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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : B01F 5/20, 3/18

A1

(11) International Publication Number: WO 88/ 09208

(43) International Publication Date: 1 December 1988 (01.12.88)

(21) International Application Number: PCT/JP88/00499

(22) International Filing Date: 24 May 1988 (24.05.88)

(31) Priority Application Numbers: 62/134579
62/281913
62/281914

(32) Priority Dates: 29 May 1987 (29.05.87)
6 November 1987 (06.11.87)
6 November 1987 (06.11.87)

(33) Priority Country: JP

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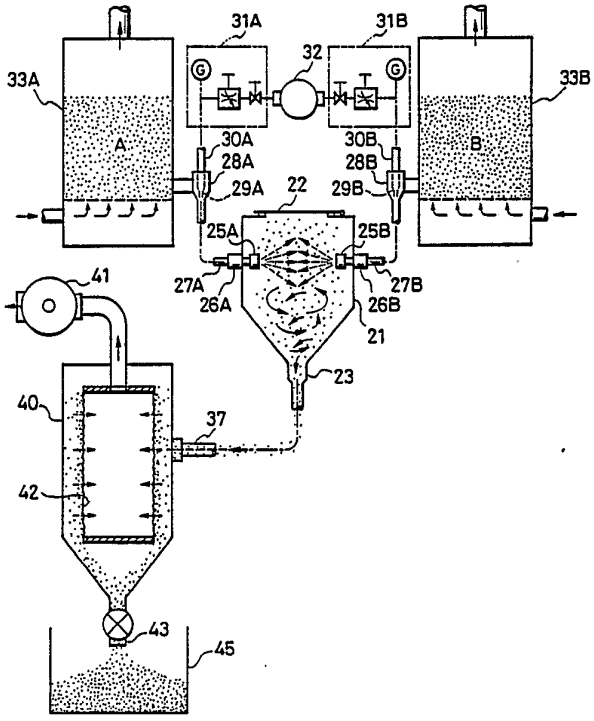
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(81) Designated States: AT (European patent), AU, BB, BE (European patent), BG, BJ (OAPI patent), BR, CF (OAPI patent), CG (OAPI patent), CH (European patent), CM (OAPI patent), DE (European patent), DK, FI, FR (European patent), GA (OAPI patent), GB (European patent), HU, IT (European patent), KR, LK, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, RO, SD, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.

(54) Title: POWDER MIXING METHOD AND APPARATUS



(57) Abstract

In a half-hermetically sealed type hopper-like container (1), different kinds of powders (A, B) are sprayed from a plurality of air spray nozzles (2, 3) and the resultant spray patterns are caused to collide against each other to thereby produce turbulence, whereby a mixture of gas and the powders is formed and the gas is separated from the mixture to thereby obtain a mixture of the different kinds of powders.

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D E S C R I P T I O N

POWDER MIXING METHOD AND APPARATUS

Technical Field

This invention relates to a powder mixing method and an apparatus therefor.

Background Art

The conventional powder mixing method may be divided broadly into the following two types. One is a method of mixing powders by rotating a rotary blade in a container (such as a ribbon blender method), and the other is a method of mixing powders by rotating a container itself and moving the powders therein up and down from gravity (such as a rotary mixer method). Both of these are a method of mechanically mixing powders. Accordingly, when the mixing ratio is a minute value or when microscopic dispersion is required, they could not always be said to be sufficient. Moreover, the volume of the container has been relatively great and the mixing time has been relatively long and further, the batch system has often been adopted and accordingly, the number of working steps has been great, and this has particularly formed a serious bottleneck in the flow line.

Recently, with the rapid development of high technology, the demand for mixing of powders at a minute ratio, microscopic uniform dispersion, etc.

has increased sharply. However, in the mixing by the conventional mechanical method, as noted above, it has been difficult to meet these requirements sufficiently.

Also, in the prior art, when setting the mixing ratio of plural kinds of powders, the weights or volumes of those powders have been severally measured by a meter. Then they have been supplied to a mixing apparatus to accomplish mixing of them. However, where precision has been required in the mixing ratio of the powders and a higher degree of dispersion has been required, the prior art has been insufficient in many points to achieve the intended purposes.

It is an object of the present invention to provide a method and an apparatus which can accomplish mixing of powders at a minute ratio and microscopical uniform dispersion of the powders simply and on a small scale and within a short time.

In the present invention, on the basis of a viewpoint entirely different from the prior art, attention was paid to air-spraying powders and mixing them under their atomized condition, and experiments were carried out, whereby the intended result could be attained.

It is another object of the present invention to set the mixing ratio more minutely and simply and disperse powders more finely and more uniformly, on the basis of a viewpoint entirely different from the

conventional measuring method using a meter or the conventional mixing apparatus, and provide a mixture of powders of good quality most effectively by the simplest method and apparatus.

Disclosure of the Inveniton

The present invention is characterized by mixing different powders in a turbulent stream.

In one aspect of the present invention, there are provided a powder mixing method and apparatus characterized in that in a half-hermetically sealed type hopper-like container, different kinds of powders are sprayed from a plurality of air spray nozzles and the resultant spray patterns are caused to collide against each other to thereby produce turbulence, whereby a mixture of gas and the powders and the gas is separated from the mixture to thereby obtain a mixture of the different kinds of powders.

The above-described method and apparatus of the present invention are further characterized in that said different kinds of powders are intermittently sprayed from the air spray nozzles in conformity with a desired mixing ratio to thereby adjust the mixing ratio of the powders.

In another aspect of the present invention, there are provided a method and apparatus characterized in that the sprays of different kinds of powders are caused to collide against a turbulence plate provided

in a hopper-like container to produce turbulence and create a mixture of gas and the powders, and the mixture is drawn out of the container and the gas is separated from the mixture to thereby mix the different kinds of powders.

Brief Description of the Drawings

Figure 1 is a side illustration of a mixing method using the collision of two air spray patterns according to the present invention.

Figure 2 is a plan illustration of the collision of three air spray patterns according to the present invention.

Figure 3 is a plan illustration of the collision of four air spray patterns according to the present invention.

Figure 4 is a perspective view showing the conical shape of the spray pattern.

Figure 5 is a perspective view showing the elongate conical shape of the spray pattern.

Figure 6 is a perspective view showing the fan-like shape of the spray pattern.

Figure 7 is a perspective view showing the cruciform shape of the spray pattern.

Figure 8 is a side view of the mixing apparatus of a first embodiment having two air spray nozzles mounted therein.

Figure 9 is a side view of a first modification

of the mixing apparatus of the first embodiment having three or more air spray nozzles mounted therein.

Figure 10 is a side view of a second modification.

Figure 11 illustrates the method of a second embodiment of the present invention.

Figure 12 is a side view of the apparatus of the second embodiment.

Figure 13 shows an example of the spray time of three kinds of powders.

Figure 14 illustrates a method of impacting the air spray of powders downwardly against a collision plate which is a basic method according to a third embodiment of the present invention.

Figure 15 illustrates a method of impacting the air spray upwardly.

Figure 16 illustrates a method of impacting the air spray laterally.

Figure 17 illustrates a method of impacting the air spray obliquely upwardly.

Figure 18 illustrates a method of impacting the air spray obliquely downwardly.

Figure 19 is a side cross-sectional view of the structure of the apparatus of the third embodiment.

Figure 20 is a side cross-sectional view of an apparatus in which the powder ejector nozzle faces upward.

Figure 21 is a side cross-sectional view of an apparatus in which the powder ejector nozzle faces laterally.

Figure 22 is a side cross-sectional view of an apparatus in which the powder ejector nozzle faces obliquely upward.

Figure 23 is a side cross-sectional view of an apparatus in which the powder ejector nozzle faces obliquely downward.

Figure 24 is a side view of a conveyor belt type supply device for the apparatus of the third embodiment.

Figure 25 is a plan view of the same supply device.

Figure 26 is a side view of a ribbon type blender hopper which is a supply device for the apparatus of the third embodiment.

Detailed Explanation of the Embodiments

A method according to a first embodiment of the present invention will first be described. Reference is had to Figure 1. In a half-hermetically sealed type hopper-like container 1, different kinds of powder A and powder B are forcibly supplied by an air ejector for powder and are sprayed from air spray nozzles 2 and 3, respectively. The head portions of the spray patterns As and Bs thereof are caused to collide against each other, whereby turbulence is

caused. Those sprays are in atomized state and therefore, different kinds of powder particles are mixed together by the turbulence of the atomized powders.

Originally, the repletion density (volume specific gravity) of the powder in the atomized state is very small, and is super-low density, say, one several thousandths to one several tens of thousandths of that of the powder in a container used in the conventional mechanical mixing. Under such a condition in which the dispersion intervals between the powder particles are very great, the powder particles go back and forth and therefore, these different kinds of powder particles readily come into one another and mix with one another, whereby uniform dispersion is accomplished easily and within a short time.

The mixture of the thus obtained atomized powders is drawn out of the hopper-like container 1, and gases and powders are separated from each other by a separate gas-powder separating apparatus, whereby mixed powders are obtained.

Various spray patterns may be mentioned as the spray patterns which are caused to collide against each other, and here, four main kinds of patterns are mentioned. First is a conically shaped spray pattern. This is a generally used spray pattern as seen in Figure 4, and it is wide in the base, and dispersion

and mixing take place in a wide zone. Next is an elongate conically shaped spray pattern as seen in Figure 5, and the collision force in the head portion of this spray pattern is greater than in the case of Figure 5 and the diffused stream spraeds in the directions of all angles and thus, wider dispersion takes place. In the case of a third spray pattern, i.e., a fan-like spray pattern, as seen in Figure 6, the cross-section in the head portion is like a convex lens, and when such patterns collide against each other, the diffused stream is divided into two leftward and rightward directions. In the last pattern of cruciform cross-section, as seen in Figure 7, the diffused stream is divided not only into the leftward and rightward directions, but also into the upward and downward directions. These have their own merits and demerits, and it is desirable that they be appropriately selected with the conditions such as the specific gravities of the powders, the mixing ratio of the powders and the pressure of the pressurized gas taken into account.

In the foregoing description, two spray patterns have been described as colliding against each other, but three or more spray patterns may also be caused to collide against one another. Reference is now had to Figures 2 and 3. The point of intersection 0 between the extensions 6, 7 and 8, or 11, 12, 13

and 14 of the air spray nozzles is the center of a substantially circular hopper-like container 5 (or 10). That is, in the central portion, these sprays are caused to collide relative to one another under substantially the same phase.

In the above-described collision type mixing method, it is desirable that the conditions of the both sprays which collide against each other be similar to each other. Consequently, in the case of two kinds of powders, it is desirable to use two air spray nozzles, and in the case of three kinds of powders, it is desirable to use three air spray nozzles. However, where the mixing ratio is not uniform but is greatly irregular, it is desirable that a small amount of powder be pre-mixed with the greater amount of powder and the mixture separated into two or three groups and be sprayed by two or three air spray nozzles.

