the extending direction of the riblet structure. Note that the structure measurement apparatus **19***c* itself may be rotated around the Z axis in order to change the traveling direction of the measurement light MLc**1**. Moreover, a plurality of structure measurement apparatus **19***c* from which the traveling directions of the

measurement lights MLc**1** are different from each other may be disposed.

(261) The structure measurement apparatus **19***c* may be configured to change the traveling direction of the measurement light MLc**2** that is detectable by the detection apparatus **192***c*, in addition to or instead of changing the traveling direction of the measurement light MLc**1**. For example, when the detection apparatus **192***c* is relatively movable relative to the coat SF of paint, the traveling direction of the measurement light MLc**2** that is detectable by the detection apparatus **192***c* may be changed by a relative movement of the detection apparatus **192***c*. Here, if the detection apparatus **192***c* is allowed to detect the measurement light MLc**2** that travels in only one direction, there is a possibility that the measurement light MLc**2** does not travel toward the detection apparatus **192***c* and thus the measurement light MLc**2** is not detectable by the detection apparatus **192***c*, depending on the extending direction of the riblet structure. However, when the traveling direction of the measurement light MLc**2** that is detectable by the detection apparatus **192***c* is changeable, the detection apparatus **192***c* is allowed to detect the measurement light MLc**2** traveling in various directions from the riblet structure extending in a certain direction. Thus, the structure measurement apparatus **19***c* is capable of measuring the characteristic of the riblet structure without being affected by the difference of the extending direction of the riblet structure.

(262) The structure measurement apparatus **19***c* may measure the characteristic of all riblet structure formed by the processing apparatus **1***c*. However, if the characteristic of all riblet structure formed by the processing apparatus **1***c* is measured, a time required to measure the characteristic of the riblet structure is too large. Thus, in the third modified example, the structure measurement apparatus **19***c* selectively measures the characteristic of the riblet structure formed in a sample area DAc that is a part of a processed area in which the processing apparatus **1***c* forms the riblet structure, as illustrated in FIG. **40**. The structure measurement apparatus **19***c* selectively measures the characteristic of the riblet structure formed in a plurality of sample areas DAc that evenly distribute in the processed area. However, the structure measurement apparatus **19***c* may selectively measure the characteristic of the riblet structure formed in a plurality of (alternatively, one) sample areas DAc that randomly distribute in the processed area.

(263) The structure measurement apparatus **19***c* may selectively measure the characteristic of the riblet structure formed in the sample area DAc in a certain area in which the riblet structure should be formed after the processing apparatus **1***c* forms the riblet structure in this certain area. For example, the structure measurement apparatus **19***c* may set the sample are DAc in a certain unit processing area SA and selectively measure the characteristic of the riblet structure formed in the set sample area DAc after the processing apparatus **1***c* forms the riblet structure in this certain unit processing area SA. Then, when the processing apparatus **1***c* forms the riblet structure in another unit processing area SA, the structure measurement apparatus **19***c* may set the sample are DAc in another unit processing area SA and selectively measure the characteristic of the riblet structure formed in the set sample area DAc. Namely, the formation of the riblet structure by the processing apparatus **1***c* and the measurement of the characteristic of the riblet structure by the structure measurement apparatus **19***c* may be alternately repeated.

(264) Alternatively, the structure measurement apparatus **19***c* may selectively measure the characteristic of the riblet structure that is already formed by the processing apparatus **1***c* in another area that is different from one area during a period when the processing apparatus **1***c* irradiates the one area on the surface of the coat SF of paint with the plurality of processing lights EL (namely, the riblet structure is formed in the one area). For example, the structure measurement apparatus **19***c* may selectively measure the characteristic of the riblet structure formed in the sample area DAc in another unit processing area SA that is different from one unit processing area SA and in which the processing apparatus **1***c* already forms the riblet structure during a period when the processing apparatus **1***c* forms the riblet structure in the one unit processing area SA. Namely, the formation of the riblet structure by the processing apparatus **1***c* and the measurement of the characteristic of the riblet structure by the structure measurement apparatus **19***c* may be performed

in parallel. In this case, it is expected that a throughput relating to the formation of the riblet structure improves.
(265) After the structure measurement apparatus **19***c* finishes the measurement, the measured result of the structure measurement apparatus **19***c* is outputted to the control apparatus **18**. The control apparatus **18** determines the characteristic of the riblet structure on the basis of the measured result of the structure measurement apparatus **19***c*, as described above. The control apparatus **18** determines on the basis of the determined characteristic of the riblet structure whether or not the characteristic of the riblet structure is good. Moreover, the control apparatus **18** notifies an operator of the processing apparatus **1***c* of a determined result of the goodness of the characteristic of the riblet structure through an output including at least one of a display and a speaker.
(266) For example, the control apparatus **18** may determine whether or not the size of the riblet structure in the direction intersecting with the surface of the coat SF of paint (namely, the width D of the concave structure CP**1** or the height H of the convex structure CP**2**) is good. FIG. **41**A is a cross-sectional view that illustrates an ideal riblet structure that should be formed by the processing apparatus **1***c*. When the determined size of the riblet structure is same as the size of the ideal riblet structure as illustrated in FIG. **41**B, the control apparatus **18** determines that the size of the riblet structure is normal (namely, the riblet structure is good one). In this case, the control apparatus **18** notifies that the size of the riblet structure is normal. On the other hand, when the determined size of the riblet structure is smaller than the size of the ideal riblet structure as illustrated in FIG. **41**C, the control apparatus **18** determines that the size of the riblet structure is abnormal (namely, the riblet structure is defective one). In this case, the control apparatus **18** notifies that the size of the riblet structure is abnormal (especially, the size is small). On the other hand, when the determined size of the riblet structure is larger than the size of the ideal riblet structure as illustrated in FIG. **41**D, the control apparatus **18** determines that the size of the riblet structure is abnormal (namely, the riblet structure is defective one). In this case, the control apparatus **18** notifies that the size of the riblet structure is abnormal (especially, the size is large).
(267) For example, the control apparatus **18** may determine whether or not the shape of the riblet structure is good. When the determined shape of the riblet structure is same as the shape of the ideal riblet structure as illustrated in FIG. **42**A, the control apparatus **18** determines that the shape of the riblet structure is normal (namely, the riblet structure is good one). In this case, the control apparatus **18** notifies that the shape of the riblet structure is normal. On the other hand, when the determined shape of the riblet structure is different from the shape of the ideal riblet structure as illustrated in FIG. **42**B, the control apparatus **18** determines that the shape of the riblet structure is abnormal (namely, the riblet structure is defective one). In this case, the control apparatus **18** notifies that the shape of the riblet structure is abnormal.
(268) For example, the control apparatus **18** may determine whether or not the position of the concave structure CP**1** (furthermore, the convex structure CP**2**, the same applies to the below described description) constituting the riblet structure is good. When the determined position of the concave structure CP**1** is same as the position of the concave structure CP**1** constituting the ideal riblet structure as illustrated in an upper part of FIG. **43**, the control apparatus **18** determines that the position of the concave structure CP**1** constituting the riblet structure is normal (namely, the riblet structure is good one). In this case, the control apparatus **18** notifies that the position of the concave structure CP**1** constituting the riblet structure is normal. On the other hand, when the determined position of the concave structure CP**1** is different from the position of the concave structure CP**1** constituting the ideal riblet structure as illustrated in an lower part of FIG. **43**, the control apparatus **18** determines that the position of the concave structure CP**1** constituting the riblet structure is abnormal (namely, the riblet structure is defective one). In this case, the control apparatus **18** notifies that the position of the concave structure CP**1** constituting the riblet structure is wrong.
(269) For example, the control apparatus **18** may determine the goodness of the presence or

absence of the riblet structure. When the riblet structure exists in the sample area DA as illustrated in FIG. **44**A, the control apparatus **18** determines that the riblet structure is formed (namely, the riblet structure is good one). In this case, the control apparatus **18** notifies that the riblet structure is formed. On the other hand, when the riblet structure does not exist in the sample area DA as illustrated in FIG. **44**B, the control apparatus **18** determines that the riblet structure is not formed (namely, the riblet structure is defective one). In this case, the control apparatus **18** notifies that the riblet structure is not formed.

(270) When it is determined that the riblet structure is defective one, the control apparatus **18** may control the light irradiation apparatus **18** to modify the riblet structure that is already formed. Specifically, when it is determined that the riblet structure is defective one, there is a possibility that not only the riblet structure in the sample area DA in which the defective riblet structure exists but also the riblet structure in a wider area on the coat SF of paint including this sample area DA are defective. Thus, the control apparatus **18** controls the light irradiation apparatus **11** to irradiate the wider area on the coat SF of paint including the sample area DA (hereinafter, this area is referred to as a “modification target area”) with the processing light EL to modify the riblet structure in the modification target area. For example, when the size (here, the depth D) of the concave structure CP**1** constituting the riblet structure is smaller than the size of the concave structure CP**1** constituting the ideal riblet structure as illustrated in FIG. **45**A, the control apparatus **18** may control the light irradiation apparatus **11** so that the concave structure CP**1** is enlarged by irradiating the concave structure CP**1** with the processing light EL to remove the coat SF of paint more (namely, reducing the thickness of the coat SF of paint more). As a result, as illustrated in FIG. **45**B, the size of the riblet structure in the modification target area is modified to be same as the size of the ideal riblet structure. Note that a processing condition of the processing apparatus **1***c* may be changed by using the measured result of the characteristic of the riblet structure by the structure measurement apparatus **19***c*. For example, when it is measured that the shape, the formed position or the size of the riblet structure almost goes beyond the upper/lower limit of a predetermined range (a standard), the shape, the formed position or the size of the riblet structure may be brought close to a center value of the standard by changing the processing condition of the processing apparatus **1***c*.

(271) The processing apparatus **1***c* in the third modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1**. Moreover, the processing apparatus **1***c* is capable of evaluating the goodness of the actually formed riblet structure properly.

(4-4) Fourth Modified Example

(272) Next, a processing apparatus **1***d* in a fourth modified example will be described. The processing apparatus **1***d* in the fourth modified example is configured to change the arrangement pitch P**1** of the concave structure CP**1**. When the arrangement pitch P**1** of the concave structure CP**1** changes, the arrangement pitch P**2** of the convex structure CP**2** also changes. Thus, it can be said that the processing apparatus **1***d* is configured to change the arrangement pitch P**2** of the convex structure CP**2**.

(273) In order to change the arrangement pitch P**1**, the processing apparatus **1***d* is provided with a light irradiation apparatus **11***d* instead of the above described light irradiation apparatus **11**. The light irradiation apparatus **11***d* is different from the light irradiation apparatus **11** in that it is provided with an optical system **112***d* having a zoom lens **1124***d*, as illustrated in FIG. **46**. Another feature of the light irradiation apparatus **11***d* may be same as another feature of the light irradiation apparatus **11**. The zoom lens **1124***d* is configured to change a projection magnification of the optical system **112***d* under the control of the control apparatus **18**. The zoom lens **1124***d* is configured to change an interval between the plurality of emitted processing lights EL under the control of the control apparatus **18**.

(274) When the projection magnification of the optical system **112***d* changes, the relative positional relationship between the plurality of irradiation areas EA in the direction along the surface of the

coat SF of paint changes. Specifically, as illustrated in FIG. **47**A, when the magnification of the optical system **112***d* is a first magnification (namely, the interval between the plurality of emitted processing lights EL is a first interval), an arrangement pitch of the plurality of irradiation areas EA is a first pitch Pe**1**. Note that the arrangement pitch of the plurality of irradiation areas EA means an arrangement pitch along a direction (the X axis direction in an example illustrated in FIG. **47**A) in which the plurality of irradiation areas EA move on the surface of the coat SF of paint during the step operation. On the other hand, as illustrated in FIG. **47**B, when the magnification of the optical system **112***d* is a second magnification that is larger than the first magnification (namely, the interval between the plurality of emitted processing lights EL is a second interval that is larger than the first interval), the arrangement pitch of the plurality of irradiation areas EA is a second pitch Pe**2** that is larger than first pitch Pe**1**. Namely, the control apparatus **18** changes the relative positional relationship between the plurality of irradiation areas EA in the direction along the surface of the coat SF of paint (especially, the arrangement pitch of the plurality of irradiation areas EA) by changing the projection magnification of the optical system **112***d*.

(275) When the arrangement pitch of the plurality of irradiation areas EA changes, the arrangement pitch P**1** of the plurality of concave structures CP**1** formed by the plurality of processing lights EL with which the plurality of irradiation areas EA are irradiated, respectively, also changes. Specifically, as illustrated in FIG. **47**C, the arrangement pitch P**1** of the plurality of concave structures CP**1** formed by the plurality of processing lights EL with which the plurality of irradiation areas EA the arrangement pitch of which is the first pitch Pe**1** are irradiated, respectively, is a first pitch Pp**1** corresponding to the first pitch Pe**1**. On the other hand, as illustrated in FIG. **47**D, the arrangement pitch P**1** of the plurality of concave structures CP**1** formed by the plurality of processing lights EL with which the plurality of irradiation areas EA the arrangement pitch of which is the second pitch Pe**2** are irradiated, respectively, is a second pitch Pp**2** corresponding to the second pitch Pe**2**. Since the second pitch Pe**2** is larger than the first pitch Pe**1**, the second pitch Pp**2** is also larger than the first pitch Pp**1**.

(276) Note that the relative positional relationship between the plurality of processing lights EL changes when the arrangement pitch of the plurality of irradiation areas EA changes, because the light irradiation apparatus **11***d* emits the plurality of processing lights EL that are parallel with each other. Namely, as illustrated in FIG. **47**C and FIG. **47**D, the relative positional relationship between the plurality of processing lights EL changes so that the interval (especially, the interval in the direction along the surface of the coat SF of paint) between the plurality of processing lights EL becomes larger as the arrangement pitch of the plurality of irradiation areas EA becomes larger. Thus, controlling the arrangement pitch of the plurality of irradiation areas EA is equivalent to controlling the relative positional relationship between the plurality of processing lights EL. Therefore, it can be said that the control apparatus **18** substantially changes the arrangement pitch of the concave structure CP**1** by changing the relative positional relationship between the plurality of processing lights EL

(277) The control apparatus **18** may changes the arrangement pitch P**1** of the concave structure CP**1** on the basis of which part of the processing target object S corresponds to an area in which the riblet structure will be formed. For example, when the processing target object S is the airplane PL as described above, the arrangement pitch P**1** of the concave structure CP**1** that effectively achieves the effect of the reduction of the resistance of the body PL**1** is not necessarily same as the arrangement pitch P**1** of the concave structure CP**1** that effectively achieves the effect of the reduction of the resistance of the main wing PL**2**. Thus, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** so that the arrangement pitch P**1** of the concave structure CP**1** formed by processing the coat SF of paint on the body PL**1** is different from the arrangement pitch P**1** of the concave structure CP**1** formed by processing the coat SF of paint on the main wing PL**2**.

