



(11)

EP 2 735 381 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.05.2014 Bulletin 2014/22

(51) Int Cl.: **B08B 5/02** (2006.01) **B08B 5/04** (2006.01)

(21) Application number: **13188448.8**

(22) Date of filing: 14.10.2013

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
 GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
 PL PT RO RS SE SI SK SM TR**
 Designated Extension States:
BA ME

(30) Priority: **22.11.2012 JP 2012256229**

(71) Applicants:

- **SHINKO CO., LTD.**
Taisho-ku
Osaka-shi
Osaka (JP)
- **Osaka City University**
Osaka-shi, Osaka 558-8585 (JP)

(72) Inventors:

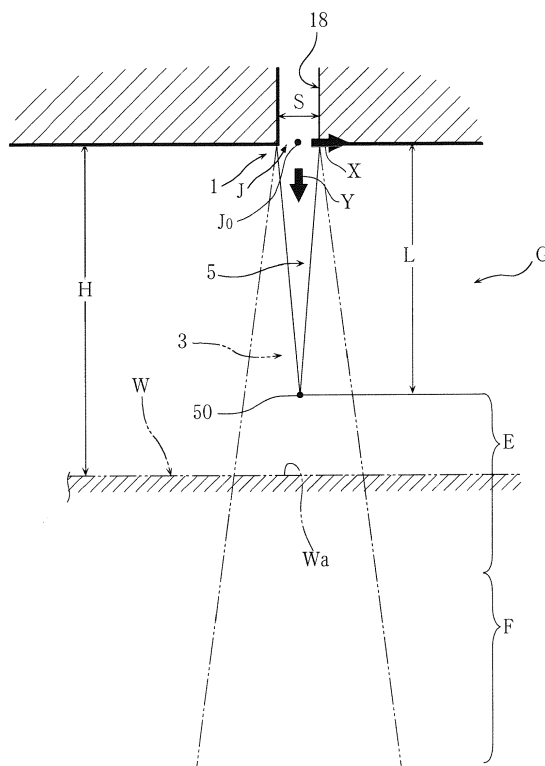
- Soemoto, Kazuhiko
Osaka (JP)
- Kato, Kenji
Osaka (JP)
- Wakimoto, Tatsuro
Osaka (JP)
- Uzawa, Hiroshi
Osaka (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **Dust-removing apparatus**

(57) An efficient dust-removing apparatus with which excellent dust-removing effect can be obtained with small amount of energy. Jet (3) from a nozzle portion (1) has a potential core (5), a transitional area (E) in which disturbance is in a developed stage, and a perfect developed area (F) of sufficiently developed diffused disturbance, and, a dust-removed face (Wa) of a work (W) is disposed within the transitional area (E) formed on a downstream side to an end (50) of the potential core (5) of the jet (3) from the nozzle portion (1).

Fig. 3



Description

[0001] This invention relates to a dust-removing apparatus.

[0002] Conventionally, in production of LCD panels for home-use liquid crystal TV, smart phones, tablet terminals, etc., removal of foreign matter such as particles is conducted by jet from a nozzle portion of a cleaner head toward a surface of a base such as plastic, glass, etc. in a clean room to improve non-defective ratio (refer to Japanese Patent Provisional Publication No. H11-235559, for example).

[0003] However, air flowing amount supplied to the cleaner head (dust-removing head) increases when the work (base) for dust removal becomes large, much energy (electricity) is consumed.

[0004] Therefore, it is an object of the present invention to provide an efficient dust-removing apparatus with which sufficient dust-removing effect can be obtained without increasing consumed energy.

[0005] This object is solved according to the present invention by dust-removing apparatus including features of claim 1. Furthermore detailed embodiments are described in the dependent claims 2 and 3.

[0006] The present invention will be described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view with a section of a principal portion showing an embodiment of the present invention;

Figure 2 is a cross-sectional view showing an example of a nozzle portion;

Figure 3 is an explanatory view of construction and function;

Figure 4 is a table showing measurement results of an embodiment and a comparison example;

Figure 5 is a graph showing a relationship between a parting dimension and a removal ratio;

Figure 6 is a graph showing a relationship between the maximum value of time average velocity and inner pressure;

Figure 7 is a graph showing distribution of time average velocity;

Figure 8 is a graph showing distribution of strength of velocity variation;

Figure 9 is a graph showing a relationship between the maximum value of strength of velocity variation and inner pressure;

Figure 10 shows graphs for comparing distributions of velocity variation spectrum in 8kPa of a first apparatus and a second apparatus;

Figure 11 shows graphs for comparing distributions of velocity variation spectrum in 11kPa of the first apparatus and the second apparatus;

Figure 12 shows graphs for comparing distributions of velocity variation spectrum in 14kPa of the first apparatus and the second apparatus;

Figure 13 is a graph showing a relationship between removal ratio and inner pressure; and

Figure 14 is a cross-sectional view of the nozzle portion of the second apparatus.