Description will now be made of the structure of the apparatus of the present invention based on the above-described method. Reference is had to Figure 8. A half-hermetically sealed type hopper-like container 21 has an openable-closable lid 22 on the upper surface thereof and has a funnel-like lower portion which terminates in a discharge port 23. Two air spray guns 26A and 26B are provided on the peripheral side wall of said container in opposed relationship with each other, and air spray

nozzles 25A and 25B are mounted on these guns so that the extensions thereof intersect each other at a point in the central portion of the container 21. The guns 26A and 26B are connected to air ejectors 28A and 28B by air transport pipes 27A and 27B, and are further connected to a pressurized air generating device 32 via air control devices 31A and 31B. The air ejectors 28A and 28B are connected to supply tanks 33A and 33B for powders to be supplied. The discharge port 23 of the hopper-like container 21 is connected to a gas-powder separating device 40 by a discharge pipe 37, and further to an exhaust device 41. In Figure 8, a bag filter is shown as the gas-powder separating device, but the gas-powder separating device may also be a cyclone, a plate-like filter, an accordion-like filter, a collision plate type powder collector or the like.

The hopper-like container 21 has been described as having two air spray nozzles 25A and 25B mounted thereon, but in some cases, three or more air spray nozzles are mounted on the hopper-like container. Such an example is shown in Figure 9. The air spray nozzles are mounted in a different manner, and plan views thereof are shown in Figures 2 and 3. In any of these figures, the spray nozzles 6, 7 and 8 (or 11, 12, 13 and 14) are on a plane and the center lines of these nozzles are substantially

at the central point of the container 5 (or 10), and it is desirable that the angle of intersection therebetween be substantially equal (α or β). In the other points, this example is entirely similar to the example in which the two air spray nozzles are mounted and therefore need not be described further.

The operation of the apparatus of Figure 8 will now be described. Reference is again had to Figure 8. The pressurized gas CA adjusted to the necessary pressure and flow rate is supplied from the pressurized gas generating device 32 via the respective control devices 31A and 31B and through gas supply pipes 30A and 30B into the air ejectors 28A and 28B. Then, at the outlets of the air injection holes 29A and 29B thereof, the powder supplied to around then is sucked and entrained in gas and is injected from the spray nozzles 25A and 25B mounted at the ends thereof. Those sprays As and Bs concentrate on the central portion and collide against each other. It is desirable that those spray patterns be of the same shape, and by the collision thereof, the head portions of the sprays (atomized) As, Bs, ... collide against each other and reflect each other or are diffused and mix with each other, to thereby cause turbulence there. Due to the turbulence of these atomized bodies, those different kinds of powder

particles are dispersed and mix together. That is, mixing of the atomized bodies takes place.

As previously mentioned, there are four kinds of the above-described spray pattern, and any of these kinds is appropriately selected with the conditions of mixing, i.e., the properties of the particles of the powder, such as, for example, the specific gravity, size, shape and mixing ratio of the particles, the speed of the injected stream and the amount of injection.

In this manner, the mixture of the powders and gas effectively dispersed and uniformly mixed together fills up the hopper-like container 21. Thereupon, negative pressure is applied to the discharge port 23 provided at the bottom of the hopper-like container 21, by the exhaust device 41 provided at the distal end of the pipe therefrom, whereby the gas-powder mixture is transported from the discharge port 23 through the discharge pipe 37 connected thereto to the gas-powder separating device 40, in which gas-powder separation is effected. In Figure 8, the bag filter 42 is shown, and in this case, the gas-powder mixture reaches the bag filter 42 by air transport, and the powder stays on the surface of the bag 42. Only the gas A passes through the bag filter 42 and enters the interior thereof, and is sucked in by the exhausted device 41 and

discharged to the outside. That is, the mixed powders gas-powder separated and staying on the surface of the bag filter 42 are shaked off by vibrations applied to the bag and are collected in a lower collecting box 35.

The state of collision of the spray patterns Cs, Ds, Es, ... in a case where there are provided three or more air spray nozzles is such that as shown in the plan views of Figures 2 and 3, the spray patterns concentratedly collide against one another at the central portion of the hopper-like container 5 (or 11), whereby mixing action takes place similar to the case where two air spray nozzles are provided.

Reference is now had to Figure 10. Air ejectors 84A, 84B, ... are directly provided instead of the guns provided on the side wall of the hopper-like container as described above. Air spray nozzles 85A, 85B, ... are mounted at the ends of these air ejectors. It is desirable that hoppers 87A, 87B, ... for supplying respective powders be provided on top of the air ejectors. The present apparatus can be said to be compact and simple as compared with the apparatus of Figure 9.

The gist of a second embodiment of the present invention resides in a method and an apparatus wherein when air-spraying plural kinds of powders in a half-hermetically sealed type

container by respective powder ejectors, the amount of air to be supplied to them is supplied in a pulse-like fashion, namely, intermittently, substantially in conformity with the mixing ratio of the powders, whereby those powders are intermittently sprayed with the air and they are caused to collide against each other and the mixed powders now in the form of atomized bodies are directed to a gas-powder separating device outside the container and are separated from gas, thereby obtaining a mixture of the powders.

The method according to the second embodiment will hereinafter be described in detail. Reference is now had to Figure 11. Plural kinds of powders A, B, ... are air-sprayed Sa, Sb in a half-hermetically sealed type funnel-like container 101 by powder ejectors 103A, 103B, ..., respectively, and become atomized bodies. The streams of those sprays collide against one another, and by the reflected flow Sr and disturbed flow Sc resulting therefrom, those atomized bodies mix with one another. The mixing ratio of them is controlled by the volume x speed of the air supplied to the powder ejectors 103A, 103B, ... If the speed of the air is constant, the volume of the air must be changed, and for that purpose, the diameter of the nozzles must be changed, but it is difficult to change the diameter of the nozzles steplessly. As other means, the diameter of the nozzles may

be unchanged and the supply of the air may be effected intermittently and the overall ratio of the amounts of air to be supplied within a predetermined time may be determined generally in conformity with the mixing ratio, whereby the ratio of the respective powders actually air-sprayed will correspond to them.

The simplest means for supplying the air intermittently as described above is to use electrical pulse signals. The use of a commercially available pulse controller 106 and solenoid type air values 105A, 105B, ... would enable the cycle and intermittence time of those pulse signals to be easily changed at the unit of millisecond. A minute mixing ratio can also be set by selecting and setting the numerical values of these pulse signals.

The atomized bodies of the powders sprayed and mixed at a predetermined mixing ratio in the manner described above are forced to the lower portion in the half-hermetically sealed type funnel-like container 101 and at the same time, are drawn outwardly by negative pressure applied to the same portion, and are directed into a gas-powder separating device 108 which is the generating source of the negative pressure, and are separated from gas, whereby there is obtained a mixture AB of the powders.

An apparatus based on the above-described

method will now be described. Reference is had to Figure 12. An openable-closable lid 112 is mounted on the upper surface of a half-hermetically sealed type funnel-like container 111, a plurality of powder ejectors 113A, 113B, ... are mounted on the side wall of the funnel-like container 111, and nozzles 117A, 117B, ... for those powder ejectors are mounted so that their center lines focus substantially at a point. The outer sides of the air injection ports 114A, 114B, ... in the powder ejectors 113A, 113B, ... are covered with powder suction pipes 115A, 115B, ... which are in communication with powder supply hoppers 118A, 118B, ... Pressurized air pipes 120A, 120B, ... to the powder ejectors 113A, 113B, ... are connected to a pressurized air generating device 125 through air flow rate regulating valves 124A, 124B, ... respectively, and air-operated type air valves 121A, 121B,... are provided on the intermediate portions of the pipes 120A, 120B, ... In the above-described method, a solenoid type air valve is provided instead of the air-operated type air valve, but actually the pressure of the pressurized air is relatively high and therefore, it seems that in more cases, the air-operated type air valve is used. Operating air pipes 130A, 130B, ... for the air-operated type air valve are connected to an operating air generating device 105 through air

flow rate regulating valves 132 and solenoid type air valves 131A, 131B, ... are provided on the intermediate portions of the pipes 130A, 130B, ... thereof. The solenoid type air valves 131A, 131B, ... are electrically connected at 139A, 139B, ... to a pulse controller 140. On the other hand, a straight pipe 111p in the lower portion 111b of the funnel-like container 111 is connected to a gas-powder separating device 150 by a pipe 145, and a gas suction device 157 is provided in the device 150. In Figure 12, a bag filter type device is shown as the gas-powder separating device. A collection container 159 for the mixture of powders is placed below the gas-powder separating device 150.

The operation of the apparatus of the second embodiment will now be described. Reference is also had to Figure 12. The powder supply hoppers 118A, 118B, ... of the powder ejectors 113A, 113B, ... are replenished with different kinds of powders A, B, ..., respectively. Set pulse signals are then transmitted from the pulse controller 140. As an example, those pulse signals are of three kinds for the powders A, B and C. The cycles of the pulse signals are the same, e.g. 20 cycles, and the mixing ratio thereof is A : B : C = 20 : 5 : 2. In this case, the ratio of the amounts of supply of the pressurized (ejected) air is also 20 : 5 : 2 under the same speed. Actually, the ratio of them somewhat differs depending on the

length of the "opening" time, but here such a difference is neglected.

Now, this ratio is applied to the pulse signals. Reference is had to Figure 13. Respective "opening" times, i.e., 40 ms and 10 ms., may be set in one cycle 50 ms. Among the set times of the pulses, there is one of the unit of millisecond depending on the pulse controller. In that case, no setting can be made for a time below the decimal point and therefore, it may be multiplied by a necessary multiple to provide an integer. For example, in the case of the mixing ratio 40 : 20 : 1.5, only 1.5 may be doubled to provide "opening" for 3 ms once in two cycles, and the others may be "open" for 40 ms and 20 ms in each cycle (see the line for the powder C' in Figure 13).

When the pulse signals transmitted from the pulse controller are set in the manner described above, said signals first operate the solenoid type air valves 131A, 131B, ... to open them. The pressure of the operating air (OA) is being applied to the valves and therefore, by the "opening" thereof, the operating air (OA) reaches the air-operated type air valves 121A, 121B, ... and opens the valves 122A, 122B, ... The pressurized air from the pressurized air generating device (CA) is being applied to those valves and therefore, this pressured air enters the air injection ports in the powder ejectors and thus, the

pressurized air flows out of the injection ports to such the powders A, B, ... present around them, and inject and spray the powders from the powder ejector nozzles 117A, 117B, ... into the half-hermetically sealed type funnel-like container 111. The flows of these sprays concentrate substantially in the central portion of the container 111, and they collide against one another and are reflected thereby. That is, the atomized various powders are dispersed and by the resultant disturbed flows, they mingle with one another. The atomized bodies thus mixed are forced downwardly through the funnel-like container 111 by the succeeding air sprays and at the same time, the negative pressure by the intake device 157 of the gas-powder separating device 150 is applied to the lower portion of the container 111 and therefore, these mixed atomized bodies are drawn out of the container 111. The atomized bodies are then directed through the gas-powder separating device 150, whereby there is obtained a mixture ABC_2 of the powders.