(278) The control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1**

on the basis of the shape of the surface of the coat SF of paint. Specifically, as described above, there is a high possibility that the shape of the surface of the coat SF of paint depends on the surface of the processing target object S under the coat SF of paint. Namely, there is a high possibility that the surface of the coat SF of paint coated on the processing target object S having the flat surface is a flat surface and there is a high possibility that the surface of the coat SF of paint coated on the processing target object S having the curved surface is a curved surface. In this case, the arrangement pitch P**1** of the concave structure CP**1** that effectively achieves the effect of the reduction of the resistance of the surface of the processing target object S having a first shape is not necessarily same as the arrangement pitch P**1** of the concave structure CP**1** that effectively achieves the effect of the reduction of the resistance of the surface of the processing target object S having a second shape that is different from the first shape. Thus, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** so that the arrangement pitch P**1** of the concave structure CP**1** formed by processing the coat SF of paint the shape of the surface of which is the first shape is different from the arrangement pitch P**1** of the concave structure CP**1** formed by processing the coat SF of paint the shape of the surface of which is the second shape. Incidentally, in this case, in order to change the arrangement pitch P**1** of the concave structure CP**1** on the basis of the shape of the surface of the coat SF of paint, the processing apparatus **1***d* may be provided with the surface characteristic measurement apparatus **19***b* that is configured to measure the shape of the surface of the coat SF of paint as with the processing apparatus **1***b*, or may collect the information relating to the shape of the surface of the coat SF of paint (for example, the above described design data). Moreover, when the light irradiation apparatus **11***d* irradiates the coat SF of paint with the plurality of processing lights EL that are parallel with each other, the interval between (the pitch of) the plurality of processing lights EL is not necessarily same as the arrangement pitch P**1** of the formed concave structure CP**1** in the situation where the shape of the processing target object S is not the flat surface. In this case, the interval between the plurality of processing lights EL may be changed so that the arrangement pitch P**1** of the formed concave structure CP**1** is a predetermined pitch. Note that the interval between the plurality of processing lights EL may be changed even when the light irradiation apparatus **11***d* irradiates the coat SF of paint with the plurality of processing lights EL that are not parallel with each other, because the interval between (the pitch of) the plurality of processing lights EL is not necessarily same as the arrangement pitch P**1** of the formed concave structure CP**1** in the situation where the shape of the processing target object S is not the flat surface.

(279) The relative positions on the surface of the coat SF of paint (especially, the positions in the direction along the surface of the coat SF of paint) of the plurality of irradiation areas EA that are irradiated with the plurality of processing lights EL, respectively, change due to the sweep with the plurality of processing lights EL. When the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change, there is a possibility that an area at which the plurality of irradiation areas EA are formed moves from an area corresponding to one part of the processing target object S (for example, an area corresponding to the body PL**1**) an area corresponding to another part of the processing target object S (for example, an area corresponding to the main wing PL**2**) during the period when the plurality of processing lights EL are emitted. Alternatively, when the relative positions on the surface of the coat SF of paint of the plurality of irradiation areas EA change, there is a possibility that a shape of a part of the surface of the coat SF of paint at which the plurality of irradiation areas EA are formed also changes during the period when the plurality of processing lights EL are emitted. Thus, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** when the coat SF of paint is irradiated with the plurality of processing lights EL (namely, the plurality of processing lights EL relatively move relative to the coat SF of paint). As described above, there is a possibility that the arrangement pitch of the formed concave structure CP**1** changes even when the interval between the processing lights EL is constant, when the shape of the processing target object S changes. In this case, the

interval between (the pitch of) the plurality of processing lights EL may be changed on the basis of the shape of the shape of the coat SF of paint.
(280) The processing apparatus **1***d* in the fourth modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1** and is allowed to change the arrangement pitches of the concave structure CP**1** and the convex structure CP**2**. Therefore, more proper riblet structure is formable compared to the case where the arrangement pitches of the concave structure CP**1** and the convex structure CP**2** are not allowed to be changed. Specifically, the riblet structure having the proper arrangement pitch that properly achieves the effect of the reduction of the resistance is formable
(281) Note that at least one of the above described light irradiation apparatuses **21***a* to **27***a* that are described with reference to FIG. **18** to FIG. **24** may be provided with the zoom lens **1124***d*. In this case, the arrangement pitches of the concave structure CP**1** and the convex structure CP**2** that constitute the riblet structure are changeable.
(282) Moreover, in the above described description, the control apparatus **18** changes the arrangement pitch P**1** of the concave structure CP**1** (namely, the arrangement pitch of the plurality of irradiation areas EA) and/or the interval between the plurality of processing lights EL by changing the projection magnification of the optical system **112***d* by using the zoom lens **1124***d*. However, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** (namely, the arrangement pitch of the plurality of irradiation areas EA) and/or the interval between the plurality of processing lights EL by using another method. Even when the processing apparatus **1***d* is provided with the above described light irradiation apparatuses **21***a* to **27***a* instead of the light irradiation apparatus **11***d*, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** (namely, the arrangement pitch of the plurality of irradiation areas EA) and/or the interval between the plurality of processing lights EL by using another method.
(283) For example, plane parallel plates each of which is configured to change an inclination angle relative to an optical axis may be disposed in the optical paths of the plurality of processing lights EL emitted from the light source system **111**, respectively, and the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL may be changed by setting the angle of the plane parallel plates to predetermined angles, respectively. At least one of the above described light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL may be provided with the plane parallel plates too.
(284) For example, when the processing apparatus **1***d* is provide with the plurality of above described irradiation units **110***b***-1** illustrated in FIG. **27**, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by moving the plurality of irradiation units **110***b***-1** in the direction along the surface of the coat SF of paint. Specifically, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by moving the plurality of irradiation units **110***b***-1** to change an arrangement interval between the plurality of irradiation units **110***b***-1**. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes. The same applies to the case where the processing apparatus **1***d* is provided with either one of the above described light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL and either one of the light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* is provided with the plurality of irradiation units **110***b***-1** in order to emits the plurality of processing lights EL.
(285) For example, when the processing apparatus **1***d* is provided with the plurality of above described light sources **1111** illustrated in FIG. **3**B, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by moving the plurality of light sources **1111** in the direction along the surface of the coat SF of paint. Specifically, the control apparatus **18** may change the arrangement

pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by moving the plurality of irradiation units **110***b***-1** to change an arrangement interval between the plurality of light sources **1111**. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes. The same applies to the case where the processing apparatus **1***d* is provided with either one of the above described light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL and either one of the light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* is provided with the plurality of light sources **1111** in order to emits the plurality of processing lights EL.

(286) For example, when the processing apparatus **1***d* divides the processing light EL from the above described single light source **1111** illustrated in FIG. **3**B and then emits from the plurality of emitting ports, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by changing positions of the plurality of emitting ports. Specifically, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by changing an arrangement interval between the plurality of emitting ports. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes. The same applies to the case where the processing apparatus **1***d* is provided with either one of the above described light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL and either one of the light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* divides the processing light EL from the single light source **1111** in order to emits the plurality of processing lights EL.

(287) For example, when the processing apparatus **1***d* is provided with the light irradiation apparatus **22***a* having the mirror array **2221***a*, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by controlling the inclination angle of each mirror M of the mirror array **2221***a* to change the position (especially, the position around the Y axis) of the reflected surface of each mirror M. For example, when the mirror array **2221***a* is provided with the plurality of mirrors M that are arranged in a matrix on the XY plane, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL that are arranged along the X axis direction by controlling the inclination angle of each mirror M in a unit of one group of mirrors M that are arranged along the Y axis direction.

(288) For example, when the processing apparatus **1***d* is provided with a light irradiation apparatus **11***d***-1** that is configured to change the relative angle between the plurality of processing lights EL, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by changing the relative angle between the plurality of processing lights EL. Specifically, FIG. **48**A illustrates an aspect in which the relative angle between the plurality of processing lights EL is in a first angle state and FIG. **48**B illustrates an aspect in which the relative angle between the plurality of processing lights EL is in a second angle state that is different from the first angle state. As illustrated in FIG. **48**A and FIG. **48**B, when the relative angle between the plurality of processing lights EL changes, angles at which the plurality of processing lights EL enters the coat SF of paint also change. On the other hand, eve when the relative angle between the plurality of processing lights EL changes, points from which the plurality of processing lights EL emit do not change from the optical system of the light irradiation apparatus **11***d***-1**. As a result, as illustrated in FIG. **48**C and FIG. **48**D, when the relative angle between the plurality of processing lights EL changes, the arrangement pitch of the plurality of irradiation areas EA changes. Specifically, as illustrated in FIG. **48**C, when the relative angle between the plurality of processing lights EL is in the first angle, the arrangement pitch of the plurality of irradiation areas EA is a third pitch Pe**3**. On the other hand, as illustrated in FIG. **48**D, when the relative angle between the plurality of processing lights EL is in the second angle, the arrangement pitch of the plurality of irradiation areas EA is a fourth pitch Pe**4** that is larger than the

third pitch Pe**3**. As a result, as a result, the arrangement pitch P**1** of the concave structure CP**1** changes. Note that the light irradiation apparatus **11***d***-1** may be a light irradiation apparatus obtained by adding an optical member for changing the relative angle between the plurality of processing lights EL to the above described light irradiation apparatus **11** and light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL.

(289) For example, when the processing apparatus **1***d* is provided with a light irradiation apparatus **11***d***-2** that is configured to irradiate the coat SF of paint with the plurality of processing lights EL that are not parallel with each other, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by changing the relative positional relationship between the light irradiation apparatus **11***d***-2** and the coat SF of paint (a distance between the light irradiation apparatus **11***d***-2** and the coat SF of paint) along the direction intersecting with the surface of the coat SF of paint (the Z axis direction in an example illustrated in FIG. **49**A and FIG. **49**B). Specifically, as illustrated in FIG. **49**A, when the distance between the light irradiation apparatus **11***d***-2** and the coat SF of paint in the Z axis direction is D**5**, the arrangement pitch of the plurality of irradiation areas EA is a fifth pitch Pe**5**. Then, as illustrated in FIG. **49**B, when the distance between the light irradiation apparatus **11***d***-2** and the coat SF of paint in the Z axis direction changes to D**6** (note that D**5**<D**6**) as a result of the light irradiation apparatus **11***d***-2** moving along the Z axis direction to be farther from the coat SF of paint by the driving system **12**, the arrangement pitch of the plurality of irradiation areas EA changes to a sixth pitch Pe**6** that is larger than the fifth pitch Pe**5**. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes. Note that the light irradiation apparatus **11***d***-2** may be a light irradiation apparatus obtained by adding an optical member for emitting the plurality of processing lights EL that are not parallel with each other to the above described light irradiation apparatus **11** and light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL.

(290) For example, when the processing apparatus **1***d* is provided with the plurality of light sources **1111** each of which is configured to emit the processing light EL, the control apparatus **18** may change the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL by changing the number of the light source **1111** that actually emits the processing light EL among the plurality of light sources **1111**. Specifically, in an example illustrated in FIG. **50**A, six light sources **1111** among the plurality of light sources **1111** are selected as the light source that emits the processing light EL. In this case, the six light sources **1111** emit the processing lights EL and the other light source **1111** does not emit the processing light EL. Alternatively, although the other light source **1111** may emit the processing light EL, the emitted processing light EL is shielded and the coat SF of paint is not irradiated with it. In this case, as illustrated in FIG. **50**B, the arrangement pitch of the plurality of irradiation areas EA is a seventh pitch Pe**7**. On the other hand, in an example illustrated in FIG. **50**C, three light sources **1111** (especially, three light sources **1111** selected every other one from the six light sources **1111** selected in the example illustrated in FIG. **50**A) among the plurality of light sources **1111** are selected as the light source that emits the processing light EL. In this case, as illustrated in FIG. **50**D, the arrangement pitch of the plurality of irradiation areas EA is an eighth pitch Pe**8** that is larger than (for example twice as large as) the seventh pitch Pe**7**. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes. The same applies to the case where the processing apparatus **1***d* is provided with either one of the above described light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* each of which is configured to emit the plurality of processing lights EL and either one of the light irradiation apparatuses **22***a* to **23***a* and **25***a* to **27***a* is provided with the plurality of light sources **1111** in order to emits the plurality of processing lights EL.

(291) Alternatively, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** and/or the interval between the plurality of processing lights EL by using another

method in addition to or instead of changing the arrangement pitch of the plurality of irradiation areas EA (namely, changing the relative positional relationship between the plurality of irradiation areas EA). For example a shutter may be disposed in the optical path of each of the plurality of processing lights EL emitted from the light source system **111**.

(292) For example, when the processing apparatus **1***d* is provide with the light irradiation apparatus **21***a* that forms, on the surface of the coat SF of paint, the interference fringe that is formed by interfering the first divided light EL**1** and the second divided light EL**2** illustrated in above described FIG. **18**, the control apparatus **18** may change the arrangement pitch P**1** of the concave structure CP**1** by changing the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed (namely, a relative angle between the first divided light EL**1** and the second divided light EL**2**). Specifically, in an example illustrated in FIG. **51**A, the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed is a first angle θ**1**. In this case, as illustrated in FIG. **51**B, a pitch of the interference fringe formed on the surface of the coat SF of paint is a ninth pitch Pe**9**. On the other hand, in an example illustrated in FIG. **51**C, the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed is a second angle θ**2** that is different from the first angle θ**1**. In this case, as illustrated in FIG. **51**D, the pitch of the interference fringe formed on the surface of the coat SF of paint is a tenth pitch Pe**10** that is different from the ninth pitch Pe**9**. As a result, the arrangement pitch P**1** of the concave structure CP**1** changes.

(293) Note that the processing apparatus **1***d* is provided with a light irradiation apparatus **11***d***-3** having an angle adjusting element **2127***d* for adjusting the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed as illustrated in FIG. **52**, instead of the light irradiation apparatus **21***a*, in order to change the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed. The angle adjusting element **2127***d* is configured to change a relative angle of the first divided light EL**1** to the second divided light EL**2** by synchronously moving the light emitting port **2123***a* and the projection optical system **2125***a*. Moreover, the angle adjusting element **2127***d* may be configured to change a relative angle of the second divided light EL**2** to the first divided light EL**1** by synchronously moving the light emitting port **2124***a* and the collecting optical system **2126***a* in addition to or instead of synchronously moving the light emitting port **2123***a* and the projection optical system **2125***a*. therefore, the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed is changeable by the angle adjusting element **2127***d*.

(294) For example, when the above described arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL is changed, the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint changes. Therefore, changing the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL is equivalent to controlling the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint. Similarly, when the pitch of the interference fringe formed on the surface of the coat SF of paint by interfering the above described first divided light EL**1** and the second divided light EL**2** is changed, the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint changes. Therefore, changing the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed is equivalent to controlling the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint. Thus, the control apparatus **18** may control the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint (alternatively, the intensity distribution of the plurality of processing lights EL in a plane along the surface of the coat SF of paint) in addition to or instead of changing the arrangement pitch P**1** of the concave structure CP**1** and/or the interval between the plurality of processing lights EL. In this case, the optical system **112** may be provided with the intensity distribution adjusting element for adjusting the intensity distribution of the plurality of processing

lights EL under the control of the control apparatus **18**. The intensity distribution adjusting element may be a spatial light modulator that is configured to space-modulate the processing light, for example. Therefore, the processing apparatus **1***d* is provided with the light irradiation apparatus **24***a* having the spatial light modulator (see FIG. **21**), the control apparatus **18** may control the spatial light modulator to change the intensity distribution of the plurality of processing lights EL.

