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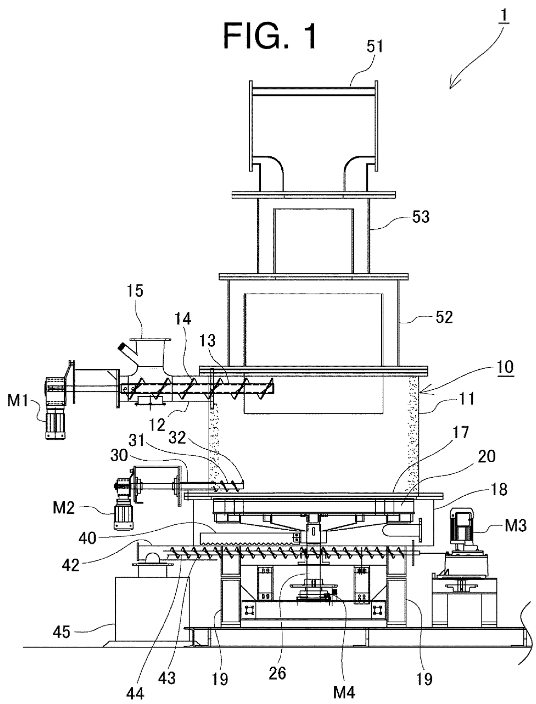
(54) **SOLID FUEL COMBUSTION DEVICE**

(57) A solid fuel combustion apparatus in which a plurality of solid fuels are fed to a combustion unit to obtain combustion heat through combustion. The combustion unit includes a first combustion chamber that burns solid fuels; a feeder that feeds the solid fuels to the first combustion chamber; a turntable that forms a lower surface portion of the first combustion chamber and turns the solid fuels fed from the feeder on the lower surface portion of the turntable, and an agitator that agitates the solid fuels accumulated on the turntable.

FIG. 1



EP 4 303 487 A1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to a solid fuel combustion apparatus. More specifically, the present invention relates to a solid fuel combustion apparatus that burns combustible solid wastes as fuels to obtain heat.

2. Description of Related Art

[0002] Solid combustible wastes such as resins (plastics) have been used as raw materials for refuse derived paper and plastics densified fuel (RPF). Even wastes can be easily burned in the calciner to obtain the same level of heat as that of the existing coke and other materials. In addition, since the wastes are treated as solid fuels, the entire volume of emissions of carbon dioxide is expected to be reduced in comparison to a case where fuels such as heavy oil or natural gas are newly burned.

[0003] When solid fuels such as RPF are burned in a calciner, they have poor flowability in the apparatus (calciner), and calcined ashes are also produced after the solid fuels are calcined. This reduces the combustion efficiency of the solid fuels in the calciner (firing furnace) if the solid fuels are simply fed into the calciner. In addition, the calciner cannot be safely operated without adequate removal of calcined ashes.

[0004] Accordingly, a calciner incorporating improvements related to the feed of solid fuels and removal of calcined ashes has been proposed (e.g., patent documents 1 and 2). However, according to the calciner described in patent documents 1 and 2, the feed of solid fuels to the inside of the calciner and the removal of calcined ashes after firing of the solid fuels have been not always sufficient, and further improvement has been desired. In addition, as the mechanism of the calciner is complicated, the mechanism for feeding the solid fuels, for example, is exposed to heat during the calcining of the solid fuels in the calciner, thereby easily reducing the durability of the apparatus. Therefore, less progress has been made in improving the apparatus in the current calciner.

[Prior Art Documents]

[Patent Documents]

[0005]

[Patent Document 1] Japanese Laid-Open Patent Publication No. 2014-211255
[Patent Document 2] Japanese Laid-Open Patent Publication No. 2008-261527

SUMMARY OF THE INVENTION

[0006] The applicant has completed a novel solid fuel combustion apparatus by obtaining an effective configuration for feeding solid fuels avoiding heat exposure during calcination, ensuring the movement of solid fuels inside the calciner, and removing calcined ashes after diligent study.

[0007] An object of the present invention is to provide a solid fuel combustion apparatus that uses combustible solid wastes such as resin (plastic) as solid fuels, avoids damage to portions related to the feed of the solid fuels due to heat exposure during calcining, and ensures excellent movement of the solid fuels inside the combustion apparatus.

[Means to Solve the Problems]

[0008] A solid fuel combustion apparatus according to an embodiment in which a plurality of solid fuels are fed to a combustion unit to obtain combustion heat through combustion is provided. The combustion unit includes a first combustion chamber that burns solid fuels; a feeder that feeds the solid fuels to the first combustion chamber; a turntable that forms a lower surface portion of the first combustion chamber and turns the solid fuels fed from the feeder on the lower surface portion of the turntable, and an agitator that agitates the solid fuels accumulated on the turntable.

[0009] Further, the first combustion chamber may be cylindrical in shape and the feeder may feed the solid fuels to the circumferential edge of the turntable.

[0010] Moreover, a hole may be formed in the turntable, into which hole combustion ash of the solid fuels falls, and a combustion ash discharger may be provided below the turntable.

[0011] Furthermore, a dust collector may be provided in a lower portion of the turntable, and the dust collector may be used to stir up the combustion ash that falls from the turntable.

[0012] In addition, a second combustion chamber may be provided above the first combustion chamber for the flame generated by the combustion of the solid fuels to rise.

[0013] Further, an air feeder that feeds air for combustion of the solid fuels may be provided in the second combustion chamber.

[0014] Moreover, the agitator may include an agitating impeller or an elongate plate object to move the solid fuels accumulated on the turntable to a vicinity of the center of the turntable.

[0015] Furthermore, the solid fuel combustion apparatus may further include: a combustion smoke imaging unit that images combustion smoke generated at a time of combustion of the solid fuels; and a fuel quantity controller that controls quantity of the solid fuels fed from the feeder to the first combustion chamber. The fuel quantity controller may control quantity of solid fuels fed from the feeder to the first combustion chamber by determining quantity of the burned solid fuels on the basis of a color of the combustion smoke imaged by the combustion smoke imaging unit.

[0016] In addition, the solid fuel combustion apparatus may further include: a combustion smoke imaging unit that images combustion smoke generated at a time of combustion of the solid fuels; and an air volume controller that controls a volume of air fed from the air feeder to the second combustion chamber. The air volume controller may control the volume of air fed from the air feeder to the second combustion chamber by determining quantity of the burned solid fuels on the basis of a color of the combustion smoke imaged by the combustion smoke imaging unit.

[Advantageous Effects of the Invention]

[0017] In the solid fuel combustion apparatus according to an embodiment of the present invention in which a plurality of solid fuels are fed to a combustion unit to obtain combustion heat through combustion, the combustion unit includes a first combustion chamber that burns solid fuels; a feeder that feeds the solid fuels to the first combustion chamber; a turntable that forms a lower surface portion of the first combustion chamber and turns the solid fuels fed from the feeder on the lower surface portion of the turntable, and an agitator that agitates the solid fuels accumulated on the turntable, thereby avoiding damage to portions related to the feed of the solid fuels configured by combustible solid wastes due to heat exposure during calcining.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is an overall side schematic diagram illustrating a solid fuel combustion apparatus according to an embodiment of the present disclosure,
FIG. 2 is a plan view illustrating a combustion unit,
FIG. 3 is a first side schematic diagram illustrating the combustion unit,
FIG. 4 is a second side schematic diagram illustrating the combustion unit,
FIG. 5 is a partial exploded view of a turntable,
FIG. 6 is a plan view illustrating a second combustion chamber,
FIG. 7 is an entire side schematic diagram illustrating the solid fuel combustion apparatus showing the turning flow created by combustion,
FIG. 8 is a schematic block diagram illustrating a controller of the solid fuel combustion apparatus, and
FIG. 9 is a flowchart illustrating a control flow of the solid fuel combustion apparatus.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] The solid fuel combustion apparatus according to an embodiment uses combustible materials called RPF (refuse derived paper and plastics densified fuel) obtained by compressing solid combustible wastes such as resin (plastic) and paper as solid fuels. The solid fuels are fed into and burned in the combustion apparatus, generating combustion heat. When the solid fuels are heated rather than burned themselves, combustible gases are generated from the solid fuels. The combustible gases are then ignited to produce a flame, which is recovered as heat of combustion. The combustion heat generated may be supplied to heat exchangers for steam generation in boilers, for example, and the combustion heat itself may be used for heating, drying, and room heating, for example. As described above, the solid fuel combustion apparatus according to the embodiment is configured to obtain combustion heat from RPF solid fuels.