Again in the second embodiment, the shape of the spray patterns of the powders is generally conical, but various shapes are possible as in the first embodiment.

In the apparatus of the second embodiment, the air-operated type air valves may be eliminated on the intermediate portions of the pressurized air pipes to the powder ejectors and instead, solenoid type air

valves may be provided and electrically connected to the pulse controller. In such case, the volume of the pressurized air is relatively small and solenoid type air valves of small capacity will be sufficiently suitable.

According to the method and apparatus of the second embodiment, plural kinds of powders are easily set and adjusted even at a mixing ratio of minute numerical value, and they are uniformly disposed within a shorter time to thereby easily obtain a mixture of the powders.

A third embodiment will now be described. It is such that powders are sprayed and the spray streams thereof are impacted against a planar surface and by the resultant colliding stream and disturbed stream, the powders in the gas are widely dispersed and uniformly mixed with one another.

The basic method of the third embodiment will first be described. Reference is had to Figure 14. A combination $PABC_1$ of several kinds of powders is injected from the injection port 203 of an air ejector 202 downwardly into a half-hermetically sealed type funnel-like container 201, and the injected stream PS_1 thereof is impacted against the surface of a planar collision plate 204, and the resultant reflected stream PS_2 is dispersed in the upper portion of the container 201, and in the lower

portion thereof, the powders are mixed with one another by a disturbed stream PS_3 induced by the reflected stream PS_2.

Originally, the repletion density (the volume specific gravity) of powder in atomized bodies is very small and is super-low density, say, one several thousandths to one several tens of thousandths of that of the powder in a container used in the conventional mechanical mixing. Under such a condition in which the dispersion intervals between the particles are very great, the particles go back and forth and therefore, these different kinds of particles readily come into one another, that is, mingle with one another, whereby uniform dispersion is accomplished easily and within a short time.

The atomized bodies $PABC_2$ comprising particles finely and uniformly mixed in this manner are forced downward to the lower portion of the container 201 by the succeeding air sprays and reach the straight tubular portion 205 thereof. The atomized bodies are then drawn out of the portion 205, and are directed to the gas-powder separating device at the next step, whereby uniformly mixed powders $PABC_3$ are obtained.

Although the sprays of the powders have been downwardly and perpendicularly impacted against the collision plate, there are available other several methods of impacting the sprays, which will be

mentioned below.

Reference is now had to Figure 15. This method comprises raising a spray stream PS_4 of powders to right above and impacting it perpendicularly against a collision plate 206 from below. The reflected stream PS_5 thereof flows downward and following it, a disturbed stream PS_6 as well as the atomized bodies therein also flow downward. Thus, the flow is relatively smooth and the disturbed stream is small, as compared with the aforedescribed method. However, in said case, there is the disadvantage that some of the powders stagnate in the upper corner portion of the container 201.

Reference is now had to Figure 16. This method comprises making the direction of the spray stream PS_7 of the powders lateral and impacting it against a collision plate 208 perpendicularly thereto. The reflected stream PS_8 thereof flies laterally and a disturbed stream PS_9 results therefrom and flows downward. A large disturbed stream is produced in the upper portion of the reflected stream PS_8, while the disturbed stream in the lower portion is small as compared with that in the upper portion and therefore, there is a fear that a difference may occur between the degrees of dispersion in the upper and lower portions.

Reference is now had to Figure 17.

This method comprises making the direction of the spray stream PS_{10} of the powders obliquely upward and impacting it against a collision plate 211 perpendicularly thereto. The resultant reflected stream PS_{11} jumps back obliquely downward and impinges on the inner wall of the container, whereby a disturbed stream PS_{12} is produced. However, this method, like the above-described method, is not free from the fear that some difference may occur between the degrees of dispersion in the upper and lower portions.

Reference is now had to Figure 18. This method comprises making the direction of the spray stream PS_{14} of the powders obliquely downward and impacting it against a collision plate 214 perpendicularly thereto. This method, like the above-described methods, is not free from the fear that a difference may occur between the degrees of dispersion in the upper and lower portions.

An apparatus according to the third embodiment will now be described. Reference is had to Figure 19. A powder ejector 223 is provided in the upper portion of a half-hermetically sealed type funnel-like container 221, a nozzle 224 for the powder ejector is provided downwardly in the container 221, an air injection port 225 is provided above the outside thereof, and the bottom 226B of a hopper 226 for the powder ejector is provided around the injection

port 225 so as to cover the latter. A supply device from a separate powder combining apparatus is connected to the hopper 226. Below the nozzle 224 for the powder ejector provided in the funnel-like container 221, a planar collision plate 222 is provided perpendicularly to the direction of the nozzle at a certain necessary interval S therefrom. The lower straight tubular portion 227 of the funnel-like container 221 is connected to a gas-powder separating device 231 by a pipe 230. The gas-powder separating device in Figure 19 is shown, for example, as being of the filter bag type.

The downwardly facing nozzle 224 for the powder ejector has been shown as the basis of the structure of the above-described apparatus, but the nozzle may face upward, laterally, obliquely upward and obliquely downward as shown in Figures 20, 21, 22 and 23, respectively.

It has been previously mentioned that there are many types of the supply means for supplying the combined powders $PABC_1$ to the present apparatus, i.e., from the manually operated type to the fully automatic type, but it is desirable that the plural kinds of powders be combined together and dispersed a little if not mixed. That is, a combining device which serves both to combine the powders and to roughly (preliminarily) mix the powders is desirable.

It is, for example, a conveyor belt supply system. This system will now be described. Reference is had to Figures 24 and 25. A conveyor belt 275 has its downstream end disposed above a powder supply hopper 226 on the present apparatus. On the upstream side of it, the discharge ports 264E, 268E and 272E of a plurality of devices for continuously supplying a constant amount of powder are provided at a necessary interval T. It is more desirable that if possible, those discharge ports 264E, 268E and 272E be not on the same straight line. In Figures 24 and 25, electromagnetic vibration type feeders 264, 268 and 272 are shown as the devices for continuously supplying a constant amount of powder, but alternatively, such devices may be mechanical vibration type feeders or rotary feeders of other type.

Besides these, said devices may be ribbon blender type hoppers. Reference is now had to Figure 26. A plurality of constant amount feeders are provided in the upper portion of a ribbon (293) type blender hopper 291. In Figure 26, rotary feeders 282 and 286 are shown. The discharge ports 283 and 287 of those feeders open to the upper portion of the interior of the ribbon type blender hopper. A powder ejector is mounted at the bottom, i.e., the discharge portion, of the hopper, and is connected by a pipe 299 to a funnel-like container 301 which is the body

of the apparatus according to the present invention.

Reference is again had to Figure 19 to describe the operation of the present embodiment. First, the powders to be mixed together are plural kinds of powders combined at the necessary combination ratio and dispersed (roughly mixed) to some extent. The combination of the powders is accomplished by a powder combining device, which may be one of various types from the manually operated type to the fully automatic type. The powders $PABC_1$ combined by such powder combining device are supplied. The combined powders $PABC_1$ are supplied into the hopper 226 of the powder ejector 223. An amount of air having the necessary air pressure is supplied from the pressurized air generating device through the air pipe 228 to the air injection port 225 provided in the lower central portion of the hopper 226. The combined powders $PABC_1$ present around the injection port 225 are sucked by the negative pressure of the high-speed air stream blowing out of the injection port 225, and are injected downwardly from the powder ejector nozzle 224 disposed therebelow. The injected stream of the air and the powders becomes a spray PS_1 and impinges on the collision plate 222, and the resultant reflected stream PS_2 is reflected upwardly in all directions and scattered. At that time, the powders are dispersed in all directions in the upper portion

of the funnel-like container 221. These scattered powderes again impinge on the inner wall of the funnel-like container 221 and are irregularly reflected thereby, that is, the disturbed stream PS_3 is produced. At this time, the dispersed powders are more uniformly mixed together in their atomized state. These mixed atomized bodies $PABC_2$ are pushed by the succeeding spray and are drawn by the negative pressure from the outside (the gas-powder separating device 231), and gather in the lower straight tubular portion 227 of the funnel-like container 221, and then are directed into the gas-powder separating device 231 by the pipe 230 connected to said portion. The mixed powders $PABC_2$ and the gas are separated by the device 231, whereby there are obtained uniformly dispersed mixed powders $PABC_3$.

The features of the operation of the powder ejector nozzles mounted in various directions are as described in connection with the method of the third embodiment and therefore need not be described here.

Reference is now had to Figures 24 and 25 to describe the operation of the device for supplying different kinds of powders. In Figures 24 and 25, plural kinds of powders PA, PB, PC, ... are supplied to hoppers 263, 267 and 271, respectively,

set constant amounts of them are continuously supplied from the discharge ports of the hoppers onto the troughs of respective feeders, and they are fed by vibrations and supplied as several streaks onto a conveyor belt 275, and then are collectively supplied into a hopper 226 for powder ejectors. Thus, the hopper 226 is filled with a rough (preliminary) mixture of powders combined at the necessary ratio, and those powders are finally finely mixed together by the apparatus of the third embodiment of the present invention at the next step. The means for supplying the plural kinds of powders onto the belt are not restricted to the above-described vibration type feeders, but may be various continuous supply devices such as rotary feeders and the like.

Reference is now had to Figure 26 to describe the operation of the ribbon type blender hopper. Different kinds of powders PA, PB, PC, ... are supplied into the ribbon type blender hopper 291 by constant amount type feeders 282, 286, ... The powders are roughly mixed together in the hopper by rotation of a ribbon 293, whereafter the roughly mixed powders are supplied into the funnel-like container 301 of the third embodiment of the present invention by a powder ejector provided at the bottom, i.e., the discharge portion of the hopper, through a pipe 299.

C L A I M S

1. A power mixing method comprising introducing different powders into a half-hermetically sealed type hopper-like container, stirring said powders by turbulent air produced in said container to thereby mix said powders and make an atomized mixture of gas and said powders, drawing said mixture out of said hopper-like container and separating the gas therefrom, thereby obtaining a mixture of the differnt powders.

2. A powder mixing method comprising causing different powders (A, B; C, D, E, ...) to collide against air spray patterns (As, Bs; Ds, Es, ...) from a plurality of air spray nozzles (2, 3; 6, 7, 8, ...) and causing the heads of said spray patterns to collide against each other, in a half-hermetically sealed type hopper-like container (1, 5), thereby causing turbulence, dispersing the different powders more uniformly by the turbulence of atomized bodies, drawing the mixed atomized bodies out of said hopper-like container and separaitng them into gas and powders, thereby obtaining a mixture of the different powders.

3. A power mixing apparatus comprising:

(a) a half-hermetically sealed type hopper-like container (21, 51) having a discharge

port (23, 53) in the lower portion thereof;

(b) a plurality of air spray nozzles (25A, 25B; 55A, 55B, 55C, ...) for powders provided from the peripheral side of said hopper-like container toward an internal point; and

(c) guns (26A, 26B; 56A, 56B, 56C, ...) for said air spray nozzles connected to air ejectors (28A, 28B; 58A, 58B, 58C, ...) for powders;

(d) the discharge port in the lower portion of said hopper-like container being connected to a gas-powder separating device (40, 70) provided with an exhaust device (41, 71).