(295) Moreover, in the above described description, the control apparatus **18** performs at least one of changing the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL, changing the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed and changing the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint for the purpose of changing the arrangement pitch P**1** of the concave structure CP**1**. However, the control apparatus **18** performs at least one of changing the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL, changing the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed and changing the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint for the purpose of maintaining the arrangement pitch P**1** of the concave structure CP**1** (namely, preventing the variation of the arrangement pitch P**1**). Specifically, as described above, the processing apparatus **1***d* sweep the unit processing area SA with the plurality of processing lights EL through the Galvano mirror **1122**. Here, a length of the optical path of the processing light EL from the Galvano mirror **1122** to a center part of the unit processing area SA is different from a length of the optical path of the processing light EL from the Galvano mirror **1122** to an edge part of the unit processing area SA in a strict sense. Thus, there is a possibility that the arrangement pitch of the plurality of irradiation areas EA at the center part of the unit processing area SA is not same as the arrangement pitch of the plurality of irradiation areas EA at the edge part of the unit processing area SA. Alternatively, there is a high possibility that the surface of the coat SF of paint is the curved surface, has a concavity and/or convexity, or is inclined, because the processing target object S is the airframe of the airplane PL and the like. Even in this case, a length of the optical path of the processing light EL from the Galvano mirror **1122** to a one part of the unit processing area SA is different from a length of the optical path of the processing light EL from the Galvano mirror **1122** to another part of the unit processing area SA in a strict sense. Thus, there is a possibility that the arrangement pitch of the plurality of irradiation areas EA at one part of the unit processing area SA is not same as the arrangement pitch of the plurality of irradiation areas EA at another part of the unit processing area SA. As a result, there is a possibility that the arrangement pitch P**1** of the concave structure CP**1** formed at one part of the unit processing area SA is not same as the arrangement pitch P**1** of the concave structure CP**1** at another part of the unit processing area SA undesirably, although the concave structures CP**1** should be formed in the unit processing area SA at constant arrangement pitch P**1**. Thus, the control apparatus **18** may perform at least one of changing the arrangement pitch of the plurality of irradiation areas EA and/or the interval between the plurality of processing lights EL, changing the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed and changing the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint so as to cancel this undesired variation of the arrangement pitch P**1** of the concave structure CP**1**. As a result, the undesired variation of the arrangement pitch P**1** of the concave structure CP**1** is canceled and the concave structures CP**1** are formable at constant arrangement pitch P**1**

(4-5) Fifth Modified Example

(296) The above described processing apparatus **1***d* in the fourth modified example changes the characteristic of the processing lights EL (for example, at least one of the relative positional relationship between the plurality of irradiation areas EA, the angle at which the first divided light EL**1** and the second divided light EL**2** are intercrossed and the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint) for the purpose of changing the

arrangement pitch P**1** of the concave structure CP**1** constituting the riblet structure. On the other hand, a processing apparatus **1***e* in the fifth modified example changes any characteristic of the processing lights EL for the purpose of changing any characteristic of the riblet structure. The presence or absence of the riblet structure, the shape of the riblet structure (for example, at least one of the shape of the cross-sectional surface of the concave structure CP**1**, the shape of the cross-sectional surface of the convex structure CP**2** and the like), the size of the riblet structure (for example, at least one of the depth D of the concave structure CP**1**, a width of the concave structure CP**1**, the arrangement pitch P**1** of the concave structure CP**1**, the height H of the convex structure CP**2**, the width of the convex structure CP**2**, the arrangement pitch P**2** of the convex structure CP**2**, and the like) and the position of the riblet structure (for example, the position of at least one of the concave structure CP**1** and the convex structure CP**2**) is one example of "any characteristic of the riblet structure" in the fifth modified example, as described in the third modified example. Thus, the processing apparatus **1***e* is different from the above described processing apparatus **1** in that it is provided with a characteristic adjustment apparatus **41***e* for adjusting the characteristic of the processing lights EL. Note that the processing apparatus **1***e* may be provided with the characteristic adjustment apparatus **41***e* separately from the light irradiation apparatus **11** or may be provided with the characteristic adjustment apparatus **41***e* that is combined with the light irradiation apparatus **11** (namely, that constitutes a part of the light irradiation apparatus **11**). Another feature of the processing apparatus **1***e* may be same as another feature of the processing apparatus **1**.

(297) The control apparatus **18** may change any characteristic of the processing lights EL so that any characteristic of the riblet structure is changed to form more proper riblet structure. For example, the control apparatus **18** may change any characteristic of the processing lights EL so that any characteristic of the riblet structure is changed to form the proper riblet structure that properly achieves the effect of the reduction of the resistance.

(298) The characteristic of the processing lights EL may include the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint. When the intensity distribution of the plurality of processing lights EL on the surface of the coat SF of paint is changed, the characteristic (especially, at least one of the shape, the position and the like) of the concave structure CP**1** changes. As a result, the characteristic (especially, at least one of the shape, the position and the like) of the riblet structure formed by the concave structure CP**1** also changes. For example, the surface of the coat SF of paint is irradiated with the plurality of processing lights EL having a first intensity distribution illustrated in FIG. **54**A, the concave structure CP**1** illustrated in FIG. **54**B is formed. On the other hand, for example, the surface of the coat SF of paint is irradiated with the plurality of processing lights EL having a second intensity distribution that is different from the first intensity distribution illustrated in FIG. **54**C, the concave structure CP**1** illustrated in FIG. **54**D having the characteristic that is different from the concave structure CP**1** illustrated in FIG. **54**B is formed.

(299) The characteristic of the processing lights EL may include the shapes of the plurality of irradiation areas EA. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the shapes of the plurality of irradiation areas EA. When the shapes of the plurality of irradiation areas EA are changed, the characteristic (especially, at least one of the shape, the position and the like) of the concave structure CP**1** changes. As a result, the characteristic (especially, at least one of the shape, the position and the like) of the riblet structure formed by the concave structure CP**1** also changes. For example, the plurality of irradiation areas EA having first shapes illustrated in FIG. **55**A are irradiated with the plurality of processing lights EL, the concave structure CP**1** illustrated in FIG. **55**B is formed. On the other hand, for example, the plurality of irradiation areas EA having second shapes that are different from the first shapes illustrated in FIG. **55**C are irradiated with the plurality of processing lights EL, the concave structure CP**1** illustrated

in FIG. **55**D having the characteristic that is different from the concave structure CP**1** illustrated in FIG. **55**B is formed.

(300) The characteristic of the processing lights EL may include the sizes of the plurality of irradiation areas EA. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the sizes of the plurality of irradiation areas EA. When the sizes of the plurality of irradiation areas EA are changed, the characteristic (especially, at least one of the shape, the position and the like) of the concave structure CP**1** changes. As a result, the characteristic (especially, at least one of the shape, the position and the like) of the riblet structure formed by the concave structure CP**1** also changes. For example, the plurality of irradiation areas EA having first sizes illustrated in FIG. **56**A are irradiated with the plurality of processing lights EL, the concave structure CP**1** illustrated in FIG. **56**B is formed. On the other hand, for example, the plurality of irradiation areas EA having second sizes that are smaller than the first sizes illustrated in FIG. **56**C are irradiated with the plurality of processing lights EL, the concave structure CP**1** illustrated in FIG. **56**D having the width that is narrower than the concave structure CP**1** illustrated in FIG. **56**B is formed.

(301) The characteristic of the processing lights EL may include the intensity of the plurality of processing lights EL. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the intensity of the plurality of processing lights EL. When the intensity of the plurality of processing lights EL is changed, the characteristic (especially, the shape and the like) of the concave structure CP**1** changes. Specifically, the energy transmitted to the coat SF of paint by the irradiation of the plurality of processing lights EL becomes larger as the intensity of the plurality of processing lights EL becomes higher, and thus, the coat SF of paint is removed more. Therefore, the depth of the formed concave structure CP**1** becomes larger as the intensity of the plurality of processing lights EL becomes higher. As a result, the characteristic (especially, the shape and the like) of the riblet structure formed by the concave structure CP**1** also changes. For example, the plurality of processing lights EL having a first intensity illustrated in FIG. **57**A are emitted, the concave structure CP**1** illustrated in FIG. **57**B is formed. On the other hand, for example, the plurality of processing lights EL having a second intensity that is higher than the first intensity illustrated in FIG. **57**C are emitted, the concave structure CP**1** illustrated in FIG. **57**D that is deeper than the concave structure CP**1** illustrated in FIG. **57**B is formed.

(302) The characteristic of the processing lights EL may include the irradiation time of the plurality of processing lights EL. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the irradiation time of the plurality of processing lights EL. When the irradiation time of the plurality of processing lights EL is changed, the characteristic (especially, the shape and the like) of the concave structure CP**1** changes. Specifically, the energy transmitted to the coat SF of paint by the irradiation of the plurality of processing lights EL becomes larger as the irradiation time of the plurality of processing lights EL becomes longer, and thus, the coat SF of paint is removed more. Therefore, the depth of the formed concave structure CP**1** becomes larger as the irradiation time of the plurality of processing lights EL becomes longer. As a result, the characteristic (especially, the shape and the like) of the riblet structure formed by the concave structure CP**1** also changes. For example, the plurality of processing lights EL having a first intensity illustrated in FIG. **57**A are emitted, the concave structure CP**1** illustrated in FIG. **57**B is formed. On the other hand, for example, the plurality of processing lights EL having a second intensity that is higher than the first intensity illustrated in FIG. **57**C are emitted, the concave structure CP**1** illustrated in FIG. **57**D that is deeper than the concave structure CP**1** illustrated in FIG. **57**B is formed.

(303) The characteristic of the processing lights EL may include the polarization state (for example, at least one of a difference between s-polarized light or p-polarized light, a difference among circular polarized light, a liner polarized light and elliptic polarized light and the like) of the plurality of processing lights EL. Namely, the control apparatus **18** may control the characteristic

adjustment apparatus **41***e* to change the polarization state of the plurality of processing lights EL. When the polarization state of the plurality of processing lights EL is changed, a degree of absorption of the plurality of processing lights EL by the coat SF of paint is likely to change. As a result, the energy added to the coat SF of paint by the irradiation of the plurality of processing lights EL is likely to change, and thus, the characteristic (especially, the shape and the like) of the plurality of concave structures CP**1** is likely to change. As a result, the characteristic (especially, the shape and the like) of the riblet structure formed by the concave structure CP**1** also changes.
(304) The characteristic of the processing lights EL may include the wavelength of the plurality of processing lights EL. Namely, the control apparatus **18** may control the characteristic adjustment apparatus **41***e* to change the wavelength of the plurality of processing lights EL. When the wavelength of the plurality of processing lights EL is changed, a degree of absorption of the plurality of processing lights EL by the coat SF of paint is likely to change. As a result, the energy added to the coat SF of paint by the irradiation of the plurality of processing lights EL is likely to change, and thus, the characteristic (especially, the shape and the like) of the plurality of concave structures CP**1** is likely to change. As a result, the characteristic (especially, the shape and the like) of the riblet structure formed by the concave structure CP**1** also changes.
(305) The control apparatus **18** the control apparatus **18** may change the characteristic of the plurality of processing lights EL when the coat SF of paint is irradiated with the plurality of processing lights EL (namely, the plurality of processing lights EL relatively move relative to the coat SF of paint). As a result, a series of concave structure CP**1** extending in a certain direction includes a part having a first characteristic and a part having a second characteristic that is different from the first characteristic. For example, as illustrated in FIG. **58**A to FIG. **58**C, a series of concave structure CP**1** extending in a certain direction includes a part having a first shape (see FIG. **53**B that is a I-I′ cross sectional surface in FIG. **58**A) and a part having a second shape (see FIG. **58**C that is a II-IF cross sectional surface in FIG. **58**A) that is different from the first shape. Namely, the shape of the cross-sectional surface of the concave structure CP**1** changes along the extending direction of the concave structure CP**1**. Alternatively, as illustrated in FIG. **59**A to FIG. **59**C, a series of concave structure CP**1** extending in a certain direction includes a part having a first width (see FIG. **54**B that is a I-I′ cross sectional surface in FIG. **59**A) and a part having a second width (see FIG. **59**C that is a II-IF cross sectional surface in FIG. **59**A) that is different from the first width. Namely, the width of the concave structure CP**1** changes along the extending direction of the concave structure CP**1**.
(306) The processing apparatus **1***e* in the fifth modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1** and is allowed to change the characteristic of the riblet structure. Therefore, more proper riblet structure is formable compared to the case where the characteristic of the riblet structure is not allowed to be changed. Specifically, the riblet structure having the proper characteristic that properly achieves the effect of the reduction of the resistance is formable.
(4-6) Sixth Modified Example
(307) Next, with reference to FIG. **60**, a processing apparatus if in a sixth modified example will be described. In the above described description, the end part **144** of the support apparatus **14** is allowed to contact with the surface of the coat SF of paint. Namely, the support apparatus **14** supports the housing apparatus **13** (moreover, the light irradiation apparatus **11** supported by the housing apparatus **13**) in a state where it contacts with the coat SF of paint. On the other hand, as illustrated in FIG. **60**, the processing apparatus if in the sixth modified example is different from the above described processing apparatus **1** in that it is provided with a support apparatus **14***f* that does not contact with the surface of the coat SF of paint instead of the support apparatus **14**. Another feature of the processing apparatus if may be same as another feature of the processing apparatus **1**.
(308) Since the support apparatus **14***f* does not contact with the surface of the coat SF of paint, the

support apparatus **14***f* support the housing apparatus **13** (moreover, the light irradiation apparatus **11** supported by the housing apparatus **13**, the same applies to the sixth modified example) without contacting with the coat SF of paint. The support apparatus **14***f* is supported by a supporting frame (alternatively, any supporting member and the like) Ff that is separated from the coat SF of paint (moreover, the processing target object S). The support apparatus **14***f* supports the housing apparatus **13** in a state where it contacts with the supporting frame Ff.
(309) The support apparatus **14***f* is provided with the beam member **141**, as with the support apparatus **14**. Moreover, the support apparatus **14***f* is provided with a plurality of column members **142***f* disposed at the beam member **141**, instead of the plurality of leg members **142** of the support apparatus **14**. The column member **142***f* is a bar-like member that extends from the beam member **141** toward the +Z size. An end part (an end part at the +Z side in the example illustrated in FIG. **60**) **144***f* of the column member **142***f* is allowed to contact with the supporting frame Ff. The end part **144***f* is configured to adhere to the supporting frame Ff in a state where it contacts with the supporting frame Ff, as with the end part **144** of the leg member **142**.
(310) The column member **142***f* is a member that is configured to extend and contract along the Z axis by the driving system **15**, as with the leg member **142**. Namely, a state of the column member **142***f* is switchable between a third expansion state in which the column member **142***f* extends along the Z axis and a size thereof in the Z axis direction is relatively long and a third contraction state in which the column member **142***f* contracts along the Z axis and the size thereof in the Z axis direction is relatively short. The state of the column member **142***f* is switched between the third expansion state and the third contraction state when the support apparatus **14***f* moves, as with the leg member **142**. When the column member **142***f* is in the third expansion state, the end part **144***f* of the column member **142***f* is allowed to contact with the supporting frame Ff. On the other hand, when the column member **142***f* is in the third contraction state, the end part **144***f* does not contact with the supporting frame Ff. Namely, when the column member **142***f* is in the third contraction state, the end part **144***f* is away from the support frame Ff toward the −Z side. Therefore, the movement of the support apparatus **14***f* is not prevented by a contact between the end part **144***f* of the column member **142***f* and the supporting frame Ff. Note that the column member **142***f* may be attachable to an overhead crane that is movable along at least one of the X axis and the Y axis. Moreover, the support apparatus **14***f* may be at least one of a crane and a robot arm.
(311) The processing apparatus if in the sixth modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1**.
(312) Note that the support apparatus **14** is vibrationally separated from the coat SF of paint in the processing apparatus **1***f*, because the support apparatus **14***f* does not contact with the coat SF of paint. The light irradiation apparatus **11** is vibrationally separated from the coat SF of paint in the processing apparatus **1***f*, because the support apparatus **14***f* supports the light irradiation apparatus **11**. Therefore, there is a possibility that the irradiation position (namely, the position of the irradiation area EA) of the processing light EL by the light irradiation apparatus **11** is shifted from a desired irradiation position on the surface of the coat SF of paint, if the coat SF of paint relatively moves relative to the light irradiation apparatus **11** due to the vibration and the like. Namely, there is a possibility that the relative positional relationship between the coat SF of paint and the light irradiation apparatus **11**. Thus, in the sixth modified example, the control apparatus **18** relatively moves the irradiation area EA relative to the support apparatus **14***f* on the basis of at least one of a vibration state of the coat SF of paint relative to the support apparatus **14***f* and the relative positional relationship between the coat SF of paint and the support apparatus **14***f* so that the relative position of the irradiation area EA relative to the coat SF of paint does not change. The relative positional relationship between the coat SF of paint and the irradiation area EA changes if the coat SF of paint vibrates (alternatively, moves) relative to the support apparatus **14***f*, and thus, the control apparatus **18** changes the relative position of the irradiation area EA relative to the coat SF of paint on the basis of the relative positional relationship between the coat SF of paint and the

irradiation area EA so that the relative position of the irradiation area EA relative to the coat SF of paint is maintained.