[0020] Especially, the combustion efficiency of RPF solid fuels is high since they are made mainly from resins (plastics) and paper as waste materials. Further, the solid fuel combustion apparatus according to the embodiment is capable of processing combustible wastes. Accordingly, a reduction in a volume of emissions of carbon dioxide is more expected when heat is generated in comparison to a case where fuels such as heavy oil, and natural gas, for example, are newly burned. Obviously, a number of solid fuels are fed into the combustion apparatus. Accordingly, even if a solid fuel is simply referred to, it corresponds to multiple (multiple pieces, multiple quantities) of solid fuels.

[0021] FIG. 1 is an overall side schematic diagram illustrating a solid fuel combustion apparatus according to an embodiment of the present disclosure. The solid fuel combustion apparatus 1 includes a first combustion chamber 11 as a main portion of a combustion unit 10 and into which solid fuels are brought and burned. A second combustion chamber 52, third combustion chamber 53, and connecting chamber 51 are provided immediately above the first combustion chamber 11 in this order. The second and third combustion chambers 52 and 53 correspond to spaces for amplifying the flame produced by the combustion of solid fuels in the first combustion chamber 11 to increase the heat of combustion. In the solid fuel combustion apparatus 1 according to the embodiment, the first combustion chamber 11, the second combustion chamber 52, and the third combustion chamber 53 are all cylindrical in shape. This is because it is convenient for the heat flow to rise while swirling as described below. The connecting chamber 51 corresponds to a space for connecting the generated combustion heat to a heat exchanger of a boiler or heat transfer piping (both not shown). The third combustion chamber 53 may be omitted depending on the size of the solid fuel combustion apparatus 1 itself.

[0022] The combustion unit 10 according to the embodiment mainly includes the first combustion chamber 11 that burns the solid fuels fed therein, a feeder 12 that feeds solid fuels to the first combustion chamber 11, a turntable 20 that forms and turns a lower surface portion 17 of the first combustion chamber 11, and an agitator 30 that agitates the solid fuels fed thereto.

[0023] The turntable 20 includes a hole 22 (see FIG. 5) into which the calcined ashes of the solid fuels fall. A dust collecting chamber 18 is formed below the turntable 20 provided at the lower surface portion 17 of the first combustion chamber 11.

[0024] A calcined ash discharger 42 is provided in the dust collecting chamber 18 below the turntable 20. The calcined ashes that fall into the dust collecting chamber 18 are conveyed by the calcined ash discharger 42 to the calcined ash collecting box 45.

[0025] In the solid fuel combustion apparatus 1 shown in FIG. 1, legs 19 support the dust collecting chamber 18 and the first combustion chamber 11 as well as configurations thereabove. The turntable 20 is connected to a turntable shaft portion 26 and driven by a turning motor M4. The calcined ash discharger 42 is driven by a discharging motor M3.

[0026] The portions of the configuration will be described with reference to the overall side schematic diagram of the solid fuel combustion apparatus 1 shown in FIG. 1 along with a plan view of the combustion unit 10 shown in FIG. 2. The feeder 12 includes a feeding rotary shaft 13 and a feeding impeller 14 mounted on the feeding rotary shaft 13 in a spiral manner. The feeding impeller 14 corresponds to a spiral propeller, referred to as Archimedes screw, or Archimedes spiral, for example. The feeding rotary shaft 13 and feeding impeller 14 are rotated by the feeding motor M1. RPF as solid fuels is fed through the feeding port 15 (hopper) into the feeder 12. As the feeding motor M1 is driven to rotate feeding rotary shaft 13 and feeding impeller 14, the solid fuels move from the position of the feeding port 15 through the feeding impeller 14 to the tip end of the feeder 12, and fall from the tip end of the feeder 12 into the interior of the first combustion chamber 11.

[0027] As understood from FIG. 2, the tip end of the feeder 12 does not enter deeply into the first combustion chamber 11, but stays approximately at the inner wall surface. Accordingly, the tip end of the feeder 12 is located immediately above the circumferential edge 21 of the turntable 20. The fact that the tip end of the feeder 12 does not enter deeply into the first combustion chamber 11 allows the feeder 12 (feeding rotary shaft 13 and feeding impeller 14) to be less prone to thermal damage, thereby reducing the frequency of replacement of the portions in the combustion apparatus 1. The turntable 20 shown in FIG. 2 may be disassembled for replacement. Specifically, the linear portion shown in the turntable 20 indicates a portion to be detached.

[0028] As understood from the side schematic diagram in FIG. 3, if solid fuels R continue to be dropped from the position at the tip end of the feeder 12, they will be accumulated at the circumferential edge 21 of the turntable 20 in the first combustion chamber 11. Accordingly, an uneven portion of the solid fuels R accumulated on the top surface of the turntable 20 needs to be moved. Accordingly, the solid fuel combustion apparatus 1 includes the agitator 30.

[0029] The agitator 30 includes an agitating rotary shaft 31 and an agitating impeller 32 mounted on the agitating rotary shaft 31 in a spiral manner. The agitating impeller 32 corresponds to a spiral propeller, referred to as Archimedes screw, or Archimedes spiral, for example. The agitating rotary shaft 31 and the agitating impeller 32 are rotated by the agitating motor M2. When the solid fuels R are fed from the feeder 12, the solid fuels R accumulate unevenly on a portion of the lower surface portion 17 of the first combustion chamber 11. Even if the turntable 20 turns, they are still deposited on the circumferential edge 21 of the turntable 20. Accordingly, the solid fuels R accumulated at the circumferential edge 21 of the turntable 20 are moved to the vicinity of the center of the turntable 20 through the agitating impeller 32 of the agitator 30.

[0030] FIG. 1 illustrates that portions of the agitating impeller 32 of the agitator 30 are provided at a slight distance upward from the turntable 20 located on the lower surface portion 17 of the first combustion chamber 11. In addition, FIG. 2 illustrates that the agitating impeller 32 of the agitator 30 extends from the circumferential edge 21 of the turntable 20 toward the center of the turntable 20. As understood from the side schematic diagram in FIG. 4, the solid fuels R scraped by the agitating impeller 32 of the agitator 30 are moved from the circumferential edge 21 of the turntable 20 to the vicinity of the center. Simultaneously, the turntable 20 itself is turning at the lower surface portion 17 of the first combustion chamber 11.

[0031] Therefore, no matter where the solid fuels have accumulated on the circumferential edge 21 of the turntable 20, through the operation of the agitator 30 and the turning of the turntable 20, the solid fuels are constantly being drawn away from the circumferential edge 21 to the vicinity of the center of the turntable 20, and the accumulation (deposition) of the solid fuels changes into a mountain shape (see FIG. 3 and FIG. 4 illustrating the positional change of the solid fuels).

[0032] The position of the agitator 30 advances in the direction of the center of the turntable 20 from the viewpoint of demonstrating the performance of agitating. In this case, the agitating rotary shaft 31 and agitating impeller 32 of the agitator 30 are thermally exposed to the combustion heat (thermal power) of the solid fuels. However, the combustion heat of the solid fuels is not hot enough to damage the agitator 30 at a location in the vicinity of the circumferential edge 21 of the turntable 20. Rather, the upper portion of the first combustion chamber 11, and a portion even higher above it become hotter.

Accordingly, the agitator 30 located in the vicinity of the turntable 20 is less effected from thermal damage caused by the combustion of the solid fuels.