4. A powder mixing method characterized by intermittently air-spraying powders into a half-hermetically sealed type container by a plurality of air spray means on the basis of a necessary mixing ratio, causing the heads of such sprays to collide against each other to mix the powders, drawing out atomized bodies comprising a mixture of the particles of the different powders from the lower portion of said half-hermetically sealed type container, directing said atomized bodies into a gas-powder separating device and separating gas therefrom, thereby obtaining a mixture of the different powders.

5. An apparatus for setting and adjusting the mixing ratio of powders and mixing the powders, comprising:

(a) a half-hermetically sealed type funnel-like container having a discharge port at the bottom thereof, said discharge port being connected to the outside;

(b) a plurality of powder ejectors mounted on the side wall of said container at substantially equally divided angles as viewed in a plane, the center lines of said powder ejectors being focused substantially at the central portion of said container; and

(c) air valves provided on respective supply air pipes to said plurality of powder ejectors;

(d) said air valves being connected to a pulse controller;

(e) said discharge port provided at the bottom of said container being connected to a gas-powder separating device with an intake device.

6. A powder mixing method characterized by air-spraying plural kinds of powders precombined at a necessary ratio or roughly mixed after combined into a half-hermetically sealed type funnel-like container from above toward below by a powder ejector, impacting said powders against a planar collision

plate substantially perpendicular to the stream of the spray, dispersing the particles of the plural kinds of powders in their atomized state produced by the resultant reflected stream, mixing the particles of said plural kinds of powders with one another by turbulence produced after said reflected stream, drawing out the atomized mixture from the bottom of said funnel-like container by the negative pressure from the outside, and obtaining plural kinds of mixed powders by a gas-powder separating device provided outside.

7. A powder mixing apparatus comprising:

(a) a half-hermetically sealed type funnel-like container having an outer connecting portion having a discharge port in the lower portion thereof;

(b) a powder ejector for supplying powders into said container; and

(c) planar collision plates fixed in said funnel-like container substantially at right angles at a necessary interval downstream of said ejector;

(d) said discharge port in the lower portion of said funnel-like container being connected to a gas-powder separating device with an exhaust device by a pipe.

8. A powder mixing apparatus according to Claim 7, wherein the discharge ports of a plurality

of powder feeders are disposed on the upper surface of the same conveyor belt, and the distal end of said conveyor belt which is a discharge portion is disposed in the upper portion of a hopper for supplying powders to said powder ejector.

9. A powder mixing apparatus according to Claim 7, further comprising a blender for powders and a plurality of feeders provided above said blender and wherein said powder ejector is provided in the lower discharge portion of said blender.