(313) Thus, the processing apparatus **14***f* is provide with a vibration measurement apparatus **51***f* that measures the relative vibration state of the coat SF of paint relative to the support apparatus **14***f*. An optical measurement apparatus using various measurement basis such as a moire topography method using a grid irradiation method or a grid projection method, a holography interference method, an auto collimation method, a stereo method, an astigmatism method, a critical angle method or a knife edge method may be used as the vibration measurement apparatus, for example. Note that the processing apparatus **14***f* may be provided with a vibration measurement apparatus having a displacement sensor, a speed sensor or an acceleration sensor that measures the vibration state thereof. The control apparatus **18** changes the position of the irradiation area EA relative to the support apparatus **14***f* on the basis of a measured result of the vibration measurement apparatus **51***f* so that the position of the irradiation area EA relative to the coat SF of paint does not change even when the coat SF of paint vibrates relative to the support apparatus **14***f*. Here, when the coat SF of paint moves relative to the support apparatus **14***f* in one moving direction by one moving distance due to the vibration and the irradiation area EA does not move relative to the support apparatus **14***f*, the coat SF of paint moves relative to the irradiation area EA in one moving direction by one moving distance. Namely, the irradiation area EA moves on the surface of the coat SF of paint in another moving direction that is opposite to one moving direction by one moving distance. Thus, it is necessary to move the irradiation area EA in a same manner as the coat SF of paint in order not to change the relative position of the irradiation area EA relative to the coat SF of paint. Namely, the relative position of the irradiation area EA relative to the coat SF of paint does not change if the irradiation area EA moves in one moving direction by one moving distance in accordance with the movement of the coat SF of paint. More specifically, the relative position of the irradiation area EA relative to the coat SF of paint does not change if the irradiation area EA moves relative to the support apparatus **14***f* in one moving direction by one moving distance. Thus, the control apparatus **18** moves the irradiation area EA relative to the support apparatus **14***f* toward a direction that is same as the moving direction of the coat SF of paint relative to the support apparatus **14***f* by a moving distance that is same as the moving distance of the coat SF of paint relative to the support apparatus **14***f*. Note that irradiation area EA may be moved by moving the light irradiation apparatus **11** by the driving system **12**, by moving and/or by controlling the attitude of at least one optical member of the optical member(s) of the light irradiation apparatus **11** (for example, controlling the rotational state of the Galvano mirror M), or by another method.

(314) Note that there is a possibility that the vibration state of the support member **14** is not same as the vibration state of the coat SF of paint even in the above described processing apparatus **1** and the like in which the support apparatus **14** is allowed to contact with the coat SF of paint. Thus, even in the above described processing apparatus **1** and the like, the control apparatus **18** may relatively move the irradiation area EA relative to the support apparatus **14***f* on the basis of the vibration state of the coat SF of paint relative to the support apparatus **14***f* (namely, the relative position of the coat SF of paint relative to the support apparatus **14***f*) so that the relative position of the irradiation area EA relative to the coat SF of paint does not change.

(4-7) Seventh Modified Example

(315) Next, with reference to FIG. **61**, a processing apparatus **1***g* in a seventh modified example will be described. The above described processing apparatus **1** is configured to move the light irradiation apparatus **11** relative to the coat SF of paint by the driving systems **12** and **15** without moving the processing target object S. On the other hand, the processing apparatus **1***g* in the seventh modified example is different from the above described processing apparatus **1** in that it is configured to move the coat SF of paint (namely, the processing target object S) relative to the light irradiation apparatus **11** without moving the light irradiation apparatus **11**. Another feature of the processing apparatus **1***g* may be same as another feature of the processing apparatus **1**.

(316) In order to move the processing target object S, the processing apparatus **1**_g_ is provided with a stage **61**_g_. The stage **61**_g_ is supported by a surface plate **62**_g_ from the −Z side. The stage **61**_g_ is housed in the containing space SP. The state **61**_g_ is disposed to face the light irradiation apparatus **11**. The stage **61**_g_ is configured to hold the processing target object S so that the coat SF of paint faces the light irradiation apparatus **11**. The stage **61**_g_ is configured to hold the processing target object S so that the coat SF of paint is irradiated with the plurality of processing lights EL from the light irradiation apparatus **11**. The stage **61**_g_ is configured to release the held processing target object S.

(317) The stage **61**_g_ is movable by a driving system **63**_g_. The stage **63**_g_ is movable while holding the processing target object S. The stage **61**_g_ is movable relative to the light irradiation apparatus **11**. The stage **61**_g_ is movable relative to the irradiation areas EA that are irradiated with the plurality of processing lights EL from the light irradiation apparatus **11**. The driving system **63**_g_ moves the stage to change the relative positional relationship between the light irradiation apparatus **11** and the coat SF of paint (namely, the relative positional relationship between the irradiation areas EA and the coat SF of paint) under the control of the control apparatus **18**. The driving system **63**_g_ may move the stage **61**_g_ along at least one of the X axis and the Y axis. As a result, the irradiation areas EA moves on the coat SF of paint along at least one of the X axis and the Y axis. The driving system **63**_g_ may move the stage **61**_g_ along the Z axis. The driving system **63**_g_ may move the stage **61**_g_ along at least one of the θX direction, the θY direction and the θZ direction in addition to at least one of the X axis, the Y axis and the Z axis.

(318) The processing target object S moves relative to the light irradiation apparatus **11** due to the movement of the stage **61**_g_, the coat SF of paint moves relative to the housing apparatus **13** (especially, the end part **134** of the partition member **132**) and the support apparatus **14** (especially, the end part **144** of the leg member **142**). Thus, if the stage **61**_g_ moves in a state where at least one of the end parts **134** and **144** contacts with the coat SF of paint, there is a possibility that the movement of the stage **61**_g_ (namely, the movement of the processing target object S) is prevented by the contact between the coat SF of paint and at least one of the end parts **134** and **144**. Thus, in the seventh modified example, the end parts **134** and **144** do not contact with the coat SF of paint. In this case, the end part **134** contacts with the surface plate **62**_g_, for example. As a result, the housing apparatus **13** maintains the sealability of the containing space SP with the surface plate **62**_g_. Moreover, the end part **144** also contacts with the surface plate **62**_g_, for example. The support apparatus **14** self-stands on the surface plate **62**_g_. Namely, the support apparatus **14** supports the containing space **13** in a state where the end parts **144** contacts with the surface plate **62**_g_.

(319) In the seventh modified example, the light irradiation apparatus **11** is not necessarily moved, the processing apparatus **1**_g_ is not necessarily provided with the driving system **12** that moves the light irradiation apparatus **11** and the driving system **15** that moves the support apparatus **15**. However, the processing apparatus **1**_g_ may move the light irradiation apparatus **11** as with the above described processing apparatus **1** and may be provided with at least one of the driving systems **12** and **15** in this case.

(320) The processing apparatus **1**_g_ in the seventh modified example is configured to change the relative position between the coat SF of paint and the irradiation areas EA by moving the stage **61**_g_ (namely, moving the processing target object S), although the above described apparatus **1** realized it by moving the light irradiation apparatus **11**. Moreover, the processing apparatus **1**_g_ is configured to change the relative position between the coat SF of paint and the irradiation areas EA by moving the stage **61**_g_ (namely, moving the processing target object S), although the above described apparatus **1** realized it by rotating the Galvano mirror **1122**. Thus, the processing apparatus **1**_g_ also achieves an effect that is same as the effect achievable by the above described processing apparatus **1**. Namely, the processing apparatus **1**_g_ is allowed to alternately repeat the scan operation for sweeping the surface of the coat SF of paint with the plurality of processing lights EL along the Y axis (namely, for moving the plurality of irradiation areas EA along the Y axis) and the step

operation for moving the plurality of irradiation areas EA along the X axis by the predetermined amount by moving the processing target object S by the movement of the stage **61***g*. As a result, the plurality of unit processing areas SA are sweepable with the plurality of processing lights EL and thus the above described riblet structure is formable by the processing apparatus **1***g*.

(4-8) Eighth Modified Example

(321) Next, with reference to FIG. **62**, a processing apparatus **1***h* in an eighth modified example will be described. The above described processing apparatus **1** moves the light irradiation apparatus **11** by the driving system **12** in a state where the light irradiation apparatus **11** is supported by the housing apparatus **13**. Namely, the processing apparatus **1** moves the light irradiation apparatus **11** without contacting with the coat SF of paint. On the other hand, the processing apparatus **1***h* in the eighth modified example is different from the above described processing apparatus **1** in that it moves a light irradiation apparatus **11***h* in a state where the light irradiation apparatus **11***h* is not supported by the housing apparatus **13**. Thus, the processing apparatus **1***h* in the eighth modified example is different from the above described processing apparatus **1** in that the housing apparatus **13** does not necessarily support the light irradiation apparatus **11**. Namely, the processing apparatus **1***h* in the eighth modified example is different from the above described processing apparatus **1** in that it is provided with the light irradiation apparatus **11** that is not supported by the housing apparatus **13**. Moreover, the processing apparatus **1***h* in the eighth modified example is different from the above described processing apparatus **1** in that it is provided with a driving system **12***h* for moving the light irradiation apparatus **11** that is not supported by the housing apparatus **13** instead of the above described driving system **12**. Another feature of the processing apparatus **1***h* may be same as another feature of the processing apparatus **1**.

(322) Since the housing apparatus does not support the light irradiation apparatus **11***h*, the light irradiation apparatus **11***h* is placed on the surface of the coat SF of paint. The light irradiation apparatus **11***h* is different from the above described light irradiation apparatus **11** in that it is provided with a contacting part **113***h* that is allowed to contact with the surface of the coat SF of paint. Another feature of the light irradiation apparatus **11***h* may be same as another feature of the light irradiation apparatus **11**. The light irradiation apparatus **11***h* is placed on the surface of the coat SF of paint in a state where it contacts with the surface of the coat SF of paint through the contacting part **113***h*. Thus, the light irradiation apparatus **11***h* is supported by the coat SF of paint.

(323) The driving system **12***h* moves the light irradiation apparatus **11***h* relative to the coat SF of paint (namely, relative to the processing target object S) under the control of the control apparatus **18**. More specifically, the driving system **12***h* moves the light irradiation apparatus **11***h* along the surface of the coat SF of paint. In this case, the driving system **12***h* moves the light irradiation apparatus **11***h* in the state where the light irradiation apparatus **11***h* contacts with the surface of the coat SF of paint through the contacting part **113***h*. Thus, the contacting part **113***h* is a member having a relatively small friction resistance to the coat SF of paint. Alternatively, the contacting part **113***h* is a member having a relatively small rolling resistance (for example, at least one of a tire, a ball and the like). Thus, the light irradiation apparatus **11***h* is movable along the surface of the coat SF of paint as if it self-run on the surface of the coat SF of paint.

(324) The light irradiation apparatus **11***h* emits the processing lights EL in the state where the light irradiation apparatus **11***h* contacts with the surface of the coat SF of paint through the contacting part **113***h*. The light irradiation apparatus **11***h* may emits the processing lights EL during a period when the light irradiation apparatus **11***h* moves along the surface of the coat SF of paint. As a result, the irradiation areas EA moves relative to the coat SF of paint, and thus, the scan operation for sweeping the surface of the coat SF of paint with the plurality of processing lights EL along the Y axis (namely, for moving the plurality of irradiation areas EA along the Y axis) is performable. Namely, the light irradiation apparatus **1***h* is allowed to form the riblet structure by alternately repeating the scan operation and the above described step operation by the movement of the light irradiation apparatus **11***h* without rotating the Galvano mirror **1122**. However, the light irradiation

apparatus **1***h* may alternately repeat the scan operation and the above described step operation by rotating the Galvano mirror **1122**.

(325) As described above, the processing apparatus **1***h* is disposed relative to the coat SF of paint to be suspended from the coat SF of paint by the support apparatus **14** (for example, to be suspended from the airframe of the airplane PL that is one example of the processing target object S) in some cases (see the above described FIG. **6**A). When the processing apparatus **1***h* is suspended from the coat SF of paint in this manner, there is a possibility that the light irradiation apparatus **11***h* drops, because the light irradiation apparatus **11***h* is not supported by the housing apparatus **13**. Thus, the light irradiation apparatus **11** itself may be configured to contact to the coat SF of paint. For example, the contacting part **113***h* may be configured to contact to the coat SF of paint. For example, the contacting part **113***h* may be provided with a suction mechanism that is configured to suck the coat SF of paint. Alternatively, as illustrated in FIG. **63**, a suction part **114***h* that makes the light irradiation apparatus **11***h* be disposed above the coat SF of paint may be used. In FIG. **63**, the light irradiation apparatus **11***h* is supported by a frame **115***h*. Wheels **113***h* that are the contacting parts and suction nozzles **114***h***1** that constitute a part of the suction part **114***h* are disposed at the frame **115***h*. The suction nozzles **114***h***1** are connected to suction pumps **114***h***3** through suction pipes **114***h***2**. The suction pumps **114***h***3** makes the light irradiation apparatus **11***h* be sucked to the coat SF of paint by depressurizing a space between the suction nozzles **114***h***1** and the coat SF of paint through the suction pipes **114***h***2**. Note that the wheels **113***h* are configured to drive by the driving apparatus **12***h*. Note that the suction part **114***h* is not limited to an above described negative pressure suction type, and may be a magnetic attraction type, for example.

(326) The processing apparatus **1***h* in the eights modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1**. Moreover, the processing apparatus **1***h* is movable along the surface of the coat SF of paint in the state where the light irradiation apparatus **11***h* contacts with the surface of the coat SF of paint. Therefore, the light irradiation apparatus **11** is movable along the surface of the coat SF of paint whatever the shape of the surface of the coat SF of paint is. Thus, the processing apparatus **1***h* processes the coat SF of paint without being much subjected to a restraint of the shape of the surface of the coat SF of paint.

(4-9) Ninth Modified Example

(327) Next, with reference to FIG. **64**, a processing apparatus **1***i* in a ninth modified example will be described. As illustrated in FIG. **64**, the processing apparatus **1***i* is different from the above described processing apparatus **1** in that it is further provided with a position measurement apparatus **71***i*. Another feature of the processing apparatus **1***i* may be same as another feature of the processing apparatus **1**.