[0033] In addition, the agitator 30 allows for the movement of the solid fuels even during their combustion. Accordingly, the unburned solid fuels are moved on the turntable 20 by the agitator 30. The unburned solid fuels can then be fully burned at the moved location. This also clarifies that the agitator 30 contributes to improving the combustion efficiency of the solid fuels brought into the first combustion chamber 11.

[0034] With respect to the agitating impeller 32 mounted on the agitating rotary shaft 31 of the agitator 30, in the positive rotational direction, the solid fuels are moved to the vicinity of the center of the turntable 20 as described above. Here, the agitator 30 may reverse the rotational direction of the agitating impeller 32 (reverse rotation). When the agitating impeller 32 is reversed, the burned ashes (clinker, for example) remaining on the turntable 20 from the solid fuels are scraped off and discharged from the combustion unit 10 (first combustion chamber 11).

[0035] As another form of the agitator 30, an elongate plate object (not shown) may be employed as a substitute for the agitating rotary shaft 31 and agitating impeller 32. In this regard, an elongate rod object may be employed. The elongate plate object is inserted into the first combustion chamber 11 from the same position as that of the agitator 30 of the first combustion chamber 11. The position, angle, and length of insertion of the elongate plate object into the interior of the first combustion chamber 11 are suitably adjusted. Even by replacing the agitator 30 with the elongate plate object, the solid fuels are continually drawn from the circumferential edge 21 to the vicinity of the center of the turntable 20 through the rotation of the turntable 20.

[0036] As understood from the entire side schematic diagram in FIG. 1 (side schematic diagrams in FIGS. 3 and 4), the dust collecting chamber 18 is formed below the lower surface portion 17 (turntable 20) of the first combustion chamber 11. Here, the partial exploded view in FIG. 5 shows the turntable 20 roughly cut in half, with the lower half of FIG. 5 showing only the turntable 20, and the upper half showing the inside of the dust collecting chamber 18 immediately below the turntable 20.

[0037] A considerable number of holes 22 are formed in the board surface of the turntable 20. The solid fuels R used (see FIGS. 3 and 4) correspond to an irregularly shaped mass of approximately 3 to 7 cm. The combustion residue from the burning of the solid fuels in the first combustion chamber 11 becomes calcined ashes As. The calcined ashes As then pass through the holes 22 and fall into the dust collecting chamber 18 immediately below the turntable 20. The shape of each hole 22 may be round, square, or even an elongate slit shape as appropriate. The arrangement of the holes 22 may be radial from the center of the turntable 20, arc-shaped, or other as appropriate.

[0038] A dust collector 40 is connected to the turntable shaft portion 26 at a lower portion of the turntable 20 (see FIG. 5). The dust collector 40 corresponds to a plate member that contacts the bottom surface of the dust collecting chamber 18 and has a length corresponding to the radius of the inside bottom surface of the dust collecting chamber 18 (see FIGS. 1, 3, and 4). The calcined ashes As that fall into the dust collecting chamber 18 are stirred up across the entire bottom surface of the chamber 18 by the dust collector 40, which turns in conjunction with the turning of the turntable 20 (turntable shaft portion 26) by the turning motor M4. The collected calcined ashes As are then guided through the dust collecting opening 41 to the calcined ash discharger 42.

[0039] As shown in FIGS. 1, 3, and 4, the calcined ash discharger 42 includes a discharging impeller 43 mounted on a discharging rotary shaft 44 in a spiral manner. The discharging impeller 43 corresponds to a spiral propeller, referred to as Archimedes screw, or Archimedes spiral, for example. The discharging rotary shaft 44 and the discharging impeller 43 are rotated by the discharging motor M3. The calcined ashes As that fall from the dust collecting opening 41 and enter the calcined ash discharger 42 are efficiently dropped through a calcined ash discharging opening 46 into a calcined ash collecting box 45 by the discharging impeller 43.

[0040] According to the solid fuel combustion apparatus 1 according to the embodiment, the turntable 20 is driven to turn at a rotational speed of one rotation per minute. The rotational speed is appropriate depending on the size of the device itself. The turntable 20 is driven to turn when the solid fuels are brought in and formed into a mountain shape on the turntable 20, and when the calcined ashes are removed after the combustion. If the bringing of the solid fuels to the first combustion chamber 11 is continuous, the turntable 20 is always driven to turn.

[0041] As shown in FIG. 1, the solid fuel combustion apparatus 1 according to the embodiment includes a second combustion chamber 52 and a third combustion chamber 53 above the first combustion chamber 11. During combustion of combustible gases produced from the heated solid fuel, air is fed from the outside of the combustion apparatus 1 to increase its combustion efficiency. Specifically, the second combustion chamber 52 includes an air feeder as shown in the plan view in FIG. 6. In the embodiment, a first air feeder 55 and a second air feeder 56 are provided. Air enters the second combustion chamber 52 from both the first air feeder 55 and the second air feeder 56. The wind pressure of the incoming air triggers a swirling flow of flame (flame vortex, or heat flow) inside the second combustion chamber 52, including the first combustion chamber 11, as shown by the arcuate arrow in FIG. 6.

[0042] The swirling flow of the flame generated by the combustion of the solid fuels (combustible gas) spreads to the first combustion chamber 11 and the second combustion chamber 52. As shown in the entire side schematic diagram in FIG. 7, the swirling flow of the flame indicated by the arcuate arrows then vertically rises through the first combustion chamber 11, the second combustion chamber 52, and the third combustion chamber 53. As described above, the flame grows from the solid fuels accumulated in the first combustion chamber 11 to a height where it reaches the second combustion chamber 52 and third combustion chamber 53, thereby creating a swirling flow of flame. The temperature on the upper side of the flame is high relative to the size of the rising flame. Therefore, to obtain more combustion heat from the solid fuels per weight, it is desirable that the second combustion chamber 52 be provided above the first combustion chamber 11, and even the third combustion chamber 53 be provided.

[0043] From the series of descriptions and illustrations, the efficient combustion of the solid fuels in the solid fuel combustion apparatus 1 according to the embodiment is described. The mechanism of the control of the combustion conditions in the solid fuel combustion apparatus 1 according to the embodiment will now be described. In the example of the solid fuel combustion apparatus 1 according to the embodiment, the color of the combustion smoke (black, white, or colorless, for example) generated when the solid fuels are burning is identified to determine whether the solid fuels are burning well (complete or incomplete combustion), thereby controlling the solid fuel feeding rate and air feeding rate.

[0044] FIG. 8 is a block diagram illustrating a schematic configuration of the controller 100 implemented in the solid fuel combustion apparatus 1 according to the embodiment. The controller 100 is configured by a microcomputer or other hardware needed for receiving various signals, performing computations, storing, or controlling operations, for example, as well as a CPU 101, ROM 102, RAM 103, storage 104, and input/output interface (I/O) 105, for example.

[0045] When the functional units of the controller 100 (computer) in FIG. 8 are embodied by software, the controller 100 is embodied by executing the instructions of the program as software that embodies the functions. The recording medium for storing this program may include a "non-transient tangible medium" such as a CD, DVD, semiconductor memory, or programmable logic circuit. The program may also be supplied to the controller 100 of the solid fuel combustion apparatus 1 via any transmission medium capable of transmitting the program (communication network, and broadcast wave, for example).

[0046] The storage 104 of the controller 100 may correspond to a known storage device such as an HDD or SSD. The storage 104 may be directed to an external server (not shown). The storage 104 stores various data, information, programs, and other data needed to execute the programs. The functional units that execute various computations, operations, and other arithmetic operations may correspond to the CPU 101 and other arithmetic elements, for example. In addition, input devices such as a keyboard, or mouse, for example (not shown), a display (a display or other display device not shown), output devices for outputting data, for example, may also be appropriately connected to theI/O 105of the controller 100.