FIG. 1

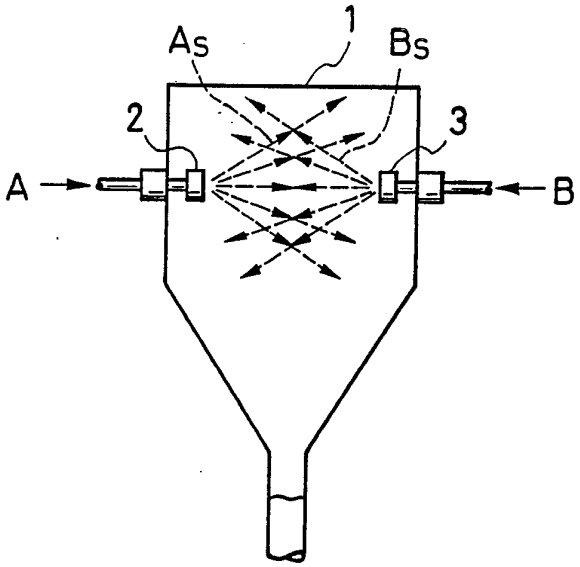


FIG. 2

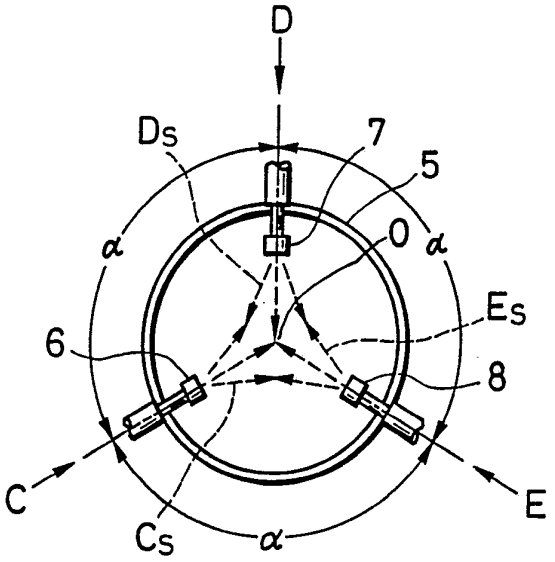


FIG. 3

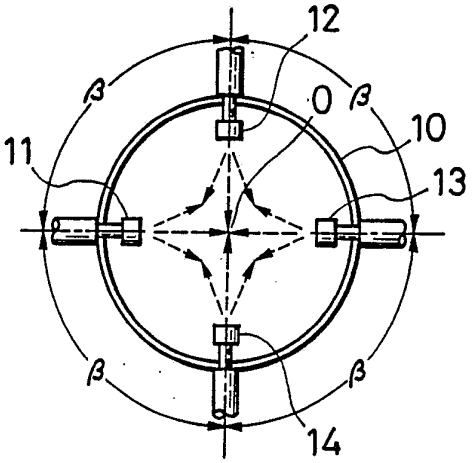


FIG. 4

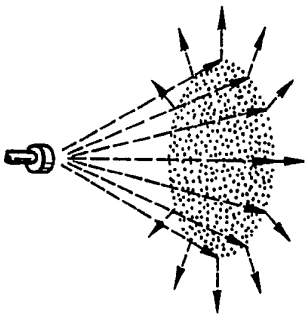


FIG. 5

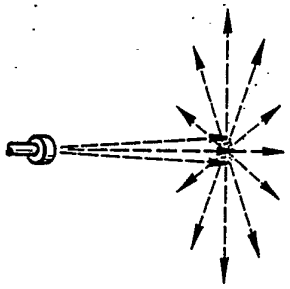


FIG. 6

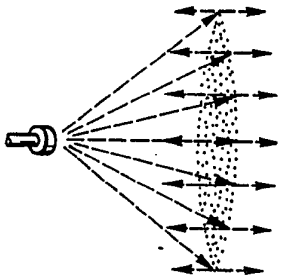


FIG. 7

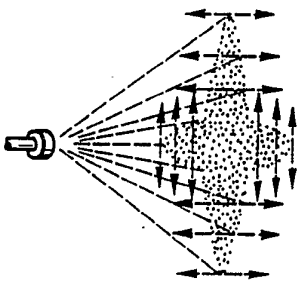


FIG. 8

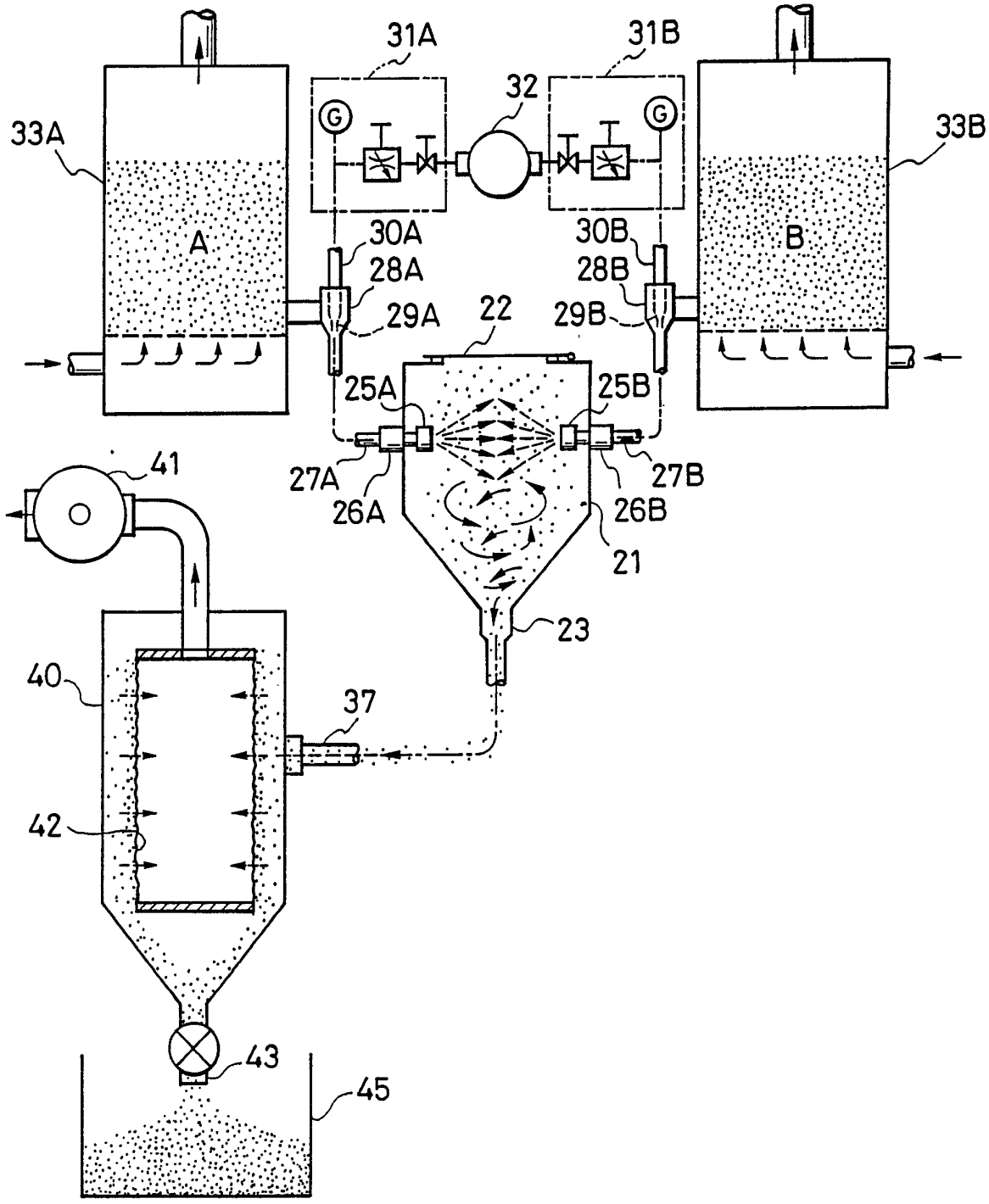

31A
31B
32
33A
33B
A
B
G
G
30A
28A
29A
22
30B
28B
29B
25A
25B
27A
26A
27B
26B
21
23
41
40
37
42
43
45

FIG. 9

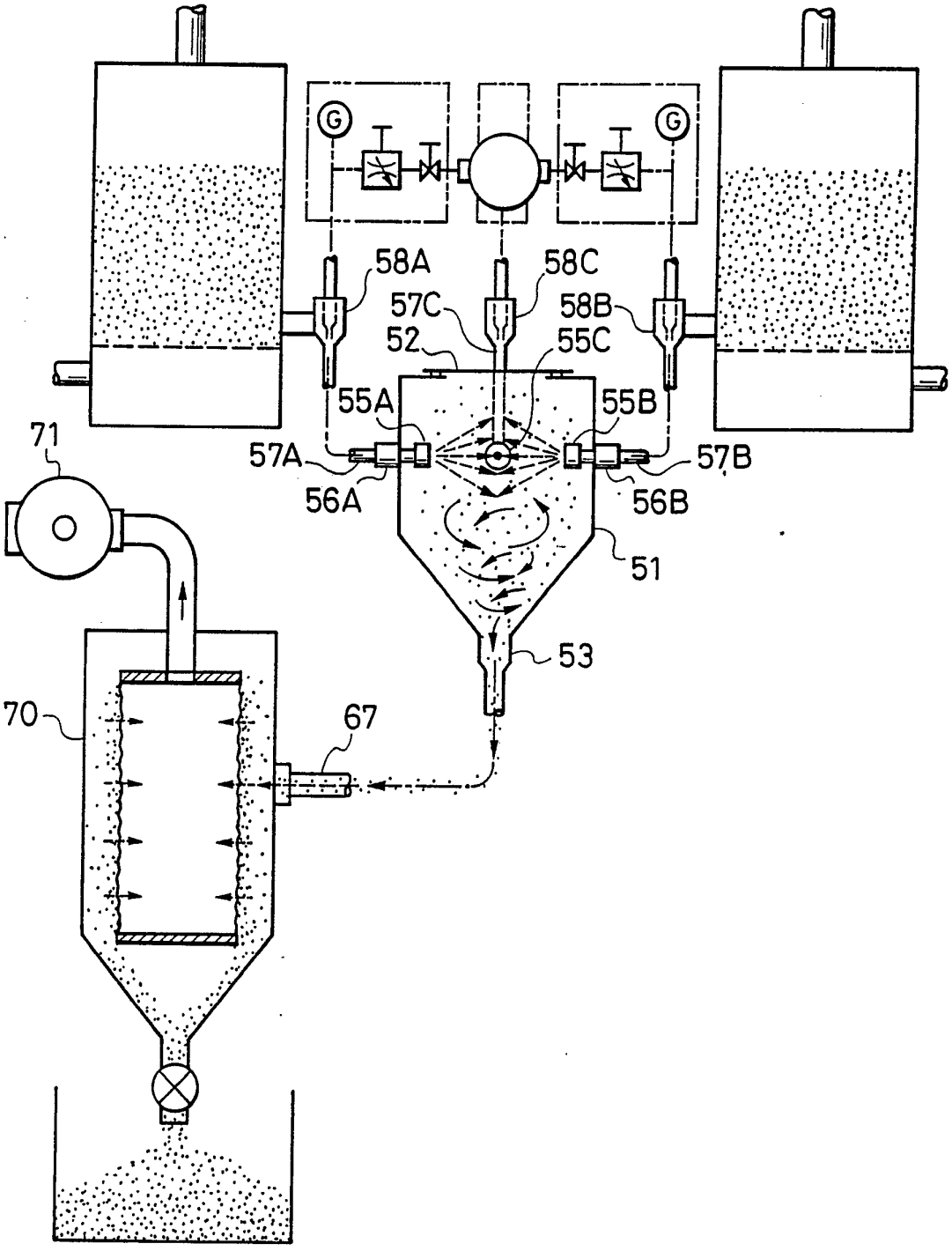


FIG. 10

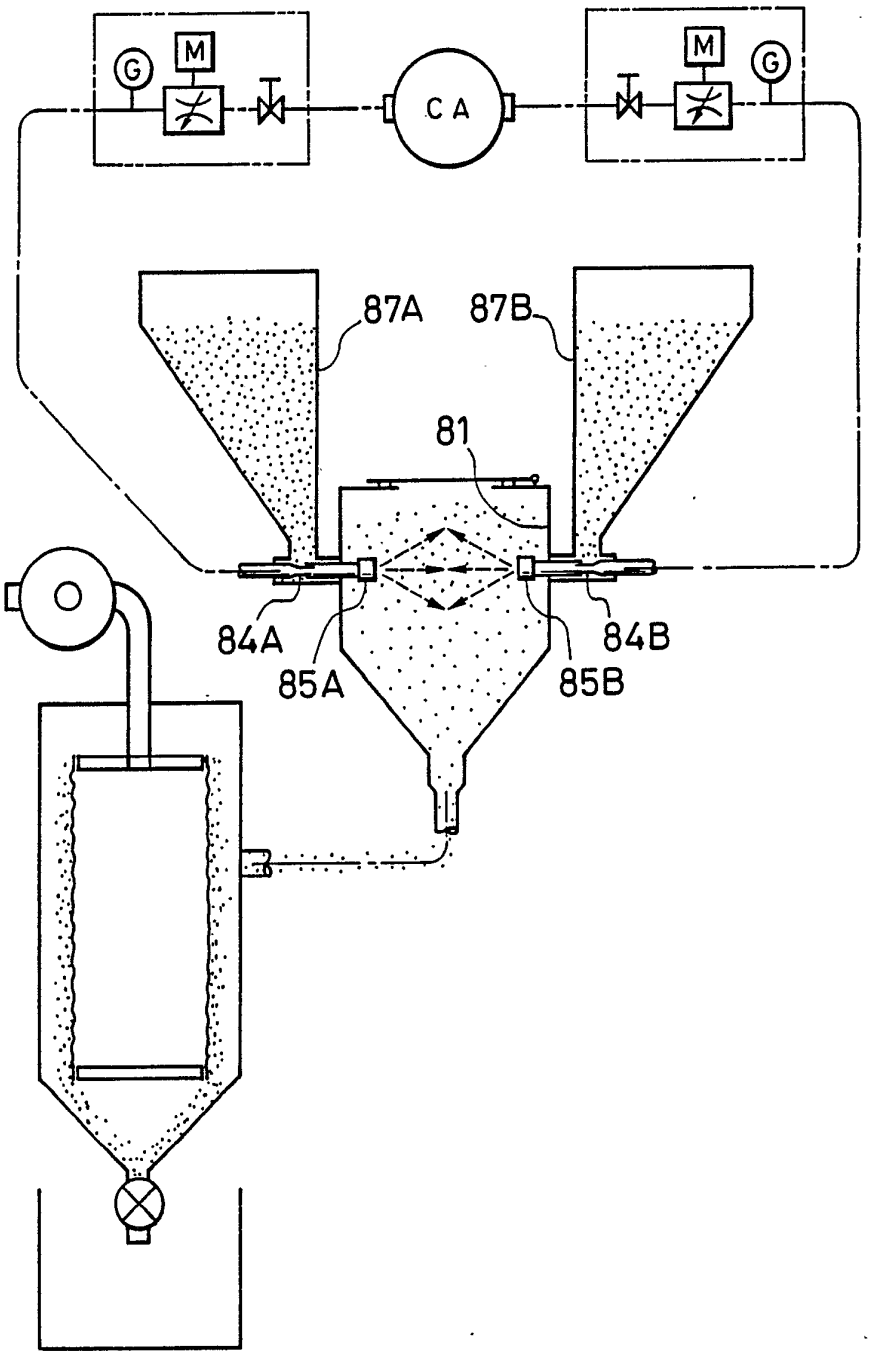
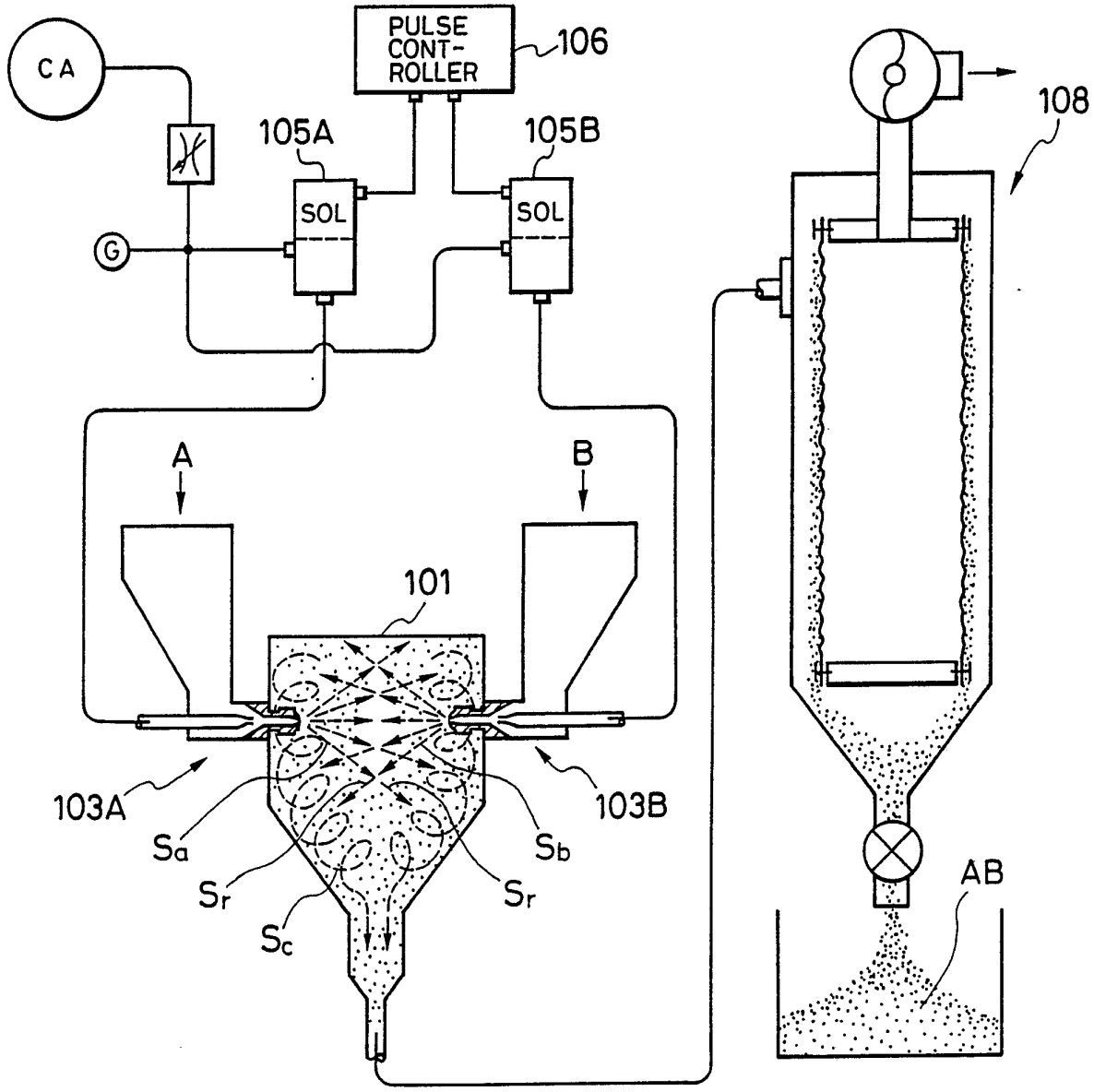