(328) The position measurement apparatus **71***i* measures the positions of the plurality of irradiation areas EA relative to the coat SF of paint (namely, relative to the processing target object S). In the ninth modified example, in order to measure the positions of the plurality of irradiation areas EA, the position measurement apparatus **71***i* includes an imaging device (for example, a camera) **72***i* that is configured to capture an image of both of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** at the same time, and indirectly measures the positions of the irradiation areas EA relative to the coat SF of paint by measuring the position of the light irradiation apparatus **11** relative to the coat SF of paint. In order to capture the image of both of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** at the same time, the imaging device **72***i* is aligned with respect to at least one of the coat SF of paint (namely, the processing target object S) and the light irradiation apparatus **11** so that both of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** are included in an imaging range of the imaging device **72***i*. In this case, the imaging device **72***i* is typically disposed at a position that is away from the coat SF of paint and the light irradiation apparatus **11** by a predetermined distance or more. In this case, the imaging device **72***i* captures the image of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** from the position

that is away from the coat SF of paint and the light irradiation apparatus **11** by the predetermined distance or more. Namely, the imaging device **72***i* captures the image of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** in a state where it overviews the coat SF of paint and the light irradiation apparatus **11**.
(329) Since the imaging device **72***i* captures the image of both of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** at the same time, an imaged result of the imaging device **72***i* (namely, a measured result of the position measurement apparatus **71***i*) includes information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint.
(330) Here, as described above, the light irradiation apparatus **11** is housed in the containing space SP surrounded by the partition member **132**. When the partition member **132** is a member through which the visible light is allowed to pass through, the imaging device **72***i* is allowed to directly capture the image of the light irradiation apparatus **11** housed in the containing space SP. As a result, the measured result of the position measurement apparatus **71***i* includes the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint. Thus, the partition member **132** may be the member through which the visible light is allowed to pass through. Even in this case, the fact remains that the processing light EL is shielded by the partition member **132** as long as the processing light EL is the invisible light.
(331) Alternatively, when the partition member **132** is a member that shields the visible light, there is a possibility that it is difficult for the imaging device **72***i* to directly capture the image of the light irradiation apparatus **11**. However, even in this case, it is possible for the device **72***i* to capture the image of the housing apparatus **13** that supports the light irradiation apparatus **11** and the support apparatus **14** that supports the housing apparatus **13**. Therefore, in this case, the measured result of the position measurement apparatus **71***i* includes information relating to a position of at least one of the housing apparatus **13** and the support apparatus **14** relative to the coat SF of paint. Moreover, when the position of at least one of the housing apparatus **13** and the support apparatus **14** relative to the coat SF of paint changes, the position of the light irradiation apparatus **11** supported by the housing apparatus **13** and the support apparatus **14** relative to the coat SF of paint also changes. Namely, the position of the light irradiation apparatus **11** relative to the coat SF of paint depends on the position of at least one of the housing apparatus **13** and the support apparatus **14** relative to the coat SF of paint. Therefore, when a positional relationship between at least one of the housing apparatus **13** and the support apparatus **14** and the light irradiation apparatus **11** is known, the information relating to the position of at least one of the housing apparatus **13** and the support apparatus **14** relative to the coat SF of paint is convertible to the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint. Therefore, even when the partition member **132** is the member that shields the visible light, the measured result of the position measurement apparatus **71***i* substantially includes the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint. Note that the positional relationship between at least one of the housing apparatus **13** and the support apparatus **14** and the light irradiation apparatus **11** is known information to the control apparatus **18**, because the control apparatus **18** controls the driving systems **12** and **15** to move the light irradiation apparatus **11** and the support apparatus **14**, respectively. Therefore, the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint is collectable by the control apparatus **18** from the measured result of the position measurement apparatus **71***i*, even when the partition member **132** is the member that shields the visible light.
(332) Alternatively, when the imaging device **72***i* is a device that captures the image of at least a part of the coat SF of paint and at least a part of the light irradiation apparatus **11** by using illumination light that is the invisible light, the imaging device **72***i* is capable of directly capturing the light irradiation apparatus **11** even when the partition member **132** is the member that shields the visible light. Therefore, the imaging device **72***i* may capture the image of at least a part of the

coat SF of paint and at least a part of the light irradiation apparatus **11** by using the illumination light that is the invisible light that is allowed to pass through the partition member **132**. However, there is a possibility that the coat SF of paint evaporates by the irradiation of the illumination light when the invisible light having the wavelength that is absorbed by the coat SF of paint to a certain degree and an intensity of the illumination light is equal to or higher than an intensity that allows the coat SF of paint to evaporate. Thus, the intensity of the illumination light used by the imaging device **72***i* is set to an intensity lower than the intensity that allows the coat SF of paint to evaporate. Namely, the intensity of the illumination light is too low to evaporate the coat SF of paint.

(333) The measured result of the position measurement apparatus **71***i* is outputted from the position measurement apparatus **71***i* to the control apparatus **18** through a wired or wireless communication line. The control apparatus **18** receives the measured result of the position measurement apparatus **71***i*. The control apparatus **18** determines the position of the light irradiation apparatus **11** relative to the coat SF of paint from the measured result of the position measurement apparatus **71***i*, and eventually determines the positions of the plurality of irradiation areas EA relative to the coat SF of paint. Specifically, the measured result of the position measurement apparatus **71***i* includes the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint, as described above. Here, the position of the light irradiation apparatus **11** relative to the coat SF of paint changes, the positions of the plurality of irradiation areas EA relative to the coat SF of paint also change. Namely, the positions of the plurality of irradiation areas EA relative to the coat SF of paint depends on the position of light irradiation apparatus **11** relative to the coat SF of paint. Therefore, when a positional relationship between the light irradiation apparatus **11** and the plurality of irradiation areas EA is known, the information relating to the position of the light irradiation apparatus **11** relative to the coat SF of paint is convertible to the information relating to the positions of the plurality of irradiation areas EA relative to the coat SF of paint. Moreover, the control apparatus **18** controls the light irradiation apparatus **11** (especially, the Galvano mirror **1122**) to change the positions of the plurality of irradiation areas EA on the painted surface SF. Thus, the positional relationship between the light irradiation apparatus **11** and the plurality of irradiation areas EA is known information to the control apparatus **18**. Therefore, the control apparatus **18** is capable of determining the positions of the plurality of irradiation areas EA relative to the coat SF of paint on the basis of the measured result of the position measurement apparatus **71***i* and the positional relationship between the light irradiation apparatus **11** and the plurality of irradiation areas EA (in other words, a controlled state of the Galvano mirror **1122**).

(334) The control apparatus **18** controls at least one of the light irradiation apparatus **11**, the driving system **12** and driving system **15** to form the riblet structure on the basis of the determined positions of the plurality of irradiation areas EA. For example, the control apparatus **18** may control the light irradiation apparatus **11**, the driving system **12** and driving system **15** so that the irradiation areas EA are set at desired positions on the coat SF of paint. Alternatively, for example, the control apparatus **18** may associate the determined positions of the plurality of irradiation areas EA (alternatively, the position of the light irradiation apparatus **11** relative to the coat SF of paint) with the characteristic of the surface (for example, at least one of the shape, the reflectance and the like of the surface) of the coat SF of paint described in the second modified example and may perform the advance measurement control operation in the above described second modified example on the basis of the associated information.

(335) The processing apparatus **1***i* in the ninth modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1**. Moreover, the processing apparatus **1***i* properly determines the positions of the irradiation areas EA relative to the coat SF of paint. Therefore, the processing apparatus **1***i* processes the coat SF of paint properly (namely, with a relatively high accuracy) while setting the plurality of irradiation areas EA to proper positions on the surface of the coat SF of paint.

(336) Note that the position measurement apparatus **71***i* captures the image of the surface of the coat SF of paint as described above. Thus, the control apparatus **18** may determine at least one of the shape of the surface of the coat SF of paint and a position at which the determined shape exists on the surface of the coat SF of paint from the image of the surface of the coat SF of paint that is captured by the position measurement apparatus **71**. Thus, the position measurement apparatus **71***i* may be used as the surface characteristic measurement apparatus **19***b* for measuring the shape of the surface of the coat SF of paint that is used in the above described second modified example. In this case, the control apparatus **18** may determine the "shape of the surface of the coat SF of paint" that is used in the first specific example to the third specific example of the advance measurement control operation in the second modified example from the measured result of the position measurement apparatus **71***i*, for example. Alternatively, the control apparatus **18** may determine at least one of the shape of "the structural object having the size that is equal to or larger than the allowable size that exists on the surface of the coat SF of paint" that is used in the fourth specific example of the advance measurement control operation in the second modified example and the position of an area on the surface of the coat SF of paint at which this structural object exists from the measured result of the position measurement apparatus **71***i*, for example.
(337) Note that the position measurement **71***i* may directly measure the positions of the irradiation areas EA relative to the coat SF of paint, although the position measurement **71***i* indirectly measures the positions of the irradiation areas EA in the above described example. For example, the light irradiation apparatus **11** irradiates the coat SF of paint with the processing lights EL having a weak intensity (an intensity that does not evaporate the coat SF of paint and that is detectable by the imaging device **72***i*) to form the irradiation areas EA on the coat SF of paint. The positions of the irradiation areas EA relative to the coat SF of paint may be directly measured by imaging the positions of the irradiation areas EA by the imaging device **72***i*. Note that the positions of the irradiation areas EA may be directly measured during a period when the coat SF of paint is processed.
(338) Moreover, in the above described description, an example in which the processing apparatus **1***i* itself is provided with the position measurement apparatus **71***i* is described. However, since the position measurement apparatus **71***i* (especially, the imaging device **72***i*) is disposed at the position that is away from the light irradiation apparatus **11** by the predetermined distance as described above, the position measurement apparatus **71***i* may be an apparatus that is different from the processing apparatus **1***i*. Namely, not only the processing apparatus **1***i* but also a processing system that is provided with the processing apparatus **1** and the position measurement apparatus **71***i* between which information is transmittable through a wired or wireless communication line achieves an effect that is same as the effect achievable by the above described processing apparatus **1***i* in the ninth modified example.
(4-10) Tenth Modified Example
(339) Next, with reference to FIG. **65**, a processing apparatus **1***j* in a tenth modified example will be described. The processing apparatus **1***j* in the tenth modified example is same as the above described processing apparatus **1***j* in the ninth modified example in that it measures the positions of the plurality of irradiation areas EA relative to the coat SF of paint and controls at least one of the light irradiation apparatus **11**, the driving system **12** and driving system **15** to form the riblet structure on the basis of the measured result. The processing apparatus **1***j* is different from the above described processing apparatus **1***i* in that it is provided with a position measurement apparatus **71***j* instead of the position measurement apparatus **71***i*. Another feature of the processing apparatus **1***j* may be same as another feature of the processing apparatus **1***i*.
(340) The position measurement apparatus **71***j* is same as the position measurement apparatus **71***i* in that it measures the positions of the plurality of irradiation areas EA relative to the coat SF of paint (namely, relative to the processing target object S). In the tenth modified example, in order to measure the positions of the plurality of irradiation areas EA, the position measurement apparatus

71*j* is provided with a first measurement apparatus **711***j* and a second measurement apparatus **712***j*. The first measurement apparatus **711***j* and the second measurement apparatus **712***j* measure the positions of the plurality of irradiation areas EA relative to the coat SF of paint in cooperation.

(341) The first measurement apparatus **711***j* is disposed at a first position that has a predetermined first positional relationship with the coat SF of paint. The predetermined first positional relationship is known to the control apparatus **18**. Namely, the control apparatus **18** has information relating to the predetermined first positional relationship. In an example illustrated in FIG. **65**, the first measurement apparatus **711***j* is disposed at the surface of the coat SF of paint. However, the first measurement apparatus **711***j* may be disposed at a position other than the surface of the coat SF of paint. For example, the first measurement apparatus **711***j* may be disposed in the coat SF of paint, may be disposed at the processing target object S or may be disposed at another position.

(342) The second measurement apparatus **712***j* is disposed at a second position that has a predetermined second positional relationship with the light irradiation apparatus **11**. The predetermined second positional relationship is known to the control apparatus **18**. Namely, the control apparatus **18** has information relating to the predetermined second positional relationship. In an example illustrated in FIG. **65**, the second measurement apparatus **712***j* is disposed at the light irradiation apparatus **11**. However, the second measurement apparatus **712***j* may be disposed at a part of the processing apparatus **1***j* other than the light irradiation apparatus **11**. Alternatively, the second measurement apparatus **712***j* may be disposed at a position other than the processing apparatus **1***j*.

(343) The first measurement apparatus **711***j* includes a signal output apparatus that is configured to output (namely, transmit) a signal toward a surrounding area. In this case, the position measurement apparatus **71***j* is provided with a plurality of (for example, two or three or more) first measurement apparatuses **711***j* at different disposed positions. Moreover, in this case, the second measurement apparatus **712***j* includes a signal detection apparatus that detects the signals outputted from the plurality of first measurement apparatuses **711***j*. A measured result of the second measurement apparatus **712***j* (namely, a detected result of the signal detection apparatus) is outputted to the control apparatus **18**. The control apparatus **18** determines a position of the second measurement apparatus **712***j* relative to each of the plurality of first measurement apparatuses **711***j* from the measured result of the second measurement apparatus **712***j*. The control apparatus **18** may determine the position of the second measurement apparatus **712***j* relative to each of the plurality of first measurement apparatuses **711***j* by using an existing method (for example, a three-dimensional positioning method and the like such as a GPS (Global Positioning System) for determining the position of the signal detection apparatus relative to the plurality of signal output apparatuses.

(344) Then, the control apparatus **18** determines the position of the light irradiation apparatus **11** relative to the coat SF of paint on the basis of the position of the second measurement apparatus **712***j* relative to each of the plurality of first measurement apparatuses **711***j*. Specifically, a positional relationship between the second measurement apparatus **712***j* and each of the plurality of first measurement apparatuses **711***j* is equivalent to the positional relationship between the light irradiation apparatus **11** and the coat SF of paint, because the first positional relationship between each of the plurality of first measurement apparatuses **711***j* and the coat SF of paint and the second positional relationship between the second measurement apparatus **712***j* and the light irradiation apparatus **11** are known to the control apparatus **18**. Thus, the control apparatus **18** determines the position of the light irradiation apparatus **11** relative to the coat SF of paint on the basis of not only the position of the second measurement apparatus **712***j* relative to each of the plurality of first measurement apparatuses **711***j* but also the first positional relationship between each of the plurality of first measurement apparatuses **711***j* and the coat SF of paint and the second positional relationship between the second measurement apparatus **712***j* and the light irradiation apparatus **11** that are known to the control apparatus **18**. An operation after the position of the light irradiation apparatus **11** relative to the coat SF of paint is determined in the tenth modified example is same as

that of the second modified example. Namely, the control apparatus **18** determines the positions of the plurality of irradiation areas EA relative to the coat SF of paint on the basis of the determined position of the light irradiation apparatus **11** relative to the coat SF of paint

(345) The processing apparatus **1***j* in the tenth modified example achieves an effect that is same as the effect achievable by the above described processing apparatus **1***i* in the ninth modified example.