[0047] The combustion smoke imaging unit 110 may correspond to a publicly known CCD camera, and CMOS image sensor, for example. The color (black, white, or colorless, for example) of the combustion smoke K generated when the solid fuels are burning in the first combustion chamber 11 is imaged. The upper portion of the color of the combustion smoke is then transmitted to the controller 100.

[0048] The fuel quantity controller corresponds to the feeding motor M1 of the agitator 30 in FIG. 8. The quantity of the solid fuels fed from the agitator 30 to the first combustion chamber 11 is increased or decreased by controlling increasing and decreasing of the rotational speed of the feeding rotary shaft 13 and the feeding impeller 14 of the feeding motor M1.

[0049] The air volume controller corresponds to the air feeder F in FIG. 8. The air feeder F may correspond to a known blower, for example, which feeds air (oxygen) to the first air feeder 55 and the second air feeder 56 in the embodiment. The volume of air fed from the air feeder F to the second combustion chamber 52 is controlled to be increased or decreased to increase or decrease the volume of oxygen in the first combustion chamber 11.

[0050] As shown in FIG. 8, a combustion smoke imaging unit 110, feeding motor M1 (fuel quantity controller), and air feeder F (air volume controller) are connected to the I/O 105 and controlled by the CPU 101 in the controller 100.

[0051] With reference to the flowchart in FIG. 9, the form of the control of the combustion conditions of the solid fuels will be described below. First, combustion smoke generated during the combustion of the solid fuels is imaged by a combustion smoke imaging unit 110 (step S101). The information on the imaged combustion smoke is transmitted to the controller 100 to determine the amount of combustion of the solid fuels. That is, a determination of a smoke color is performed as to whether the color of the combustion smoke corresponds to one of the colors (e.g., black, white, or colorless) of the smoke (step S102). For example, it is determined whether the color of the imaged combustion smoke is more black on the basis of a comparison between the color and a pre-defined reference color of the smoke color. If the color of the combustion smoke is relatively white or colorless as a result of the determination of the smoke color, the combustion state of the solid fuels may be determined to be generally complete. In this case, the current quantity of fed solid fuels and current volume of the fed air are maintained at the current level. Accordingly, the status quo is maintained for the feeding motor M1 (fuel quantity controller) and the air feeder F (air volume controller), and the process ends with no change.

[0052] In contrast, if the color of the combustion smoke is relatively black or dark gray as a result of the determination of the smoke color, the combustion state of the solid fuels is likely to be incomplete combustion. In this case, the current quantity of the fed solid fuels and current volume of the fed air need to be changed to transition the state to the complete combustion. This instructs the feeding motor M1 (fuel quantity controller) and air feeder F (air volume controller) to change (step S104). The process is completed as described above. The combustion smoke is then imaged again, the determination of the smoke color is performed, and the combustion state of the solid fuels is checked.

[0053] Specifically, the feeding motor M1 (fuel quantity controller) is controlled to reduce the quantity of solid fuels fed from the feeder 12 to the first combustion chamber 11. The air feeder F (air volume controller) is also controlled to increase the volume of the air fed from the air feeders (first air feeder 55 and second air feeder 56) to the second combustion chamber 52. The control to increase the quantity of solid fuels or to decrease the volume of air may be employed. Both the feeding motor M1 (fuel quantity controller) and the air feeder F (air volume controller) may be controlled simultaneously.

[0054] Further, even in the case of increasing or decreasing the amount of combustion heat needed at a time when the solid fuel combustion apparatus 1 is in operation, control is also performed over either or both the feeding motor M1 (fuel quantity controller) or the air feeder F (air volume controller) via the controller 100.

[Description of the Reference Numerals]

[0055]

1: solid fuel combustion apparatus
10: combustion unit
11: first combustion chamber
12: feeder
13: feeding rotary shaft
14: feeding impeller
17: lower surface portion
18: dust collecting chamber
20: turntable
30: agitator
31: agitating rotary shaft
32: agitating impeller
40: dust collector
41: dust collecting opening
42: calcined ash discharger
43: discharging impeller
44: discharging rotary shaft
45: calcined ash collecting box
51: connecting chamber
52: second combustion chamber
53: third combustion chamber
M1: feeding motor (fuel quantity controller)
M2: agitating motor
M3: discharging motor
M4: turning motor
R: solid fuel
As: calcined ash
100: controller (computer)
101: CPU
102: ROM
103: RAM
104: storage
105: input/output interface
110: combustion smoke imaging unit
F: air feeder
K: combustion smoke

Claims

1. A solid fuel combustion apparatus in which a plurality of solid fuels are fed to a combustion unit to obtain combustion heat through combustion, wherein the combustion unit includes:

a first combustion chamber that burns the solid fuels;
a feeder that feeds the solid fuels to the first combustion chamber;
a turntable that forms a lower surface portion of the first combustion chamber and turns the solid fuels fed from the feeder on the lower surface portion of the chamber; and
an agitator that agitates the fuels accumulated on the turntable.

2. The solid fuel combustion apparatus according to claim 1, wherein the first combustion chamber is cylindrical in shape and the feeder feeds the solid fuels to a circumferential edge of the turntable.

3. The solid fuel combustion apparatus according to claim 1, wherein

a hole is formed in the turntable, into which hole combustion ash of the solid fuels falls, and
a combustion ash discharger is provided below the turntable.

4. The solid fuel combustion apparatus according to claim 3, wherein

a dust collector is provided in a lower portion of the turntable, and
the dust collector stirs up the combustion ash that falls from the turntable.

5. The solid fuel combustion apparatus according to claim 1, wherein
a second combustion chamber is provided above the first combustion chamber for flame generated by combustion of the solid fuels to rise.

6. The solid fuel combustion apparatus according to claim 5, wherein
an air feeder that feeds air for combustion of the solid fuels is provided in the second combustion chamber.

7. The solid fuel combustion apparatus according to claim 1, wherein
the agitator includes an agitating impeller or an elongate plate object to move the solid fuels accumulated on the turntable to a vicinity of the center of the turntable.

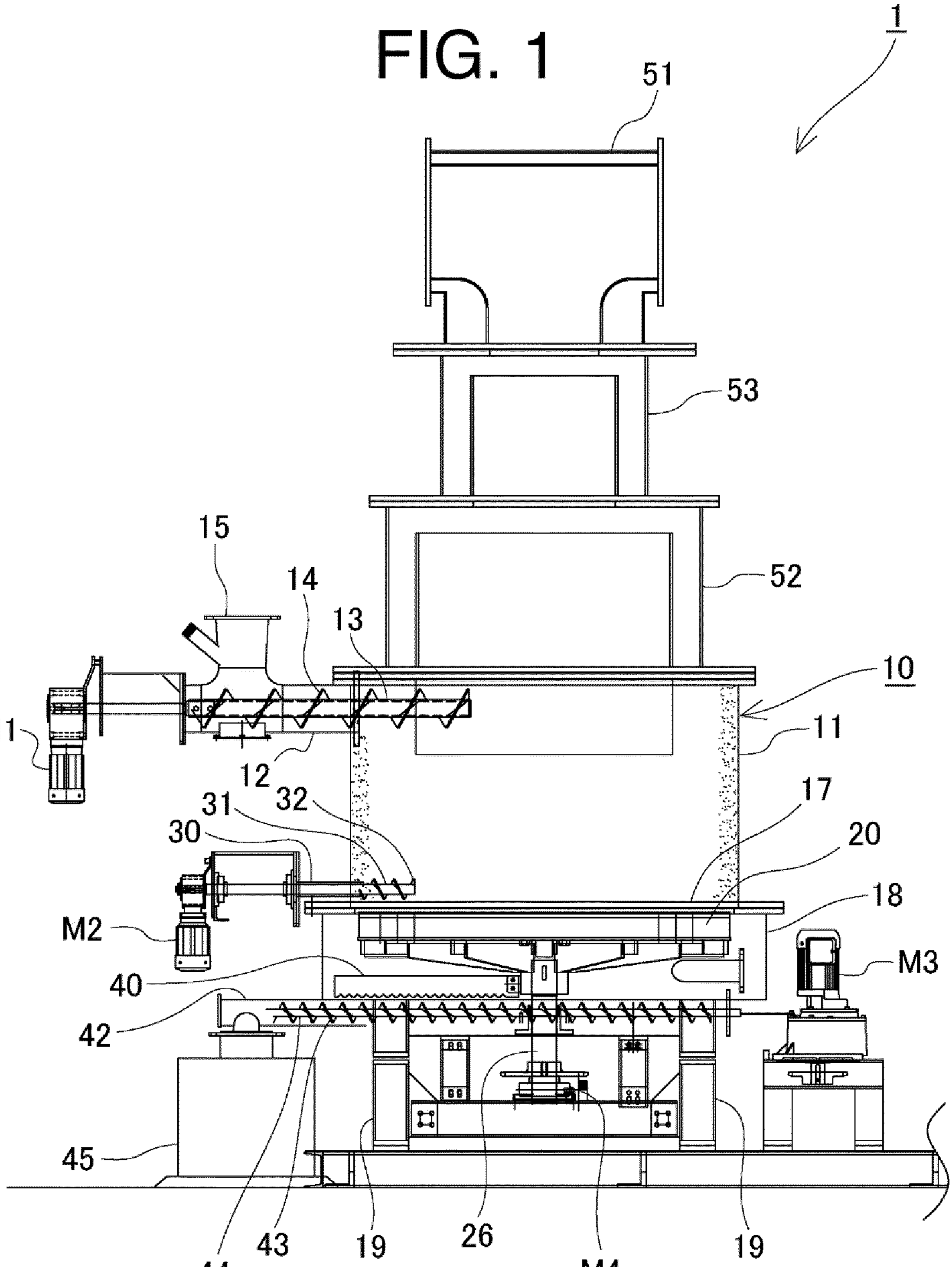
8. The solid fuel combustion apparatus according to claim 1, further comprising:

a combustion smoke imaging unit that images combustion smoke generated at a time of combustion of the solid fuels; and
a fuel quantity controller that controls quantity of the solid fuels fed from the feeder to the first combustion chamber, wherein
the fuel quantity controller controls quantity of solid fuels fed from the feeder to the first combustion chamber by determining quantity of the burned solid fuels on the basis of a color of the combustion smoke imaged by the combustion smoke imaging unit.

9. The solid fuel combustion apparatus according to claim 6, further comprising:

a combustion smoke imaging unit that images combustion smoke generated at a time of combustion of the solid fuels; and
an air volume controller that controls a volume of air fed from the air feeder to the second combustion chamber, wherein
the air volume controller controls the volume of air fed from the air feeder to the second combustion chamber by determining quantity of the burned solid fuels on the basis of a color of the combustion smoke imaged by the combustion smoke imaging unit.

FIG. 1


1
51
53
52
15
14
13
10
11
M1
12
31
32
17
30
20
18
M2
M3
40
42
45
44
43
19
26
M4
19

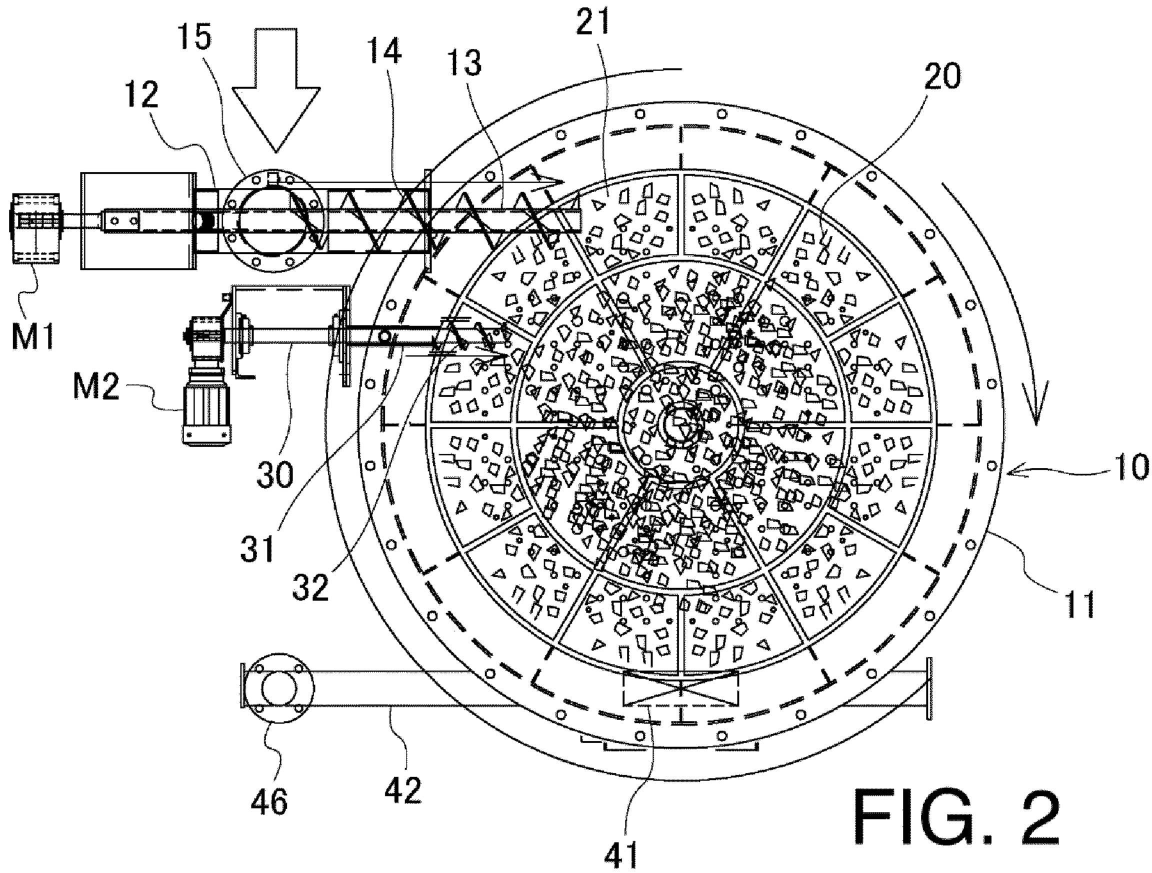


FIG. 2

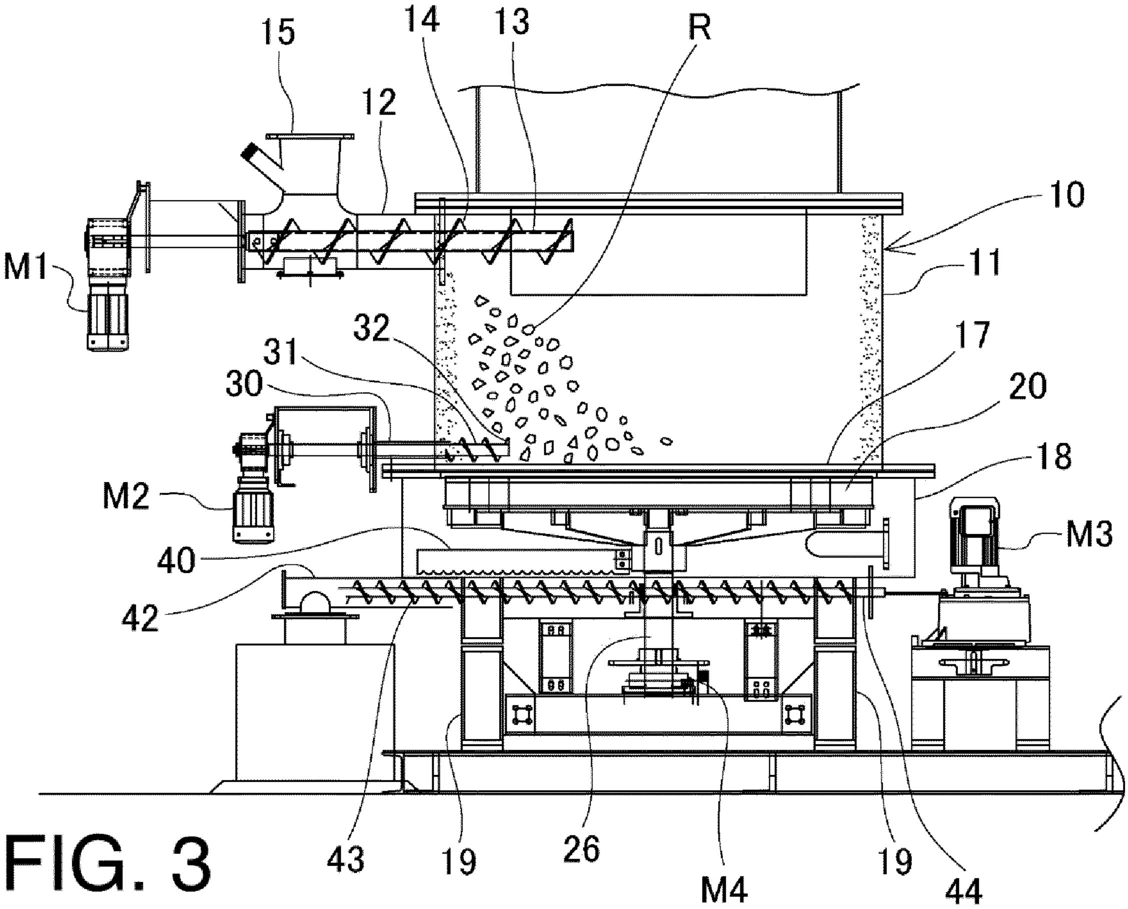


FIG. 3

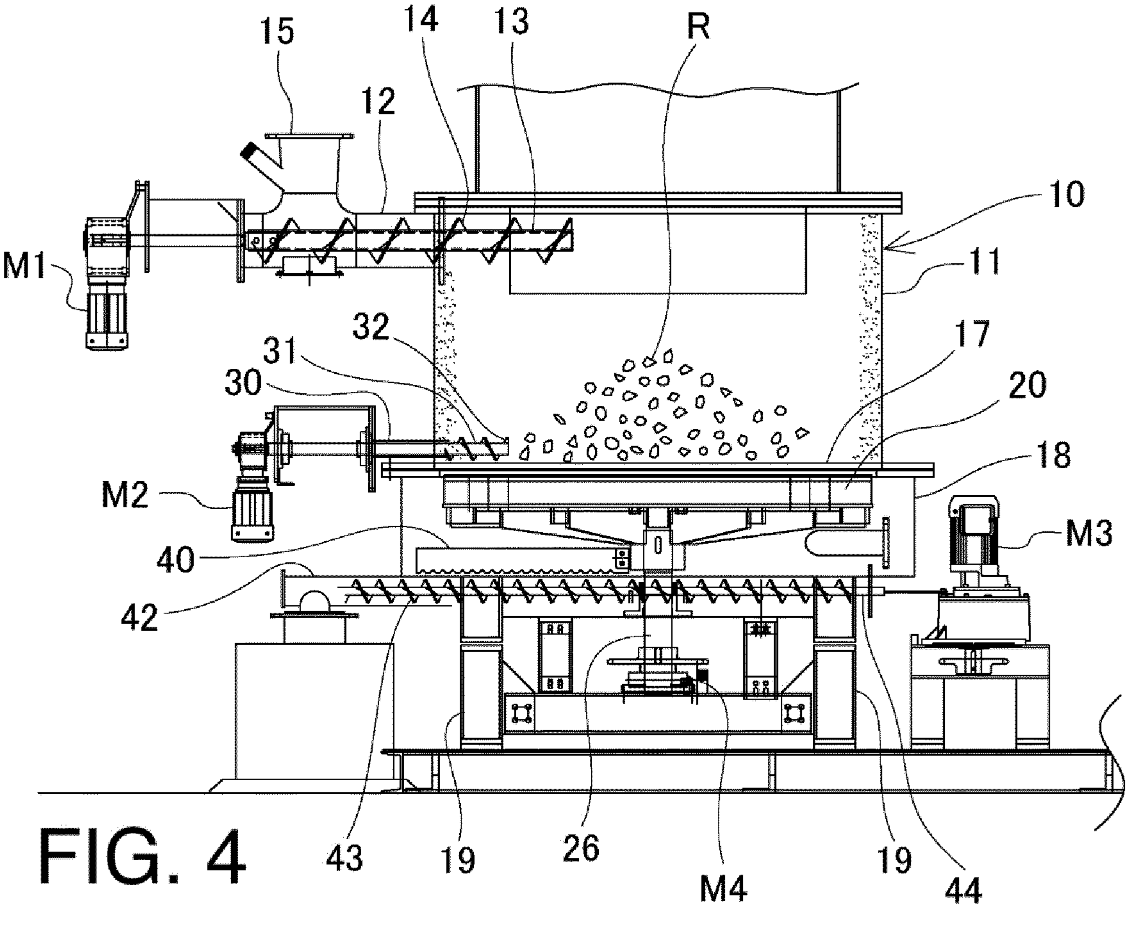


FIG. 4

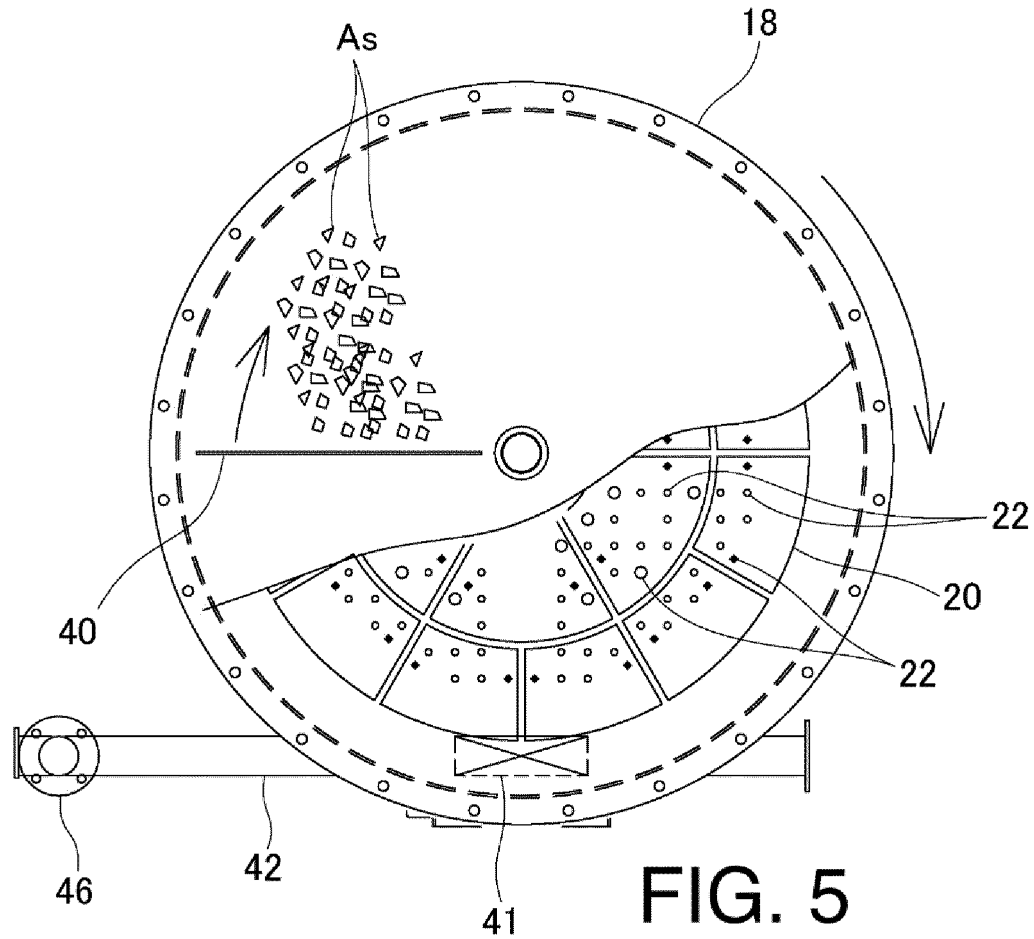


FIG. 5

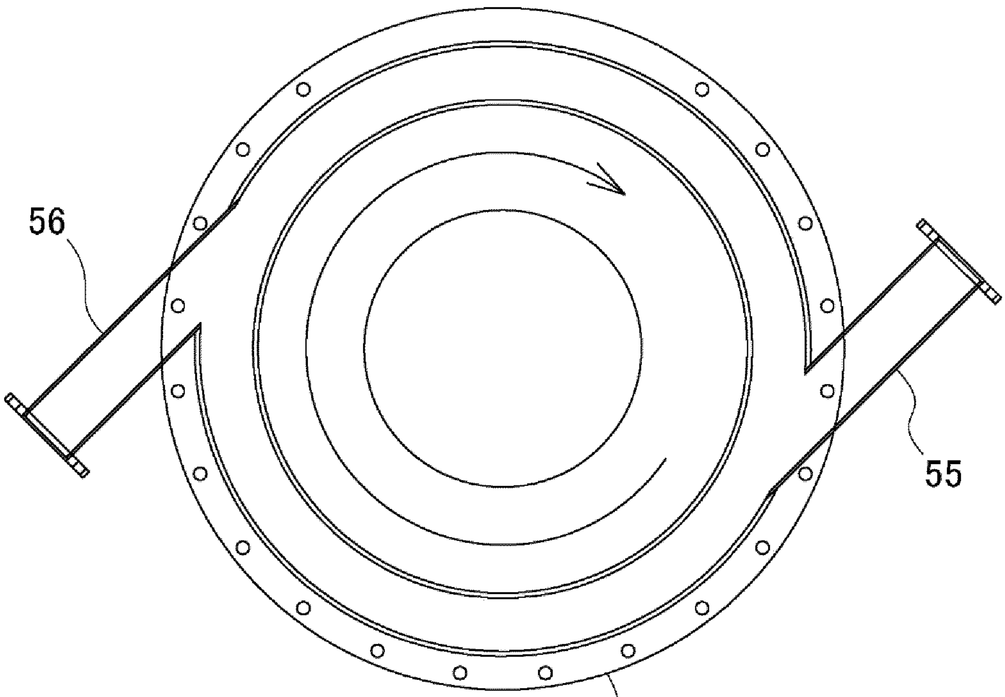
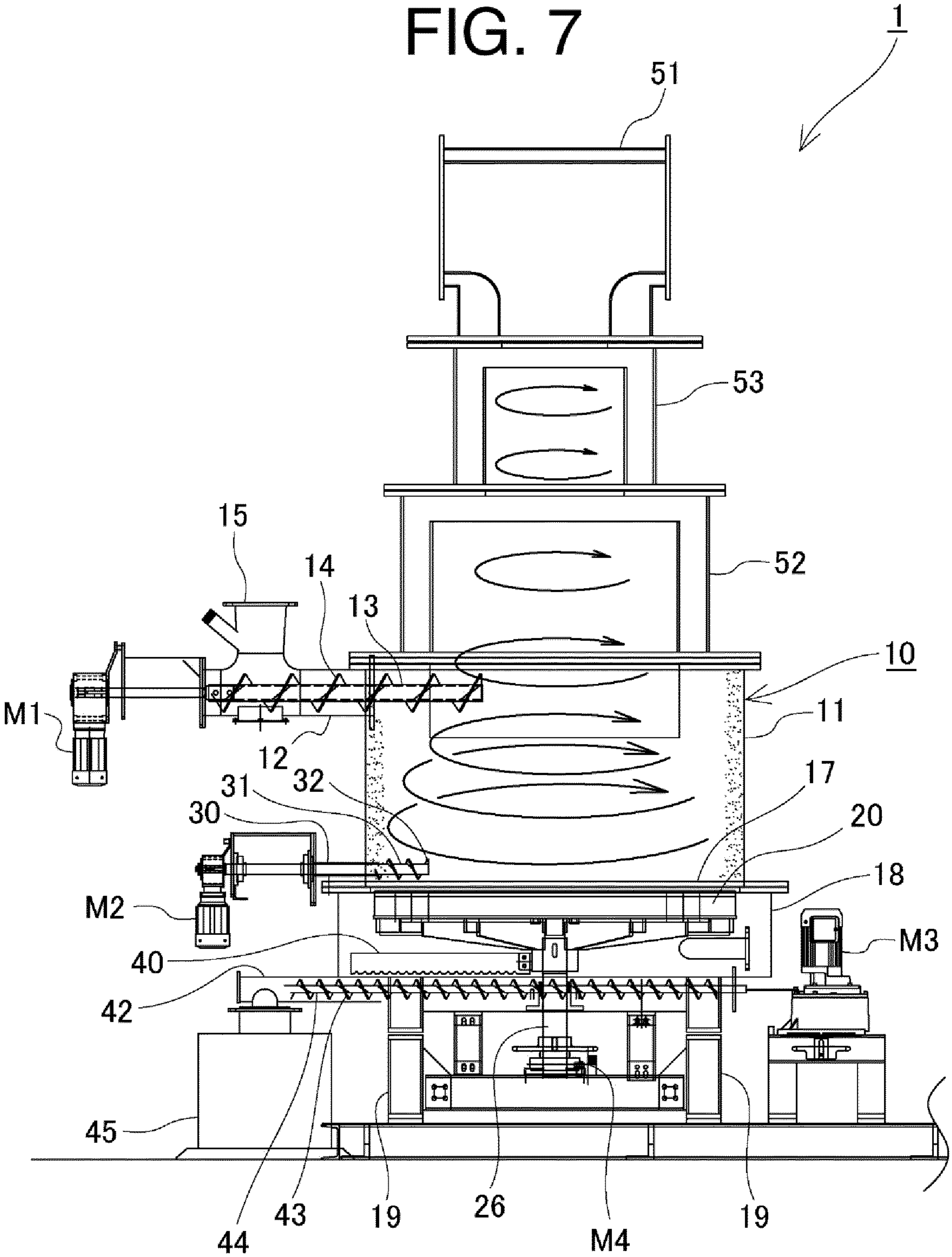