FIG. 11


CA
PULSE CONT-ROLLER
106
105A
105B
SOL
SOL
G
A
B
101
103A
103B
Sa
Sb
Sr
Sr
Sc
108
AB

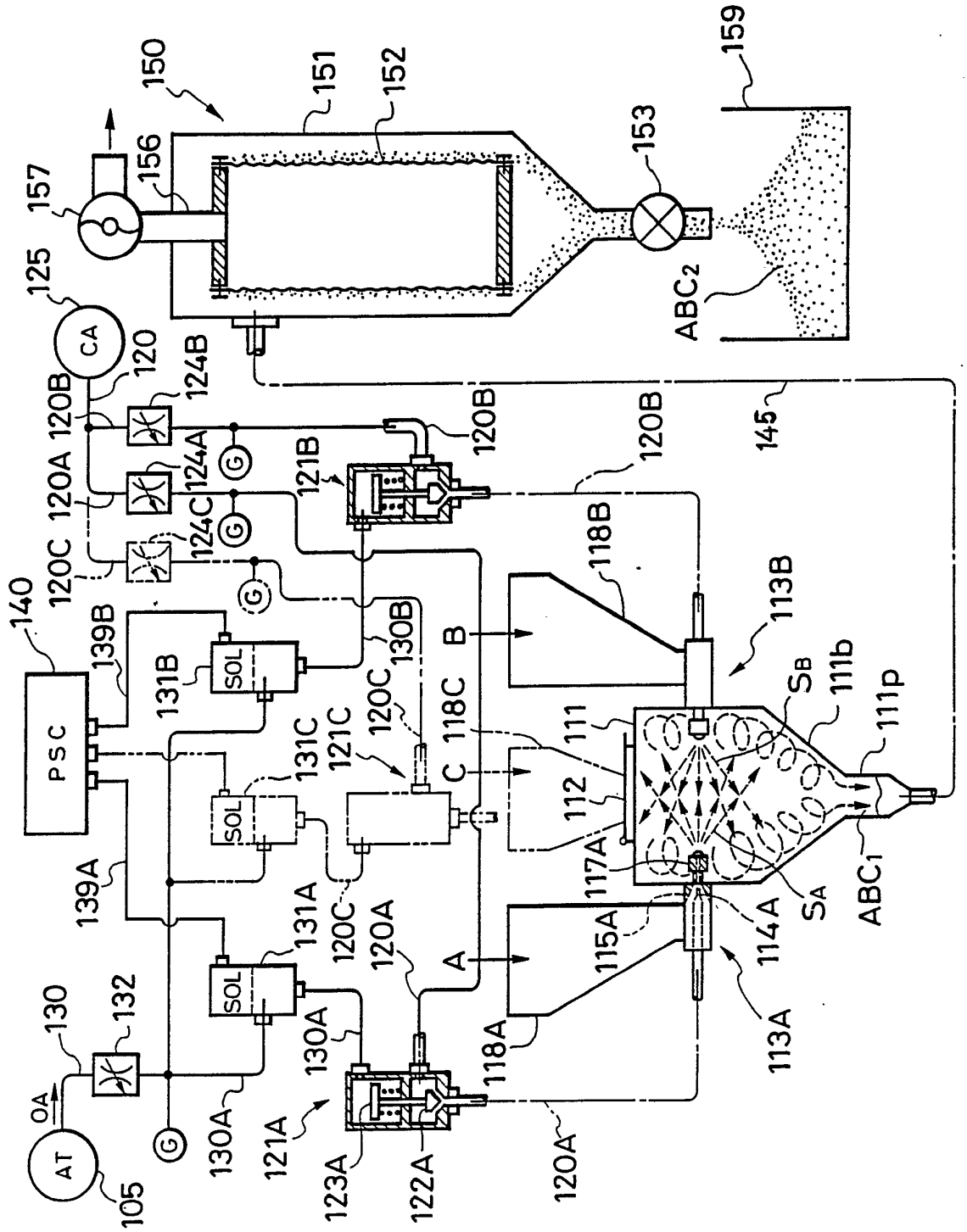

150
151
152
153
156
157
159
125
CA
120
124B
120B
120A
124A
124C
120C
121B
118B
113B
145
140
PSC
139B
131B
SOL
130B
B
C
118C
111
111b
111p
S_B
131C
121C
112
117A
S_A
ABC_1
139A
131A
120A
115A
114A
A
130
132
OA
AT
105
130A
121A
123A
122A
118A
113A
ABC_2