(346) Note that the first measurement apparatus **711***j* may not include the signal output apparatus that is configured to output (namely, transmit) the signal toward the surrounding area. For example, the first measurement apparatus **711***j* may include any detected apparatus that is detectable by the second measurement apparatus **712***j*. A marker is one example of any detected apparatus. Moreover, in this case, the second measurement apparatus **712***j* may include a detection apparatus that is configured to detect any detected apparatus. An imaging device such as a camera is one example of any detection apparatus. Even in this case, the position of the second measurement apparatus **712***j* relative to the first measurement apparatus **711***j* is determined by the control apparatus **18** from the measured result of the second measurement apparatus **712***j*. Thus, the positions of the plurality of irradiation areas EA relative to the coat SF of paint is determined by the control apparatus **18**

(4-11) Eleventh Modified Example

(347) Next, a processing apparatus **1***k* in an eleventh modified example will be described. The processing apparatus **1***k* sets the plurality of unit processing areas SA on the surface of the coat SF of paint and irradiates the plurality of unit processing areas SA with the plurality of processing lights EL in order, as with the above described processing apparatus **1**. In the eleventh modified example, each unit processing area SA partially overlaps with adjacent another unit processing area SA. Namely, each unit processing area SA includes an overlapped area SAa that overlaps with anther unit processing area SA and a non-overlapped area Sab that does not overlap with anther unit processing area SA. For example, as illustrated in FIG. **66**A, a unit processing area SA**1** includes an overlapped area SAa**1-2** that partially overlaps with a unit processing area SA**2** adjacent to the +X side of the unit processing area SA**1** (however, that does not overlap with a unit processing area SA**6**), an overlapped area SAa**1-5** that partially overlaps with a unit processing area SA**5** adjacent to the +Y side of the unit processing area SA**1** (however, that does not overlap with the unit processing area SA**6**), an overlapped area SAa**1-256** that partially overlaps with the unit processing areas SA**2** and SA**5** and that partially overlaps with the unit processing area SA**6** adjacent to the unit processing area SA**1** in an oblique direction, and a non-overlapped area Sab**1** that does not overlap with the other unit processing areas SA. For example, as illustrated in FIG. **66**B, the unit processing area SA**2** includes an overlapped area SAa**2-1** that partially overlaps with the unit processing area SA**1** adjacent to the −X side of the unit processing area SA**2** (however, that does not overlap with the unit processing area SA**5**), an overlapped area SAa**2-3** that partially overlaps with a unit processing area SA**3** adjacent to the +X side of the unit processing area SA**2** (however, that does not overlap with a unit processing area SA**7**), an overlapped area SAa**2-6** that partially overlaps with the unit processing area SA**6** adjacent to the +Y side of the unit processing area SA**2** (however, that does not overlap with the unit processing areas SA**5** and SA**7**), an overlapped area SAa**2-156** that partially overlaps with the unit processing areas SA**1** and SA**6** and that partially overlaps with the unit processing area SA**5** adjacent to the unit processing area SA**2** in an oblique direction, an overlapped area SAa**2-367** that partially overlaps with the unit processing areas SA**3** and SA**6** and that partially overlaps with the unit processing area SA**7** adjacent to the unit processing area SA**2** in an oblique direction, and a non-overlapped area Sab**2** that does not overlap with the other unit processing areas SA.

(348) The processing apparatus **1***k* is different from the above described processing apparatus **1** in that it emits the plurality of processing lights EL so that the characteristic of the processing lights EL with which the overlapped area SAa is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped area SAb, compared to the processing

apparatus **1**. This is because there is a possibility that the overlapped area SAa at which one unit processing area SA partially overlaps with another unit processing area SA is irradiated redundantly with the processing light EL with which one unit processing area SA is irradiated and the processing light EL with which another unit processing area SA is irradiated. On the other hand, the non-overlapped area Sab included in one unit processing area SA is irradiated with the processing light EL with which one unit processing area SA is irradiated, but is not irradiated with the processing light EL with which another unit processing area SA is irradiated. Thus, there is a possibility that the characteristic of the concave structure CP**1** formed in the overlapped area SAa is different from the characteristic of the concave structure CP**1** formed in the non-overlapped area SAb, if the characteristic of the processing lights EL with which the overlapped area SAa is irradiated is same as the characteristic of the processing lights EL with which the non-overlapped area SAb is irradiated. As a result, there is a possibility that the characteristic of the riblet structure is different from a necessary characteristic. Thus, in the eleventh modified example, the processing apparatus **1***k* emits the plurality of processing lights EL so that the characteristic of the processing lights EL with which the overlapped area SAa is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped area SAb is irradiated. Next, three examples in each of which the characteristic of the processing lights EL with which the overlapped area SAa is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped area Sab is irradiated will be described. Note that another feature of the processing apparatus **1***k* may be same as another feature of the processing apparatus **1**.

(4-11-1) First Specific Example in which Characteristic of Processing Light EL with which Overlapped Area SAa is Irradiated is Different from Characteristic of Processing Light EL with which Non-Overlapped Area SAb is Irradiated

(349) In a first specific example, as illustrated in FIG. **67**, the control apparatus **18** controls the light irradiation apparatus **11** so that the overlapped area SAa that is not yet irradiated with the processing lights EL (namely, the overlapped area SAa in which the concave structure CP**1** is not yet formed) is irradiated with the processing lights EL. On the other hand, the control apparatus **18** controls the light irradiation apparatus **11** so that the overlapped area SAa that is already irradiated with the processing lights EL (namely, the overlapped area SAa in which the concave structure CP**1** is already formed) is not irradiated with the processing lights EL. Moreover, the control apparatus **18** controls the light irradiation apparatus **11** so that the non-overlapped area SAb is irradiated with the processing lights EL. Namely, the control apparatus **18** sets the intensity of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated to zero and sets the intensity of the processing lights EL with which each of the overlapped area SAa that is not yet irradiated with the processing lights EL and the non-overlapped area SAb is irradiated to an intensity higher than zero. In other words, the control apparatus **18** sets the irradiation time of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated to zero and sets the irradiation time of the processing lights EL with which each of the overlapped area SAa that is not yet irradiated with the processing lights EL and the non-overlapped area SAb is irradiated to a time larger than zero. Note that FIG. **67** illustrates an example in which the overlapped area SAa**1-2** that is not yet irradiated with the processing lights EL is irradiated with the processing lights EL at a timing when the unit processing area SA**1** is irradiated with the processing lights EL and then the overlapped area SAa**2-1** that is already irradiated with the processing lights EL is not irradiated with the processing lights EL at a timing when the unit processing area SA**2** is irradiated with the processing lights EL subsequent to the unit processing area SA**1** in a situation where the unit processing area SA**1** is irradiated with the processing lights EL and then the unit processing area SA**2** that partially overlaps with the unit processing area SA**1** is irradiated with the processing lights EL.

(350) When the intensity of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated is set to zero in this manner, the riblet

structure that is already formed in the overlapped area SAa is not processed so that the characteristic thereof deteriorates (for example, the shape thereof becomes an undesired shape) by the second irradiation of the processing lights EL. Thus, the processing apparatus **1***k* achieves an effect that is same as the effect achievable by the above described processing apparatus **1** and properly forms the riblet structure even when the adjacent unit processing areas SA partially overlap with each other.

(4-11-2) Second Specific Example in which Characteristic of Processing Light EL with which Overlapped Area SAa is Irradiated is Different from Characteristic of Processing Light EL with which Non-Overlapped Area SAb is Irradiated

(351) In a second specific example, as illustrated in FIG. **68**, the control apparatus **18** controls the light irradiation apparatus **11** so that the overlapped area SAa that is not yet irradiated with the processing lights EL is irradiated with the processing lights EL the intensity of which is high enough to evaporate the coat SF of paint. On the other hand, the control apparatus **18** controls the light irradiation apparatus **11** so that the overlapped area SAa that is already irradiated with the processing lights EL is irradiated with the processing lights EL the intensity of which is too low to evaporate the coat SF of paint. Moreover, the control apparatus **18** controls the light irradiation apparatus **11** so that the non-overlapped area SAb is irradiated with the processing lights EL the intensity of which is high enough to evaporate the coat SF of paint. Namely, the control apparatus **18** sets the intensity of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated to a non-processable intensity that does not allow the coat SF of paint to evaporate and sets the intensity of the processing lights EL with which each of the overlapped area SAa that is not yet irradiated with the processing lights EL and the non-overlapped area SAb is irradiated to an intensity higher than the non-processable intensity (namely, a processable intensity that allows the coat SF of paint to evaporate). Note that FIG. **68** illustrates an example in which the overlapped area SAa**1-2** that is not yet irradiated with the processing lights EL is irradiated with the processing lights EL having the processable intensity at the timing when the unit processing area SA**1** is irradiated with the processing lights EL and then the overlapped area SAa**2-1** that is already irradiated with the processing lights EL is irradiated with the processing lights EL having the non-processable intensity at the timing when the unit processing area SA**2** is irradiated with the processing lights EL subsequent to the unit processing area SA**1** in the situation where the unit processing area SA**1** is irradiated with the processing lights EL and then the unit processing area SA**2** that partially overlaps with the unit processing area SA**1** is irradiated with the processing lights EL.

(352) When the intensity of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated is set to the non-processable intensity, the riblet structure that is already formed in the overlapped area SAa is not processed so that the characteristic thereof deteriorates by the second irradiation of the processing lights EL, as with the case where the intensity of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated is set to zero. Thus, the processing apparatus **1***k* achieves the effect that is same as the effect achievable by the above described processing apparatus **1** and properly forms the riblet structure even when the adjacent unit processing areas SA partially overlap with each other.

(353) Note that the coat SF of paint evaporates by the energy added from the emitted processing lights EL to the coat SF of paint as described above. Moreover, the energy added from the emitted processing lights EL to the coat SF of paint varies depending on not only the intensity of the processing lights EL but also the irradiation time of the processing lights EL. Thus, the control apparatus **18** may control the light irradiation apparatus **11** so that the overlapped area SAa that is not yet irradiated with the processing lights EL is irradiated with the processing lights EL for an irradiation time that is long enough to evaporate the coat SF of paint. On the other hand, the control apparatus **18** may control the light irradiation apparatus **11** so that the overlapped area SAa that is

already irradiated with the processing lights EL is irradiated with the processing lights EL for an irradiation time that too short to evaporate the coat SF of paint. Moreover, the control apparatus **18** may control the light irradiation apparatus **11** so that the non-overlapped area SAb is irradiated with the processing lights EL for an irradiation time that is long enough to evaporate the coat SF of paint. Namely, the control apparatus **18** may set the irradiation time of the processing lights EL with which the overlapped area SAa that is already irradiated with the processing lights EL is irradiated to a non-processable time that does not allow the coat SF of paint to evaporate and may set the irradiation time of the processing lights EL with which the overlapped area SAa that is not yet irradiated with the processing lights EL and the non-overlapped area SAb are irradiated to an irradiation time longer than the non-processable time (namely, a processable time that allows the coat SF of paint to evaporate).

(4-11-3) Third Specific Example in which Characteristic of Processing Light EL with which Overlapped Area SAa is Irradiated is Different from Characteristic of Processing Light EL with which Non-Overlapped Area SAb is Irradiated

(354) In a third specific example, as illustrated in FIG. **69**, the control apparatus **18** controls the light irradiation apparatus **11** so that each of the overlapped area SAa and the non-overlapped area SAb is irradiated with the processing lights EL having the processable intensity. However, in this case, the control apparatus **18** controls the light irradiation apparatus **11** so that the intensity of the processing lights EL with which the overlapped area SAa is irradiated is lower than the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated. More specifically, the control apparatus **18** controls the light irradiation apparatus **11** so that the intensity of the processing lights EL with which the overlapped area SAa is irradiated is 1/n (note that n is an integer equal to or larger than 2) times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated when the overlapped area SAa is an area in which the n unit processing areas SA areas partially overlap with each other. For example, in an example illustrated in FIG. **69**, the overlapped area SAa**1-2** (namely, the overlapped area SAa**2-1**) is an area in which two unit processing areas SA**1** and SA**2** partially overlap with each other. Thus, each of the intensity of the processing light EL with which the overlapped area SAa**1-2** is irradiated at the timing when the unit processing area SA**1** is irradiated with the processing lights EL and the intensity of the processing light EL with which the overlapped area SAa**2-1** is irradiated at the timing when the unit processing area SA**2** is irradiated with the processing lights EL is ½ times (namely, half) as much as the intensity of the processing lights EL with which each of the non-overlapped areas SAb**1** and SAb**2** is irradiated.

(355) When the intensity of the processing lights EL with which the overlapped area SAa is irradiated is 1/n times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated in this manner, the characteristic of the concave structure CP**1** formed in the overlapped area SAa is not greatly different from the characteristic of the concave structure CP**1** formed in the non-overlapped area SAb. This is because the overlapped area SAa is irradiated with the processing lights EL the intensity of which is 1/n times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated every time each of the n unit processing area SA including the overlapped area SAa is irradiated with the plurality of processing lights EL. Namely, the overlapped area SAa is irradiated with the processing lights EL the intensity of which is 1/n times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated in n times. As a result, a total amount of the energy added to the overlapped area SAa by the n times irradiations of the processing lights EL is same as a total amount of the energy added to the non-overlapped area SAb by one time irradiation of the processing lights EL. Therefore, the characteristic (for example, the depth) of the concave structure CP**1** formed in the overlapped area SAa by the n times irradiations of the processing lights EL is nearly same as the characteristic (for example, the depth) of the concave structure CP**1** formed in the non-overlapped area SAb by one time irradiation of the processing lights EL.

Namely, in the third specific example, the concave structure CP**1** is formed so that it is gradually deepened. Thus, the processing apparatus **1***k* achieves the effect that is same as the effect achievable by the above described processing apparatus **1** and properly forms the riblet structure even when the adjacent unit processing areas SA partially overlap with each other.
(356) Note that the intensity of the processing lights EL with which the overlapped area SAa is irradiated may not be set to be 1/n times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated, as long as the total amount of the energy added to the overlapped area SAa by the n times irradiations of the processing lights EL is same as the total amount of the energy added to the non-overlapped area SAb by one time irradiation of the processing lights EL. For example, in the example illustrated in FIG. **69**, the intensity of the processing lights EL is fixed to the intensity that is 1/n times as much as the intensity of the processing lights EL with which the non-overlapped area SAb is irradiated during a period when the overlapped area SAa is irradiated with the processing lights EL. However, as illustrated in FIG. **70**, the control apparatus **18** may change the intensity of the processing lights EL continuously (alternatively, discontinuously) during the period when the overlapped area SAa is irradiated with the processing lights EL.
(357) Moreover, as described above, the energy added from the processing lights EL to the coat SF of paint varies depending on not only the intensity of the processing lights EL but also the irradiation time of the processing lights EL. Thus, the control apparatus **18** may control the light irradiation apparatus **11** so that the irradiation time of the processing lights EL with which the overlapped area SAa is irradiated is shorter than the irradiation time of the processing lights EL with which the non-overlapped area SAb is irradiated. More specifically, the control apparatus **18** may control the light irradiation apparatus **11** so that the irradiation time of the processing lights EL with which the overlapped area SAa is irradiated is 1/n times as long as the irradiation time of the processing lights EL with which the non-overlapped area SAb is irradiated when the overlapped area SAa is the area in which the n unit processing areas SA areas partially overlap with each other. Note that an energy amount of the processing lights EL with which the overlapped area SAa is irradiated may be different from an amount that is 1/n times as much as an energy amount of the processing lights EL with which the non-overlapped area SAb is irradiated, when the thickness of the evaporated part of the coat SF of paint does not vary linearly to the energy amount (the intensity of the processing lights EL×irradiation time) added from the emitted processing lights EL to the coat SF of paint.
(358) Note that an example in which the processing apparatus **1***k* emits the plurality of processing lights EL so that the characteristic of the processing lights EL with which the overlapped area SAa is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped area Sab is irradiated is described in the eleventh modified example. However, the processing apparatus **1***a* that is provided with the light irradiation apparatus **21***a* (see FIG. **18**) or the light irradiation apparatus **24***a* (see FIG. **21**) that irradiates the irradiation area EA spreading on the surface of the coat SF of paint two-dimensionally with the processing light EL may also emit the processing light EL so that an intensity (alternatively, any characteristic, the same applies to this paragraph) of light component of the processing light EL with which the overlapped area SAa is irradiated is different from an intensity of light component of the processing light EL with which the non-overlapped area SAb is irradiated. Namely, the processing apparatus **1***a* that is provided with the light irradiation apparatus **21***a* or **24***a* may emit the processing light EL so that the intensity of the processing light EL with which the overlapped area SAa is irradiated is different from the intensity of the processing light EL with which the non-overlapped area SAb is irradiated. In this case, the processing apparatus **1***a* that is provided with the light irradiation apparatus **21***a* or **24***a* may adjust the intensity distribution of the processing light EL on the surface of the coat SF of paint so that the intensity of the processing light EL with which the overlapped area SAa is irradiated is different from the intensity of the processing light EL with which the non-overlapped

area SAb is irradiated, for example. Even in this case, the above described effect is achievable.