FIG. 6

FIG. 7


1
51
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M1
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M2
M3
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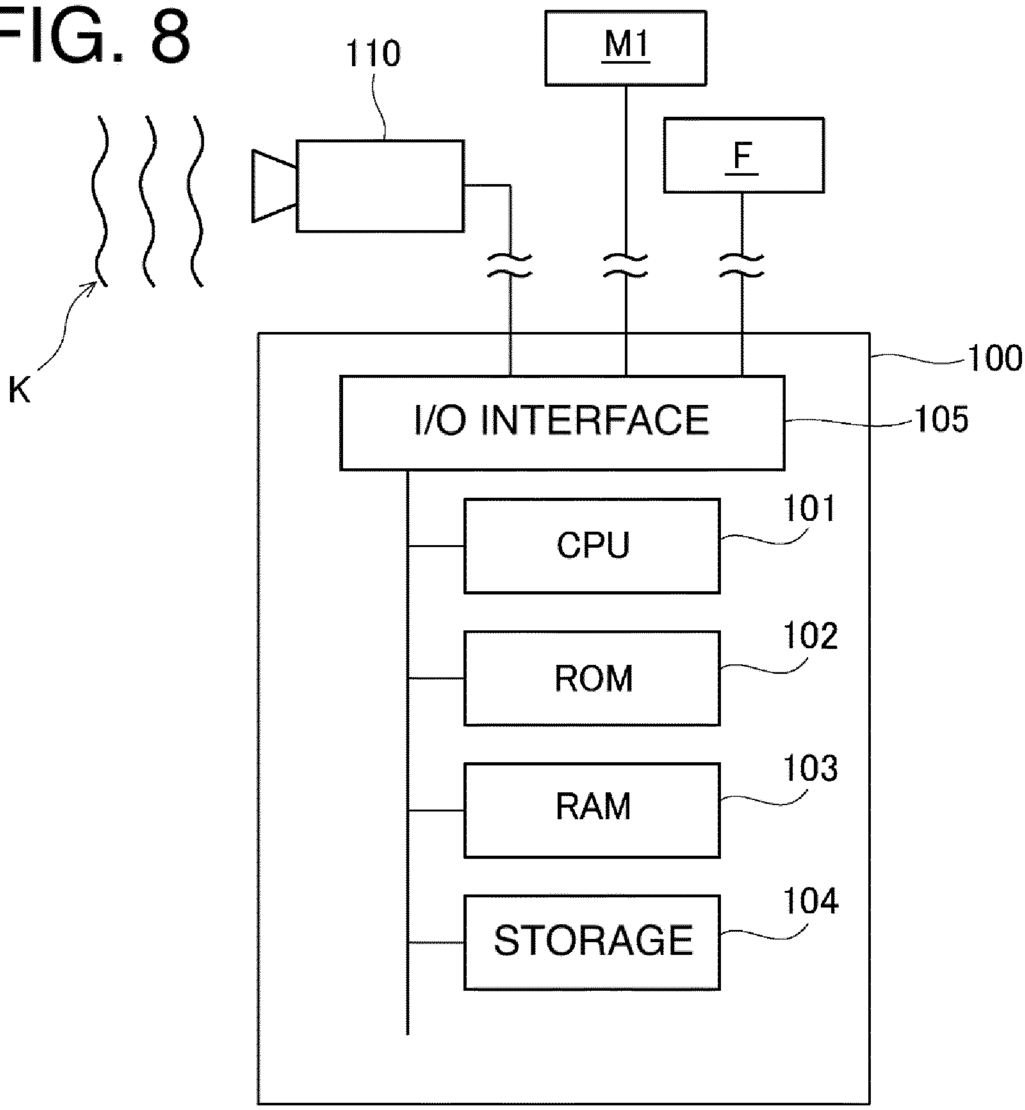
42
45
44
43
19
26
M4
19

FIG. 8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F
K
100
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CPU
101
ROM
102
RAM
103
STORAGE
104

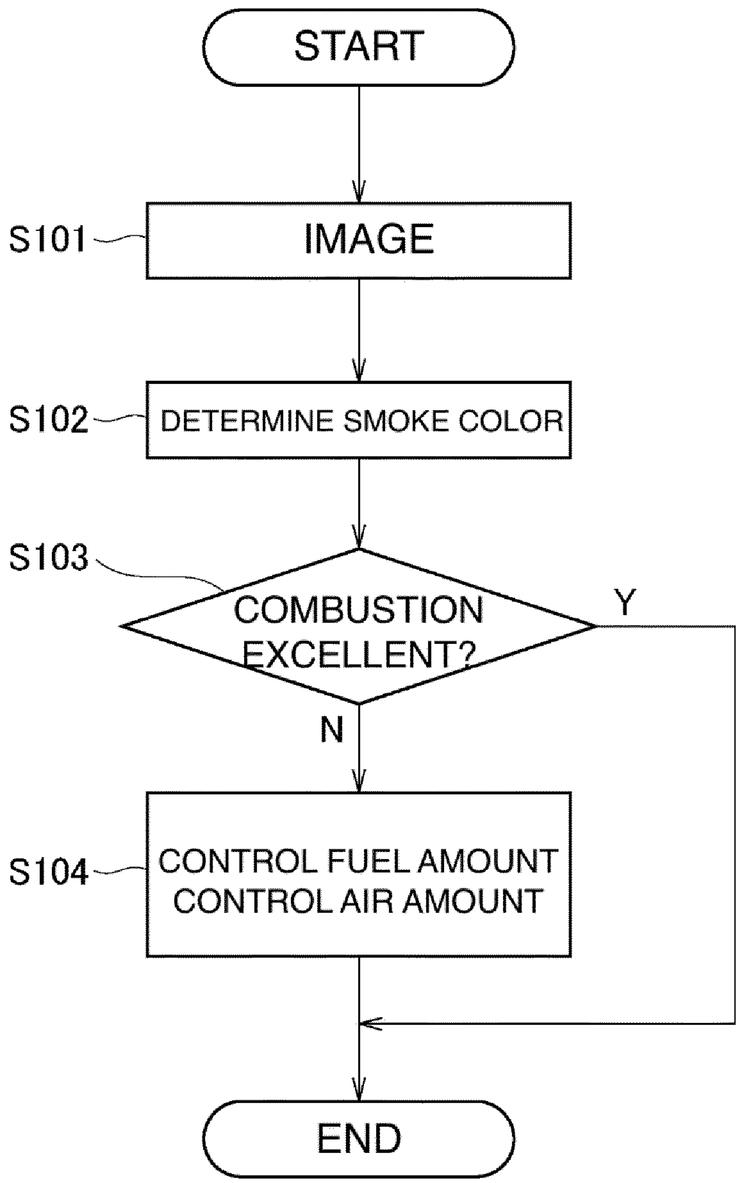
START
S101
IMAGE
S102
DETERMINE SMOKE COLOR
S103
COMBUSTION EXCELLENT?
Y
N
S104
CONTROL FUEL AMOUNT
CONTROL AIR AMOUNT
END

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/007787

A. CLASSIFICATION OF SUBJECT MATTER
F23B 30/02(2006.01)i
FI: F23B30/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
F23B30/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2012-225530 A (NARITA KK) 15 November 2012 (2012-11-15) paragraphs [0015]-[0062], fig. 1-7	1-4, 7 5-6, 8-9
Y	JP 56-94126 A (AMIKAWA, Hiroshi) 30 July 1981 (1981-07-30) page 1, lower left column, line 25 to page 2, lower right column, line 11, fig. 1-3	5-6, 8-9
Y	JP 2012-211730 A (KANEKO AGRICULTURAL MACHINERY CO LTD) 01 November 2012 (2012-11-01) paragraphs [0012]-[0013], fig. 1-7	8, 9
A	WO 2019/171466 A1 (NAT AGRICULTURE & FOOD RES ORG) 12 September 2019 (2019-09-12) entire text, all drawings	1-9
A	JP 3230152 U (GREEN POWER TECHNO KK) 14 January 2021 (2021-01-14) entire text, all drawings	1-9
A	JP 2015-34688 A (YAMAMOTO SEISAKUSHO INC) 19 February 2015 (2015-02-19) entire text, all drawings	1-9

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

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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 March 2021 (29.03.2021)	13 April 2021 (13.04.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/007787

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3136962 U (SUNCUE CO LTD) 08 November 2007 (2007-11-08) entire text, all drawings	1-9
A	JP 2018-517112 A (POSCO) 28 June 2018 (2018-06-28) entire text, all drawings	1-9
A	US 2016/0377297 A1 (UNIVERSAL LEAF TOBACCO COMPANY, INC.) 29 December 2016 (2016-12-29) entire text, all drawings	1-9
A	JP 3-17402 A (ORIBAA JIEI HOITSUTOFUIIRUDO) 25 January 1991 (1991-01-25) entire text, all drawings	1-9
A	JP 2014-211255 A (NAGAOKA IRON WORKS) 13 November 2014 (2014-11-13) entire text, all drawings	1-9
A	JP 2008-261527 A (TABATA SANGYO CO LTD) 30 October 2008 (2008-10-30) entire text, all drawings	1-9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/007787

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2012-225530 A	15 Nov. 2012	(Family: none)	
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JP 2015-34688 A	19 Feb. 2015	(Family: none)	
JP 3136962 U	08 Nov. 2007	(Family: none)	
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JP 2008-261527 A	30 Oct. 2008	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2014211255 A **[0005]**
- JP 2008261527 A **[0005]**