FIG. 12

FIG. 13

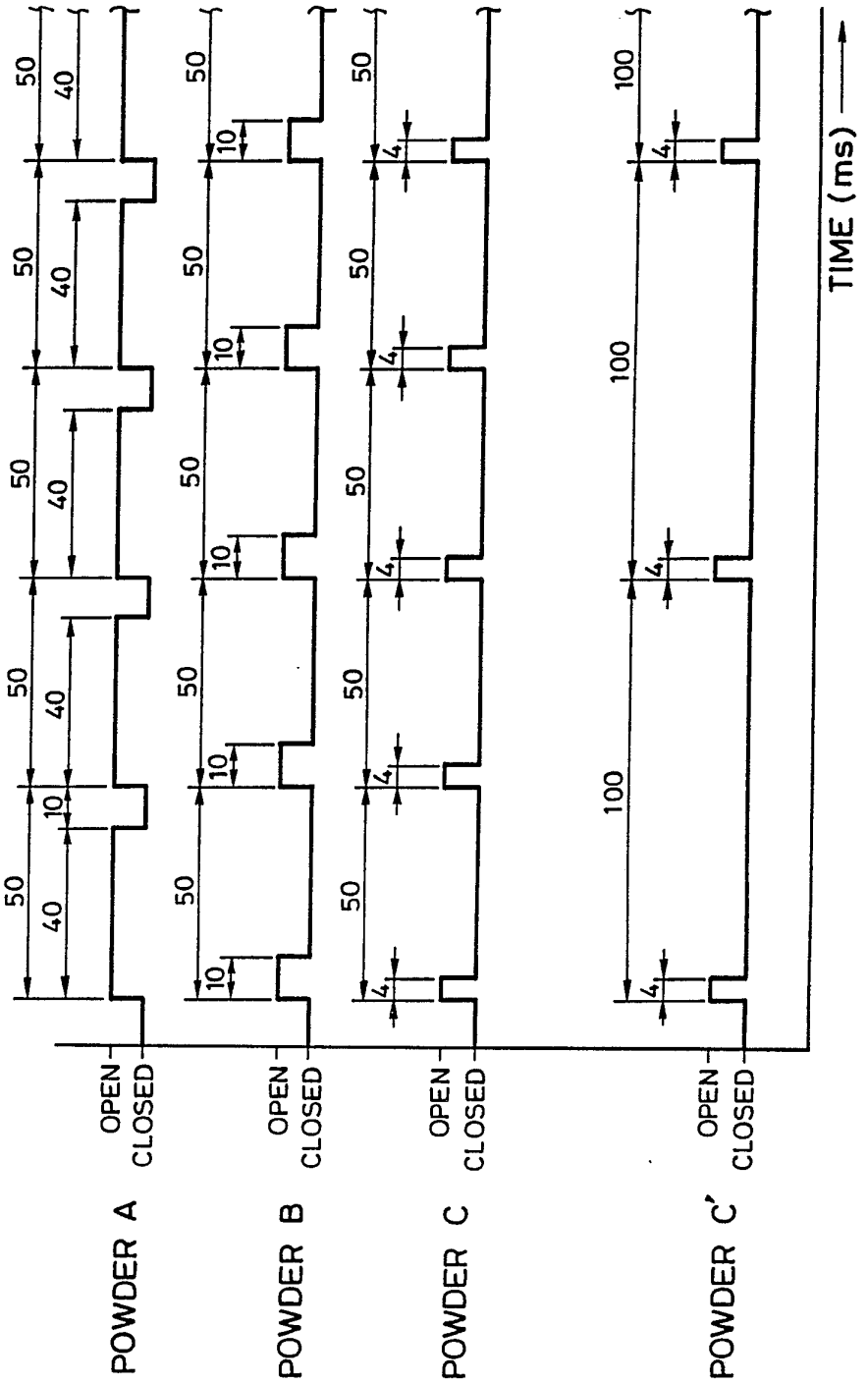

TIME (ms)
POWDER A
POWDER B
POWDER C
POWDER C'
OPEN
CLOSED
50
40
10
100
4

FIG. 14

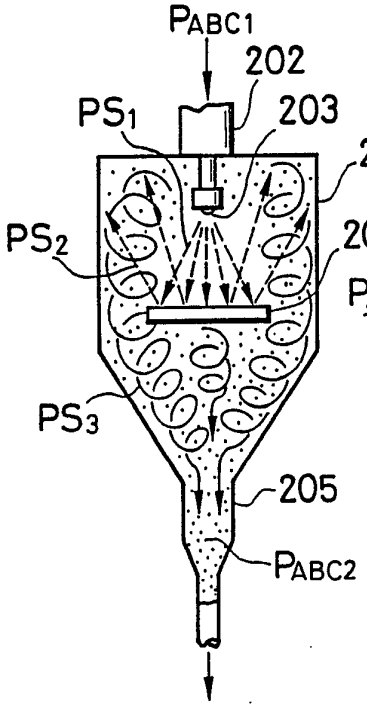


FIG. 15

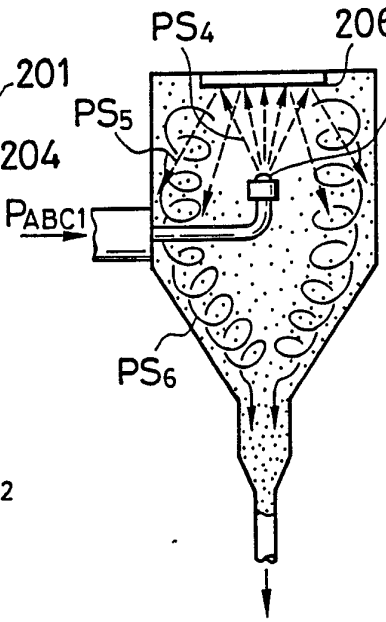


FIG. 16

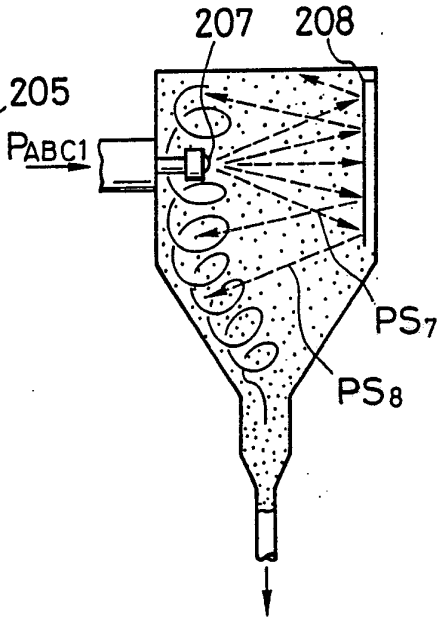


FIG. 17

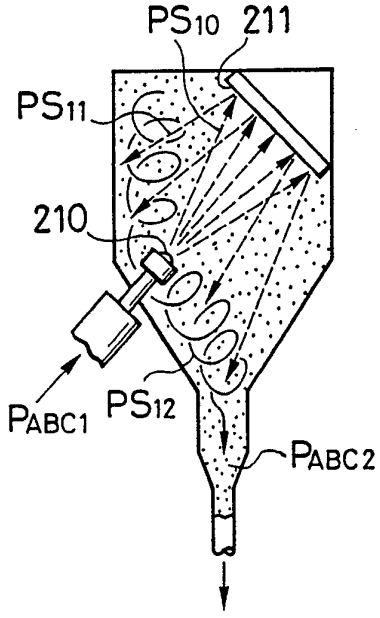


FIG. 18

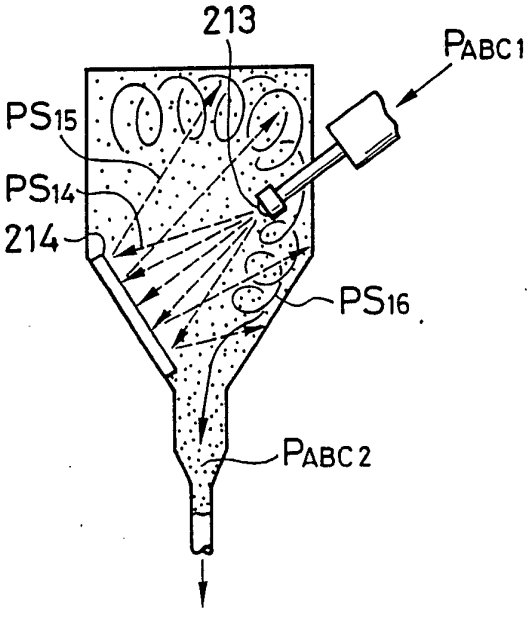


FIG. 19

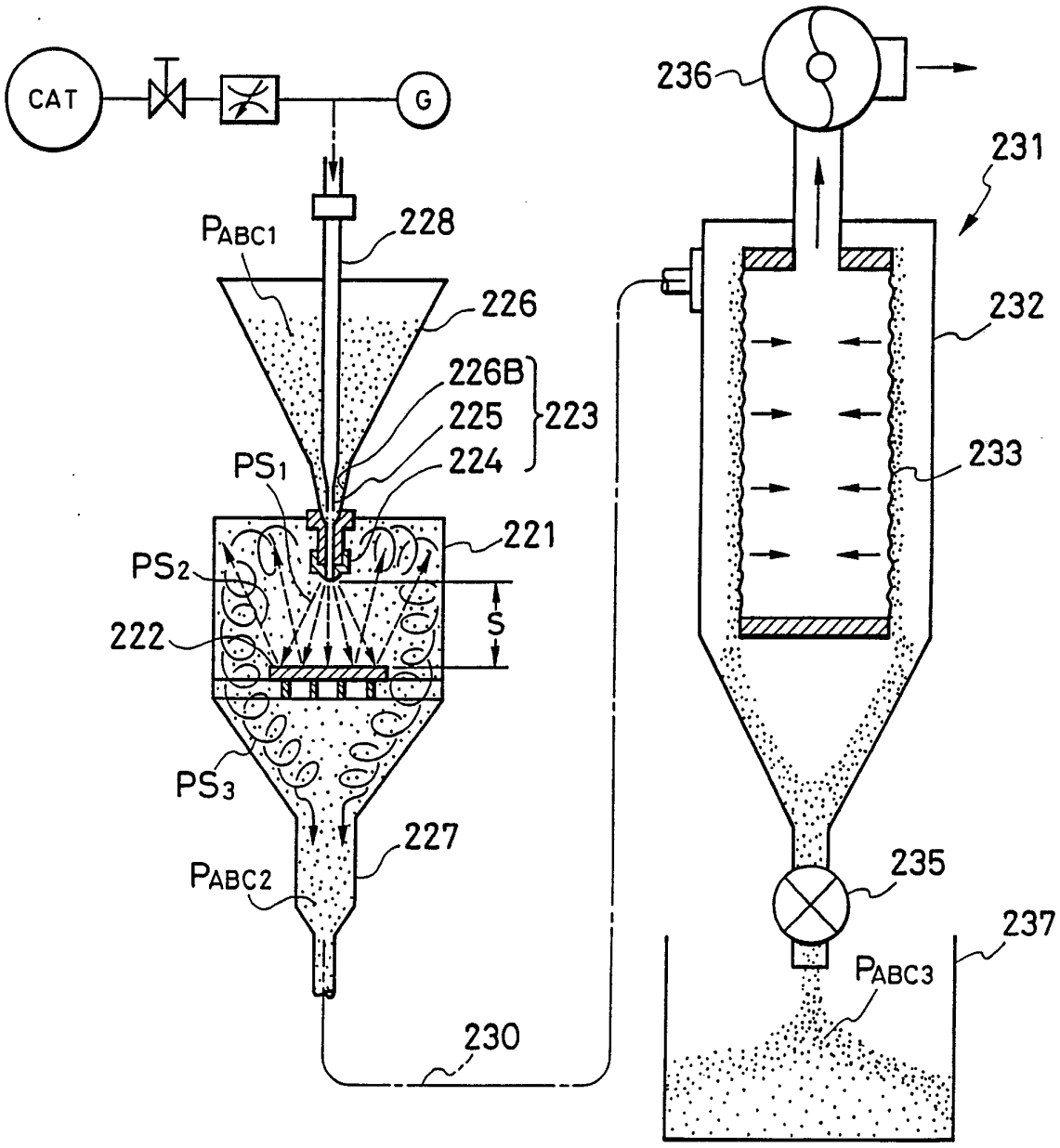

CAT
G
236
231
228
P_{ABC1}
226
232
226B
225
224
223
233
PS_1
221
PS_2
S
222
PS_3
227
235
237
P_{ABC2}
P_{ABC3}
230

FIG. 20

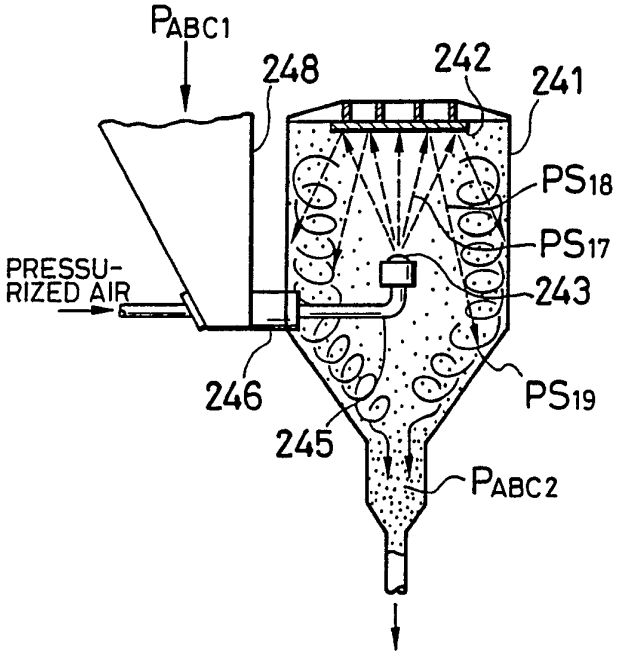


FIG. 21

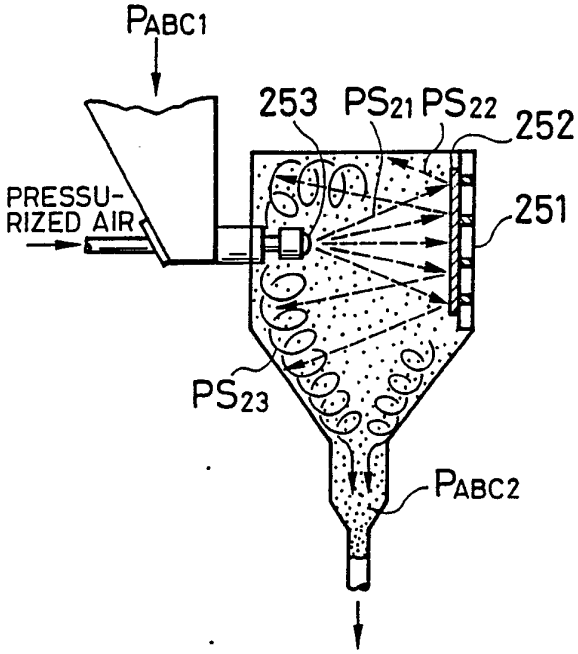


FIG. 22

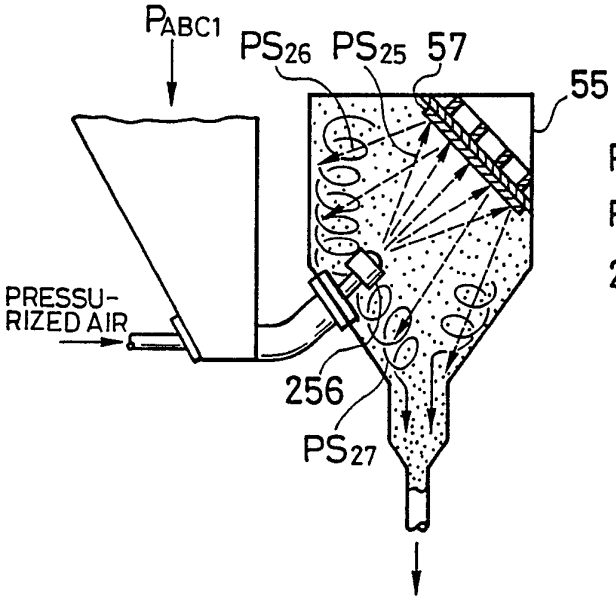


FIG. 23

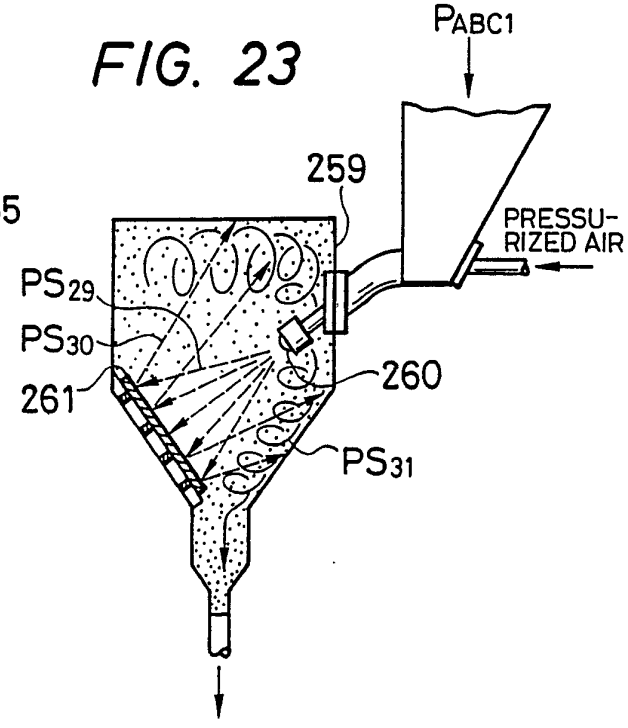


FIG. 24

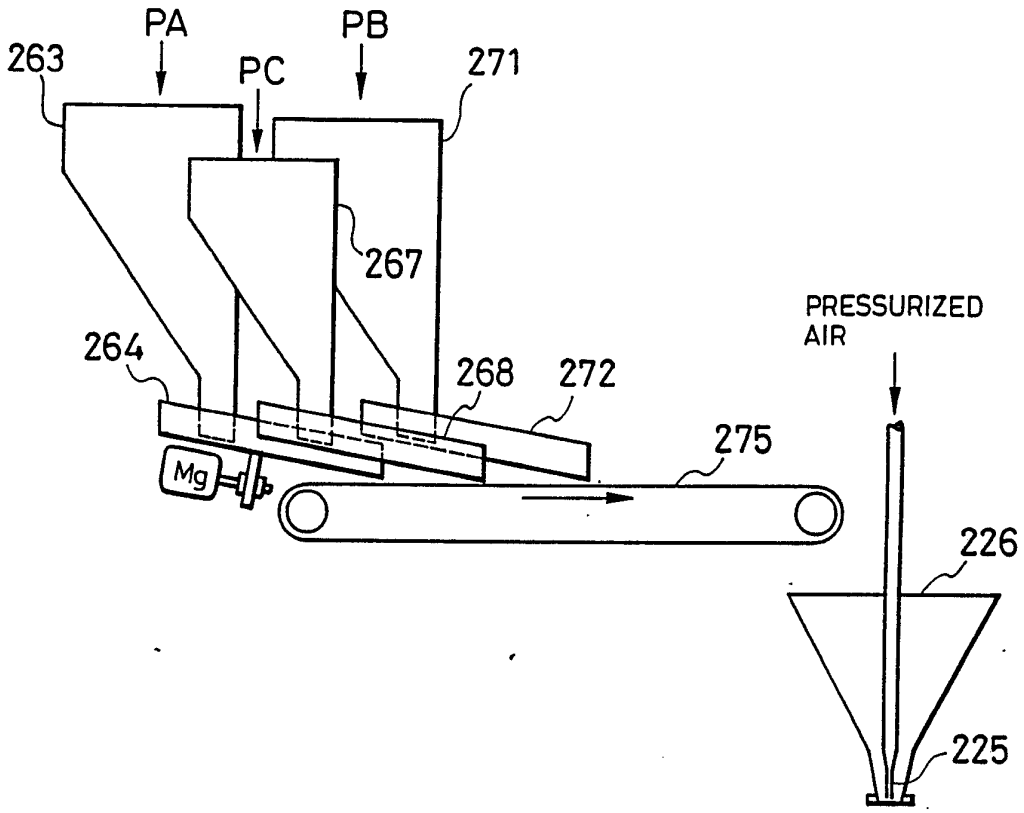

PA
PB
263
PC
271
267
PRESSURIZED
AIR
264
268
272
275
Mg
226
225

FIG. 25

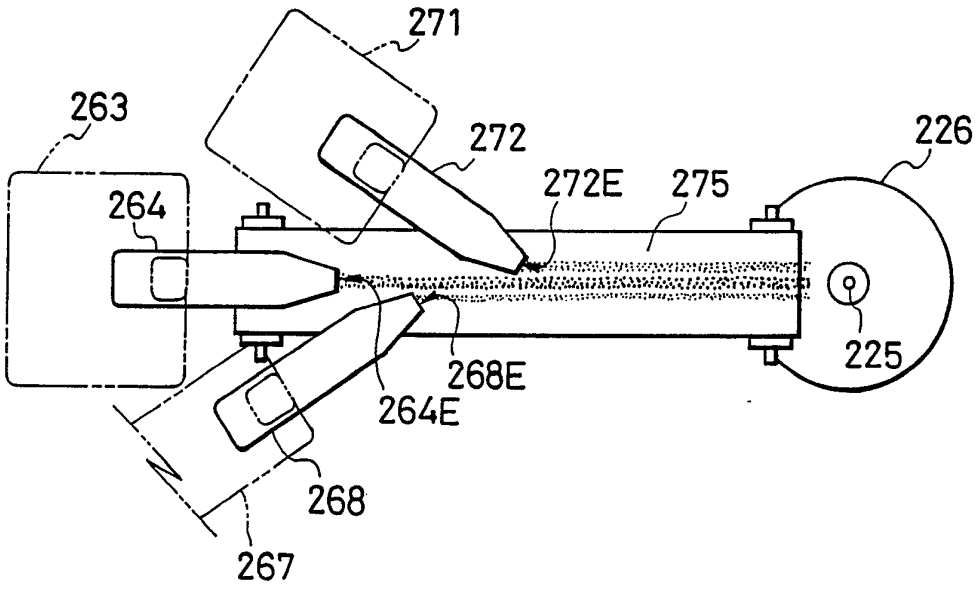
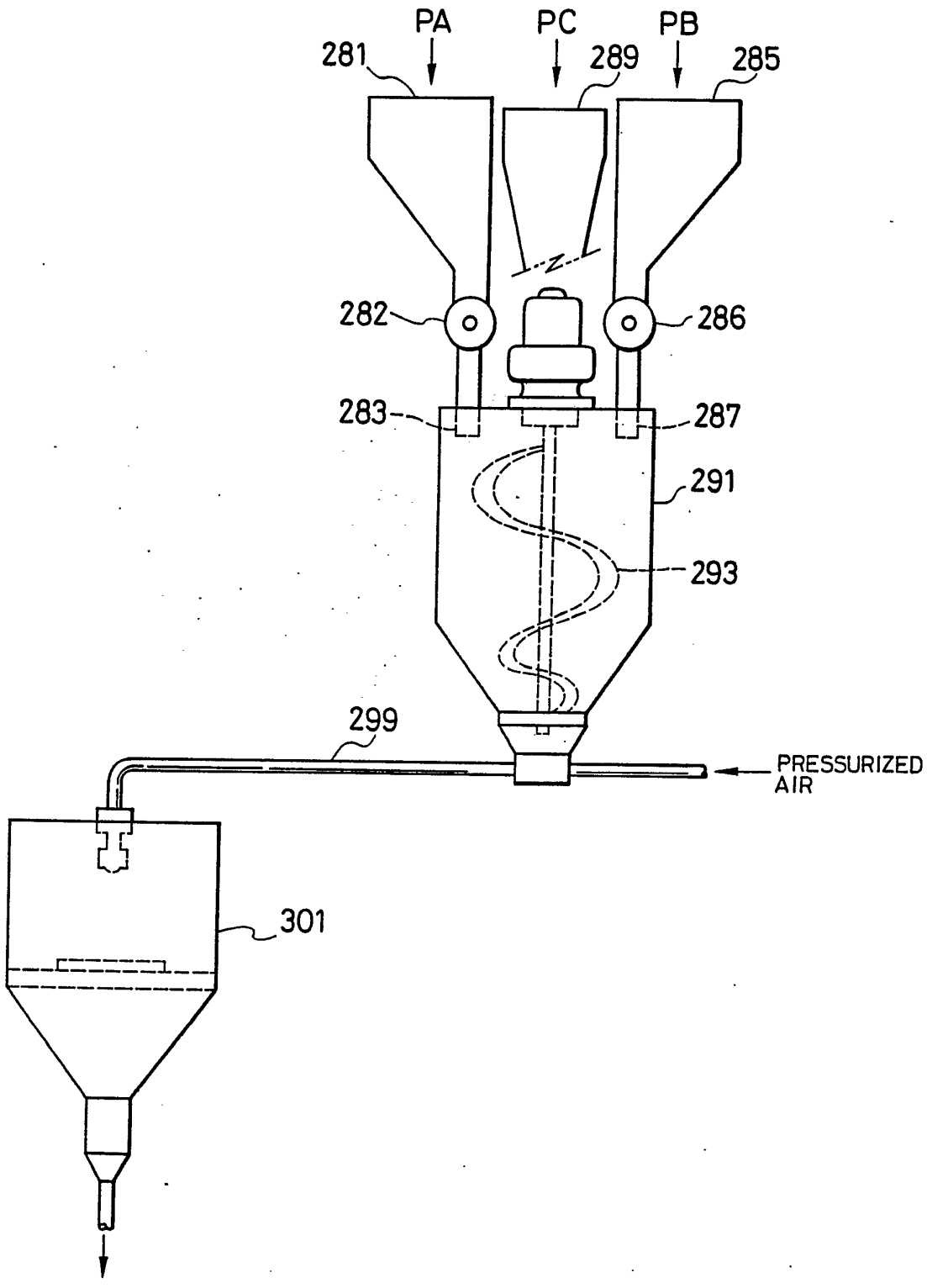

271
263
272
226
272E
275
264
225
268E
264E
268
267

FIG. 26


PA
PC
PB
281
289
285
282
286
283
287
291
293
299
PRESSURIZED AIR
301

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP 88/00499

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[4]: B 01 F 5/20; B 01 F 3/18