(4-12) Twelfth Modified Example

(359) Next, a processing apparatus **11** in a twelfth modified example will be described. The processing apparatus **11** emits the plurality of processing lights EL to alternately repeat the scan operation and the step operation in each unit processing area SA, as with the above described processing apparatus **1**. Namely, the processing apparatus **11** emits the plurality of processing lights EL to repeat the scan operation for moving the for moving the plurality of irradiation areas EA on the surface of the coat SF of paint along the Y axis while performing the step operation every time each scan operation completes. In the twelfth modified example, an area on the surface of the coat SF of paint on which at least one of the plurality of irradiation areas EA moves by a first scan operation overlaps with an area on the surface of the coat SF of paint on which at least another one of the plurality of irradiation areas EA moves by a second scan operation that is performed subsequent to the first scan operation. Namely, the surface of the coat SF of paint includes an overlapped area SAc at which the irradiation area EA is set in the first scan operation and the irradiation area EA is also set in the second scan operation and a non-overlapped area SAd at which the irradiation area EA is set in the first scan operation but the irradiation area EA is not set in the second scan operation. in other words, the plurality of irradiation areas EA include an overlapped irradiation area EAc that is set at a position at which another irradiation area EA is set during a period when the scan operation is performed in a plurality of times and a non-overlapped irradiation area EAd that is not set at the position at which another irradiation area EA is set during the period when the scan operation is performed in a plurality of times.

(360) For example, FIG. **71**A illustrates an area on the surface of the coat SF of paint in which an irradiation area EA #1 to an irradiation area EA #4 move during a period when m-th (note that n is an integer equal to or larger than 1) scan operation is performed. FIG. **71**B illustrates an area on the surface of the coat SF of paint in which an irradiation area EA #1 to an irradiation area EA #4 move during a period when (m+1)-th scan operation is performed. FIG. **71**C illustrates an area on the surface of the coat SF of paint in which an irradiation area EA #1 to an irradiation area EA #4 move during a period when (m+2)-th scan operation is performed. In an example illustrated in FIG. **71**A to FIG. **71**C, an area in which the irradiation area EA #4 move during the period when the m-th scan operation is performed is coincident with an area in which the irradiation area EA #1 move during the period when the (m+1)-th scan operation is performed. Similarly, an area in which the irradiation area EA #4 move during the period when the (m+1)-th scan operation is performed is coincident with an area in which the irradiation area EA #1 move during the period when the (m+2)-th scan operation is performed. Therefore, in the example illustrated in FIG. **71**A to FIG. **71**C, each of the irradiation areas EA #1 and EA #4 corresponds to the overlapped irradiation area EAc and each of the irradiation areas EA #2 and EA #3 corresponds to the overlapped irradiation area EAd.

(361) Note that the plurality of irradiation areas EA are arranged on the coat SF of paint along the X axis direction that intersects with the Y axis direction along which the plurality of irradiation areas EA move in the scan operation, as illustrated in FIG. **71**A to FIG. **71**C. In this case, the overlapped irradiation area EAc includes at least the irradiation areas EA at both end sides in the X axis direction among the plurality of irradiation areas EA. Namely, the non-overlapped irradiation area EAd includes the other irradiation area EA except for at least the irradiation areas EA at both end sides in the X axis direction among the plurality of irradiation areas EA.

(362) The processing apparatus **11** is different from the above described processing apparatus **1** in that it emits the plurality of processing lights EL so that the characteristic of the processing lights EL with which the overlapped area SAc is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped area SAd, compared to the processing apparatus **1***k* in the eleventh modified example. This is because there is a possibility that the area on the surface of the coat SF of paint at which the overlapped irradiation area EAc is set (namely, the

overlapped area SAc) is irradiated redundantly with the processing light EL in not only one scan operation but also another scan operation. On the other hand, the area on the surface of the coat SF of paint at which the non-overlapped irradiation area EAd is set (namely, the non-overlapped area SAd) is irradiated with the processing light EL in one scan operation but is not irradiated with the processing light EL in another scan operation. Thus, there is a possibility that the characteristic of the concave structure CP**1** formed by the processing lights EL with which the overlapped irradiation area EAc is irradiated is different from the characteristic of the concave structure CP**1** formed by the processing lights EL with which the non-overlapped irradiation area EAd is irradiated, if the characteristic of the processing lights EL with which the overlapped irradiation area EAc is irradiated is same as the characteristic of the processing lights EL with which the non-overlapped irradiation area EAd is irradiated. As a result, there is a possibility that the characteristic of the riblet structure is different from a necessary characteristic. Thus, in the twelfth modified example, the processing apparatus **11** emits the plurality of processing lights EL so that the characteristic of the processing lights EL with which the overlapped irradiation area EAc is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped irradiation area EAd is irradiated. Note that another feature of the processing apparatus **11** may be same as another feature of the processing apparatus **1***k*.
(363) A technical subject in the twelfth modified example that is caused by an existence of the overlapped irradiation area EAc and the non-overlapped irradiation area EAd is substantially same as a technical subject in the eleventh modified example that is caused by an existence of the overlapped area SAc and the non-overlapped area SAd. Therefore, the processing apparatus **11** may emits the plurality of processing lights EL from a same viewpoint of the processing apparatus **1***k* under the control of the control apparatus **18** so that the characteristic of the processing lights EL with which the overlapped irradiation area EAc is irradiated is different from the characteristic of the processing lights EL with which the non-overlapped irradiation area EAd is irradiated. For example, the control apparatus **18** may set the intensity of the processing lights EL with which the overlapped irradiation area EAc being set at the area of the coat SF of paint that is already irradiated with the processing lights EL is irradiated to zero or the non-processable intensity and may set the intensity of the processing lights EL with which each of the overlapped irradiation area EAc being set at the area of the coat SF of paint that is not yet irradiated with the processing lights EL and the non-overlapped irradiation area EAd is irradiated to the intensity higher than zero or the processable intensity. For example, the control apparatus **18** may set the irradiation time of the processing lights EL with which the overlapped irradiation area EAc being set at the area of the coat SF of paint that is already irradiated with the processing lights EL is irradiated to zero or the non-processable time and may set the irradiation time of the processing lights EL with which each of the overlapped irradiation area EAc being set at the area of the coat SF of paint that is not yet irradiated with the processing lights EL and the non-overlapped irradiation area EAd is irradiated to the irradiation time longer than zero or the processable time. For example, the control apparatus **18** may control the light irradiation apparatus **11** so that the intensity of the processing lights EL with which the overlapped irradiation area EAc is irradiated is lower than (for example, ½ times as much as) the intensity of the processing lights EL with which the non-overlapped irradiation area EAd is irradiated. For example, the control apparatus **18** may control the light irradiation apparatus **11** so that the irradiation time of the processing lights EL with which the overlapped irradiation area EAc is irradiated is shorter than (for example, ½ times as long as) the irradiation time of the processing lights EL with which the non-overlapped irradiation area EAd is irradiated.
(364) The processing apparatus **11** in the twelfth modified example achieves the effect that is same as the effect achievable by the above described processing apparatus **1** and properly forms the riblet structure even when the area EAc that is set at a position at which another irradiation area EA is set during the period when the scan operation is performed in a plurality of times is set on the coat SF of paint.

(365) Incidentally, even in the twelfth modified example, the processing apparatus **1***a* that is provided with the light irradiation apparatus **21***a* (see FIG. **18**) or the light irradiation apparatus **24***a* (see FIG. **21**) that irradiates the irradiation area EA spreading on the surface of the coat SF of paint two-dimensionally with the processing light EL may also emit the processing light EL so that an intensity (alternatively, any characteristic, the same applies to this paragraph) of light component with which the overlapped area SAc that is irradiated with the processing light EL in a plurality of times by the plurality of times of scan operation is irradiated is different from an intensity of light component with which the non-overlapped area EAd that is irradiated with the processing light EL in only one time by the plurality of times of scan operation is irradiated.

(4-13) Other Modified Example

(366) In the above described description, the plurality of the concave parts C are formed by the irradiation of the plurality of processing lights EL, respectively. Namely, one concave part C is formed by the irradiation of one processing light EL. However, one concave part C may be formed by the irradiation of two or more processing lights EL. In this case, the control apparatus **18** may control a characteristic (for example, at least one of the shape, the depth, a formed position and the like) by adjusting a characteristic (for example, the intensity distribution and the like) of two or more processing lights EL.

(367) In the above described description, the processing apparatus **1** deflects the processing lights EL by the Galvano mirror **1122** in order to sweep the surface of the coat SF of paint with the plurality of processing lights EL. However, the processing apparatus **1** may sweep the surface of the coat SF of paint with the plurality of processing lights EL by relatively moving the light irradiation apparatus **11** relative to the coat SF of paint in addition to or instead of deflecting the processing lights EL by the Galvano mirror **1122**. Namely, the control apparatus **18** may control the driving system **12** to relatively move the light irradiation apparatus **11** relative to the coat SF of paint so that the surface of the coat SF of paint is swept with the processing lights EL.

(368) One of a purpose of relatively moving the light irradiation apparatus **11** relative to the coat SF of paint is to sweep the surface of the coat SF of paint with the processing lights EL as described above. Thus, when the sweep of the coat SF of paint with the plurality of the processing lights EL is realized without moving the light irradiation apparatus **11**, the light irradiation apparatus **11** may not move. Namely, the processing apparatus **1** may not be provided with the driving system **12**.

(369) One of the purpose of relatively moving the light irradiation apparatus **11** relative to the coat SF of paint by the driving system **12** is to sweep the plurality of unit processing areas SA with the processing lights EL in order without moving the housing apparatus **13** and the support apparatus **14** when the plurality of unit processing areas SA are housed in the containing space SP of the housing apparatus **13**. Thus, when the single unit processing area SA is housed in the containing space SP, the light irradiation apparatus **11** may not move. Namely, the processing apparatus **1** may not be provided with the driving system **12**.

(370) In the above described description, the housing apparatus **13** supports the driving system **12** (moreover, the light irradiation apparatus **11**) through the supporting member **133**. However, at least one of the driving system **12** and the light irradiation apparatus **11** may be supported by a member other than the housing apparatus **13** (for example, the support apparatus **14**).

(371) In the above described description, the housing apparatus **13** is provided with the plate-like top member **131** and the pipe-like partition member **132** that extends from the top member **131** toward the −Z side. However, a shape, a disposed position and the like of the top member **131** and a shape, a disposed position and the like of the partition member **132** may be any, as long as the containing space SP surrounded by the top member **131** and the partition member **132** are secured.

(372) In the above described description, the housing apparatus **13** is provided with the single partition member **132**. However, the housing apparatus **13** may be provided with a plurality of partition members that extend from the top member **131** toward the −Z side and that are arranged to

surround the optical path of the processing lights EL. In this case, the plurality of partition members may be arranged so that adjacent two partition members partially overlap with each other along an arrangement direction thereof (for example, a circumferential direction). At least a part of the plurality of partition members may be movable relative to the top member **131**. End parts (specifically, end parts at the coat SF of paint side) of all of the plurality of partition members may be allowed to contact with the surface of the coat SF of paint. The end parts of all of the plurality of partition members may be configured to attach to the surface of the coat SF of paint. Alternatively, the end part of a part of the plurality of partition members may be allowed to contact with the surface of the coat SF of paint and the end part of another part of the plurality of partition members may not be allowed to contact with the surface of the coat SF of paint. The end part of a part of the plurality of partition members may be configured to attach to the surface of the coat SF of paint and the end part of another part of the plurality of partition members may not be configured to attach to the surface of the coat SF of paint.
(373) In the above described description, each of the top member **131** and the partition member **132** is the member that is configured to shield or reduce the processing light EL. However, at least one of the top member **131** and the partition member **132** may not be the member that is configured to shield or reduce the processing light EL. At least a part of the top member **131** may not be the member that is configured to shield or reduce the processing light EL. At least a part of the partition member **132** may not be the member that is configured to shield or reduce the processing light EL.
(374) In the above described description, each of the top member **131** and the partition member **132** is the member that does not allow the unnecessary substance that is generated by the irradiation of the processing light EL to pass therethrough. However, at least one of the top member **131** and the partition member **132** may not be the member that does not allow the unnecessary substance to pass therethrough. At least one of the top member **131** and the partition member **132** may be a member that allows the unnecessary substance to pass therethrough. At least a part of the top member **131** may not be the member that does not allow the unnecessary substance to pass therethrough. At least a part of the partition member **132** may not be the member that does not allow the unnecessary substance to pass therethrough.
(375) In the above described description, the light irradiation apparatus **11** is disposed in the containing space SP of the housing apparatus **13**. However, at least a part of the light irradiation apparatus **11** may be disposed outside the housing apparatus **13**. Even in this case, the housing apparatus **13** may house the space including the optical path of the processing lights EL between the terminal optical element of the optical system **112** and the coat SF of paint. In this case, the housing apparatus **13** may not be provided with at least one of the top member **131** and the partition member **132**, and may be provided with a member for housing the space including the optical path of the processing lights EL in addition to or instead of at least one of the top member **131** and the partition member **132**. Alternatively, even when whole of the light irradiation apparatus **11** is disposed in the containing space SP, the housing apparatus **13** may not be provided with at least one of the top member **131** and the partition member **132**, and may be provided with a member for forming the containing space SP in addition to or instead of at least one of the top member **131** and the partition member **132**. Alternatively, whole of the light irradiation apparatus **11** may be disposed outside the housing apparatus **13**. In this case, the housing apparatus **13** may not be provided with at least one of the top member **131** and the partition member **132**. Alternatively, the processing apparatus **1** may not be provided with the housing apparatus **13** itself.
(376) In the above described description, the end part **134** of the housing apparatus **13** is configured to change the shape thereof in accordance with the shape of the surface of the coat SF of paint. However, the end part **134** may not be configured to change the shape thereof in accordance with the shape of the surface of the coat SF of paint. In this case, the shape of the end part **134** may be a shape that is complementary to the shape of the surface of the coat SF of paint. For example, when

the end part **134** contacts with the coat SF of paint the surface of which is a planar shape, the shape of the end part **134** becomes a planar shape as with the coat SF of paint. For example, when the end part **134** contacts with the coat SF of paint the surface of which is curved convexly to the end part **134**, the shape of the end part **134** becomes a shape that is concave viewed from the coat SF of paint.

(377) In the above described description, the housing apparatus **13** is provided with the detection apparatus **135** that detects the unnecessary substance (namely, the substance that is generated by the irradiation of the processing light EL) in the containing space SP. However, housing apparatus **13** may not be provided with the detection apparatus **135**

(378) In the above described description, the support apparatus **14** supports the housing apparatus **13** (moreover, the driving system **12** and the light irradiation apparatus **11**) through the support member **143**. However, at least one of the housing apparatus **13**, the driving system **12** and the light irradiation apparatus **11** may be supported by a member other than the support apparatus **14**.

(379) In the above described description, the exhaust apparatus **16** is provided with the filter **162** that sorbs the unnecessary substance sucked from the containing space by the exhaust apparatus **16**. However, the exhaust apparatus **16** may not be provided with the filter **162**. For example, when the unnecessary substance is not generated by irradiating the coat SF of paint with the processing lights EL, the exhaust apparatus **16** may not be provided with the filter **162**.

(380) In the above described description, the processing apparatus **1** is provided with the exhaust apparatus **16**. However, the processing apparatus **1** may not be provided with the exhaust apparatus **16**. For example, when the unnecessary substance is not generated by irradiating the coat SF of paint with the processing lights EL, the exhaust apparatus **16** may not be provided with the exhaust apparatus **16**. For example, when the gas supplied to the containing space SP from the gas supply apparatus **17** is not necessarily exhaust (namely, is not necessarily sucked outside the containing space SP), the exhaust apparatus **16** may not be provided with the exhaust apparatus **16**. Alternatively, the processing apparatus **1** may be provided with any back-flow prevention apparatus that prevents the unnecessary substance generated by the irradiation of the processing light EL to return to the optical path of the processing lights EL (especially, the optical surface at the containing space SP side of the terminal optical element of the optical system **112**) in addition to or instead of the exhaust apparatus **16**. An adsorber apparatus that adsorbs the unnecessary substance in the containing space SP is one example of the back-flow prevention apparatus. Note that an air nozzle that blows air to the optical surface at the containing space SP side of the terminal optical element of the optical system **112** may be used in addition to or instead of the exhaust apparatus **16**.

(381) In the above described description, the gas supply apparatus **17** prevents the adherence of the dust to the optical surface **1124** by supplying the gas such as the inert gas to the optical surface **1124** of the fθ lens **1123** (namely, the optical surface at the containing space SP side of the terminal optical element of the optical system **112**). However, the processing apparatus **1** may be provided with any adherence prevention apparatus that prevents the adherence of the dust to the optical surface **1124** in addition to or instead of the gas supply apparatus **17**. For example, the processing apparatus **1** may be provided with an adherence prevention apparatus that prevents the adherence of the dust to the optical surface **1124** by ejecting liquid (for example, purified water) to the optical surface **1124**. For example, the processing apparatus **1** may be provided with an adherence prevention apparatus that prevents the adherence of the dust to the optical surface **1124** by forming a liquid immersion space that is filled with liquid (for example, purified water) and that faces the optical surface **1124**. In this case, the liquid in the liquid immersion space may be replaced if needed, because impurity enters the liquid immersion space.

(382) In the above described description, the gas supply apparatus **17** removes the dust adhered to the optical surface **1124** or prevents the adherence of the dust to the optical surface **1124** by supplying the gas such as the inert gas to the optical surface **1124** of the fθ lens **1123**. However, the processing apparatus **1** may be provided with any adherence prevention apparatus that removes the

dust adhered to the optical surface **1124** in addition to or instead of the gas supply apparatus **17**. For example, the processing apparatus **1** may be provided with an adherence prevention apparatus that removes the dust adhered to the optical surface **1124** by ejecting liquid (for example, purified water) to the optical surface **1124**. For example, the processing apparatus **1** may be provided with an adherence prevention apparatus that removes the dust adhered to the optical surface **1124** by physically wiping the optical surface **1124**.

(383) In the above described description, the processing apparatus **1** forms the riblet structure of the coat SF of paint on the surface of the processing target object S. However, the processing apparatus **1** may form any structure of the coat SF of paint having any shape on the surface of the processing target object S. Even in this case, any structure having any shape is formable by means of the control apparatus **18** controlling the light irradiation apparatus **11** so that the surface of the coat SF of paint is swept with the processing lights EL along a scanning path based on the structure that should be formed.

(384) In the above described description, the processing apparatus **1** removes the coat SF of paint by evaporating the coat SF of paint by the irradiation of the processing lights EL. However, the processing apparatus **1** may remove the coat SF of paint by changing the characteristic of the coat SF of paint by the irradiation of the processing lights EL, in addition to or instead of evaporating the coat SF of paint by the irradiation of the processing lights EL. For example, the processing apparatus **1** may remove the coat SF of paint by melting the coat SF of paint by the irradiation of the processing lights EL and removing the melted coat SF of paint. For example, the processing apparatus **1** may remove the coat SF of paint by making the coat SF of paint brittle by the irradiation of the processing lights EL and peeling the brittle coat SF of paint. In the above described description, the processing apparatus **1** processes the coat SF of paint formed on the surface of the processing target object S by the ablation. However, the processing apparatus **1** may remove a part of the coat SF of paint formed on the surface of the processing target object S by a heat processing.

(385) In the above described description, the processing apparatus **1** forms the concave part C (alternatively, the concave structure CP**1** or any structure by the concave structure CP**1** such as the riblet structure) by removing the coat SF of paint. Namely, the processing apparatus **1** processes the coat SF of paint to partially reduce the thickness of the coat SF of paint. However, the processing apparatus may process the coat SF of paint to partially increase the thickness of the coat SF of paint in addition to or instead of partially reducing the thickness of the coat SF of paint. Namely, the processing apparatus **1** may form a convex part (alternatively, the convex structure CP**2** or any structure by the convex structure CP**2**) by adding the coat SF of paint in addition to or instead of forming the concave part C by removing the coat SF of paint. For example, the processing apparatus **1** may irradiate a first part of the coat SF of paint with the processing light EL to remove the coat SF of paint at the first part and then may fix the removed coat SF of paint at a second part of the coat SF of paint to increase the thickness of the coat SF of paint at the second part (namely, to form the convex part at the second part).

(386) In the above described description, the processing apparatus **1** processes the coat SF of paint formed on the surface of the processing target object S. However, the processing apparatus **1** may process any coat that is other than the coat SF of paint and that is formed on the surface of the processing target object S. Alternatively, the processing apparatus **1** may process a structural object in which a plurality of layers are laminated. Specifically, the processing apparatus **1** may process at least one layer (typically, at least one layer including a layer that is closest to the surface) of the plurality of layers that constitute the structural object. The processing apparatus **1** may process at least one layer of the plurality of layers that constitute the structural object to form a structure of this layer. In this case, at least one layer that is processed corresponds to the above described coat SF of paint and the other layer other than the at least one layer corresponds to the processing target object S. For example, FIG. **72**A illustrates an example in which a layer S**1** and a layer S**2** are

processed without exposing a layer S**3** in a structural object in which the layer S**1** to the layer S**3** are layered. In the example illustrated in FIG. **72**A, the layer S**1** and the layer S**2** are the layers that are processed by the irradiation of the processing light EL (namely, the layers that form the riblet structure and the like) and layers that correspond to the above described coat SF of paint. On the other hand, in the example illustrated in FIG. **72**A, the layer S**3** is a layer that is not processed by the irradiation of the processing light EL (namely, the layer on which the layer for forming the riblet structure and the like is formed) and a layer that corresponds to the above described processing target object S. Alternatively, for example, FIG. **72**B illustrates an example in which the layer S**1** is processed without exposing the layer S**2** in the structural object in which the layer S**1** to the layer S**3** are laminated. In the example illustrated in FIG. **72**B, the layer S**1** is the layer that is processed by the irradiation of the processing light EL and the layer that corresponds to the above described coat SF of paint. On the other hand, in the example illustrated in FIG. **72**B, the layer S**2** and the layer S**3** are the layers that are not processed by the irradiation of the processing light EL and the layers that correspond to the above described processing target object S. Alternatively, the processing apparatus **1** may process the processing target object S itself. Namely, the processing apparatus **1** may process the processing target object S on the surface of which the coat SF of paint or any coat is not formed.
(387) Incidentally, although the processing apparatus **1** forms the riblet structure for reducing the resistance of the surface to the fluid is described in the above described embodiment, various structures such as a riblet structure for reducing noise generated when the fluid and the surface relatively move, a structure that generates swirl relative to a flow on the surface and a structure for adding hydrophobic property to the surface may be formed.
(388) The feature of each embodiment described above is allowed to be combined appropriately. For example, the feature of one modified example among the above described first modified example to the eleventh modified example may be used in modified example among the above described first modified example to the eleventh modified example. As one example, for example, the advance measurement control operation using the surface characteristic measurement apparatus **19***b* in the above described second modified example may be performed by the processing apparatus **1***c* in the third modified example. In this case, the processing apparatus **1***c* may be provided with the surface characteristic measurement apparatus **19***b* in addition to the structure measurement apparatus **19***c*. In other combination of the modified example, the processing apparatus **1** and the like may be appropriately provided with the apparatus based on the pattern of the combination. One portion of the feature of each embodiment described above may not be used. The feature of each embodiment described above may be allowed to be replaced by the feature of other embodiment appropriately. Moreover, the disclosures of all publications and United States patents that are cited in each embodiment described above are incorporated in the disclosures of the present application by reference if it is legally permitted.
(389) The present invention is allowed to be changed, if desired, without departing from the essence or spirit of the invention which can be read from the claims and the entire specification, and a processing apparatus, a processing method, a painting material, a processing system, a movable body and a manufacturing method of movable body that moves in a fluid each of which involves such changes, are also intended to be within the technical scope of the present invention.
DESCRIPTION OF REFERENCE CODES
(390) **1** processing apparatus **11** light irradiation apparatus **111** light source system **112** optical system **12** driving system **13** housing apparatus **132** partition member **14** support apparatus **15** driving system **16** exhaust apparatus **17** gas supply apparatus **18** control apparatus C concave part CP**1** concave structure CP**2** convex structure SP containing space EA irradiation area EL processing light S processing target object SF coat of paint

Claims

1. A processing apparatus comprising: a light irradiation optical system that includes at least one of a lens and a mirror and that irradiates a surface of an object with a processing light; a position change apparatus that comprises at least one of a driving system and a Galvano mirror and that changes a position of at least one of the object and an irradiation area that is formed on the surface of the object by the light irradiation optical system; and a controller that is configured to control the position change apparatus to form a structure for reducing a frictional resistance of the surface of the object to a fluid by irradiating the surface of the object with the processing light while changing the position of at least one of the irradiation area and the object to change a thickness of a part of the object, wherein the controller is configured to control the processing apparatus to form a series of grooves by: (i) forming a first groove by removing a first part of the object by setting a size of the irradiation area formed on the surface of the object by the light irradiation optical system to a first size and (ii) forming a second groove, which is connected to the first groove, by removing a second part of the object, whose size is different from a size of the first part, by changing, when irradiating the surface of the object with the processing light, the size of the irradiation area formed on the surface of the object to a second size that is different from the first size based on a positional relationship between the irradiation area and the object.
2. The processing apparatus according to claim 1, wherein the position change apparatus changes a position of the light irradiation optical system concerned with the surface of the object.
3. The processing apparatus according to claim 1, wherein the light irradiation optical system contacts the object during an irradiation of the processing light.
4. The processing apparatus according to claim 1, wherein the light irradiation optical system does not contact the object.
5. The processing apparatus according to claim 1, further comprising a measurement apparatus that includes a light emitter and a detector and that measures a relative positional relationship between the object and the light irradiation optical system, the controller being configured to control a position at which the object is irradiated with the processing light from the light irradiation optical system by using a measured result of the measurement apparatus.
6. The processing apparatus according to claim 1, wherein the position change apparatus changes a position of at least one of the object and the irradiation area that is formed on the surface of the object by the light irradiation optical system so that the irradiation area moves on the surface of the object along a moving direction.
7. The processing apparatus according to claim 1, wherein a concave or convex structural object is formed on the surface of the object, and the controller is configured to control the light irradiation optical system to change an irradiation state of the processing light when the irradiation area overlaps with the structural object.
8. The processing apparatus according to claim 1, wherein a concave or convex structural object is formed on the surface of the object, the controller is configured to control the position change apparatus so that the irradiation area does not overlap with the structural object.
9. The processing apparatus according to claim 8, wherein the object includes at least a part of an airframe of an airplane, and the structural object includes an operational structural object formed at a surface of the airframe for a flight of the airplane.
10. The processing apparatus according to claim 9, wherein the operational structural object includes at least one of a first structural object relating to an antenna, a second structural object relating to a sensor and a third structural object relating to an inflow and an outflow of a fluid.
11. The processing apparatus according to claim 1, wherein the controller is configured to control a moving speed of the irradiation area, which is formed on the surface of the object by the light irradiation optical system, relative to the object.

12. The processing apparatus according to claim 1, wherein the controller is configured to control the position change apparatus to change a relative positional relationship between the object and the irradiation area that is formed on the surface of the object by the light irradiation optical system based on a vibration state of at least one of the object and the processing apparatus.
13. The processing apparatus according to claim 1, wherein the position change apparatus moves the irradiation area that is formed on the surface of the object by the light irradiation optical system in a range along a moving direction on the surface of the object, a width of the range being a first width, and a second width of the light irradiation optical system along the moving direction is narrower than the first width.
14. The processing apparatus according to claim 1, wherein the position change apparatus includes the Galvano mirror, which is configured to deflect the processing light.
15. The processing apparatus according to claim 14, wherein the Galvano mirror includes a scanning mirror that is configured to swing or rotate.
16. The processing apparatus according to claim 1, wherein the position change apparatus changes a relative positional relationship between the light irradiation optical system and the object.
17. The processing apparatus according to claim 16, wherein the position change apparatus moves the light irradiation optical system relative to the object.
18. The processing apparatus according to claim 17, wherein the position change apparatus moves the light irradiation optical system in order to move the light irradiation optical system relative to the object.
19. The processing apparatus according to claim 18, wherein the position change apparatus moves the object in order to move the light irradiation optical system relative to the object.
20. The processing apparatus according to claim 1, wherein the light irradiation optical system is provided to be movable in a direction along the surface of the object.
21. The processing apparatus according to claim 1, wherein the controller controls the processing apparatus to change the size of the irradiation area from the first size to the second size by controlling the light irradiation optical system to change a light concentration position of the processing light.
22. A processing method comprising: irradiating a surface of an object with a processing light; moving, relative to the object, an irradiation area of the processing light with which the surface of the object is irradiated; and forming a structure for reducing a frictional resistance of the surface of the object to a fluid by moving the irradiation area to change a thickness of a part of the object, wherein the forming includes forming a series of grooves by: forming a first groove by removing a first part of the object by setting a size of the irradiation area formed on the surface of the object to a first size; and forming a second groove, which is connected to the first groove, by removing a second part of the object, whose size is different from a size of the first part, by changing, when irradiating the surface of the object with the processing light, the size of the irradiation area formed on the surface of the object to a second size that is different from the first size.