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[4]	B 01 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	DE, A, 2146047 (JUNG) 22 March 1973 see the whole document	1-3
A	--	4,5
X	US, A, 2991187 (SELLERS) 4 July 1961 see claim 1; figure	1-3
	--	
X	Patent Abstracts of Japan, volume 11, no. 43 (C-402)(2490), 7 February 1987, & JP, A, 61209032 (RES. DEV. CORP. OF JAPAN) 17 September 1986	6,7
	--	
A	Patent Abstracts of Japan, volume 8, no. 255 (C-253)(1692), 21 November 1984, & JP, A, 59136125 (HIROYUKI FUKUYA) 4 August 1984	8,9
	--	
A	GB, A, 652011 (RASMUSSEN) 11 April 1951 see page 2, lines 105-116; figure	4,5
	--	
A	Patent Abstracts of Japan, volume 9, no. 166 (C-290)(1889), 11 July 1985, & JP, A, 6038028 (SHIGEO ISOBE) 27 February 1985	1
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* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
3rd August 1988	02 SEP 1988
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

International Application No. PCT/JP 88/00499

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	FR, A, 1459378 (KAWASAKI) 18 November 1966 see abstract	4,5

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. JP 8800499 SA 22333

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 25/08/88
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 2146047	22-03-73	None	
US-A- 2991187		None	
GB-A- 652011		None	
FR-A- 1459378		None	