[0007] Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

[0008] As shown in Figure 1, a dust-removing apparatus of the present invention is provided with a cleaner head (dust-removing head) 9 having an air reserve chamber 11 to which pressurized air is supplied and a suction chamber 12 of negative pressure, and a blower device not shown in figures for pressurization and suction to supply air to the air reserve chamber 11 of the cleaner head 9 and to make the suction chamber 12 vacuum.

[0009] And, inner pressure P of the air reserve chamber 11 can be regulated by an inverter regulating the air amount supplied to the air reserve chamber 11 by the blower device.

[0010] The cleaner head 9 has a nozzle portion 1 to jet the air out of the air reserve chamber 11, and a suction hole 19 to connect the suction chamber 12 to the outside.

[0011] And, foreign matter such as particles stuck to a dust-removed face Wa of a work W such as a glass base for liquid crystal display is exfoliated by jet (air jet) 3 from the nozzle portion 1, and the foreign matter is sucked into the suction chamber 12 through the suction hole 19.

[0012] The nozzle portion 1 has a jetting groove 10 to exhaust the air in the air reserve chamber 11. The jetting groove 10 is formed along a longitudinal direction L₁₀ of the cleaner head 9.

[0013] As shown in Figure 2, the jetting groove 10 has an air flow-in portion 13 connected to the air reserve chamber 11 and straight in lateral cross section, a first cavity portion 14 (wide middle portion) continuing to a downstream side of the air flow-in portion 13, expanding as goes to an outer (jet) side, and triangular in lateral cross section, a cavity connecting portion 15 continuing to a downstream side of the first cavity portion 14 and straight in lateral cross section, a second cavity portion 16 (wide middle portion) continuing to a downstream side of the cavity connecting portion 15, expanding as goes to an outer side, and triangular in lateral cross section, a third cavity portion 17 continuing to a downstream side of the second cavity portion 16 and rectangular in cross section wider than the connecting portion 15, and a jetting slit 18 connecting a downstream side of the third cavity portion 17 and the outside. The width dimensions of the air flow-in portion 13 and the cavity connecting portion 15 are formed into the same dimension.

[0014] The nozzle portion 1 gives the air flow variations of high frequency by feedback mechanism that disturbance generated by the first and second cavity portions 14 and 16 on the downstream side (corner portion on the downstream end in the cavity) is transmitted as to influence the flow on an upstream side (exfoliated flow on the upstream in the cavity), and the influenced (vortex) influences the disturbance generated on the downstream.

[0015] As shown in Figure 3, the jet 3 jetted from the jetting slit 18 has a potential core (area) 5 not reducing velocity (constant velocity), a transitional area (developed area) E on downstream side to an end (vanishing position) 50 of the potential core 5 in which disturbance is in a developed stage, and a perfect developed area (diffused area) F of sufficiently developed diffused disturbance through the transitional area E. And, the jet 3 is a flow to which high-frequency variation (of velocity and pressure) is added by the feedback mechanism by the first and second cavity portions 14 and 16.

[0016] Conventionally, it is said that a construction, in which large amount of air is jetted with high energy, a nozzle is positioned as close as possible to the work W as to position the dust-removed face Wa of the work W within the potential core 5, is appropriate for dust removal. Therefore, large amount of energy is consumed to jet the large amount of air with high energy to a large work W.

[0017] So the inventors of the present invention, through an eager research to improve dust-removing efficiency with saving energy, made a unique idea that the dust-removed face Wa of the work W is positioned in the transitional area E on the downstream side of the end 50 of the potential core 5 of the jet 3 and on the upstream side of the perfect developed area F.

[0018] And, when a parting dimension of a gap G between an outlet portion J of the jetting slit 18 and the dust-removed face Wa is H[mm], and a length dimension of the potential core 5 (a length dimension from the outlet portion J to the end 50) is L[mm], it is revealed that dust-removing efficiency decreases when the parting dimension H is beyond 1.5 times of the length dimension L of the potential core 5 on the downstream side to the end 50 of the potential core 5 of the jet 3. That is to say, a range of $L < H \leq 3L/2$ is discovered.

[0019] Further, considering a relationship between the potential core 5 and the jetting slit 18, a slit width dimension of the jetting slit 18 is made S[mm], the length dimension L of the potential core 5 generated within a practical range of $0.1\text{mm} \leq S \leq 10\text{mm}$ is measured, and the results of measurement is that the length dimension L of the potential core 5 is 5 to 6 times of the slit width dimension S. Therefore, $H > 6S$ is considered to certainly place the dust-removed face Wa on the downstream side to the end 50 of the potential core 5.

[0020] Consequently, in the dust-removing apparatus relating to the present invention, the slit width dimension S and the parting dimension H are set as to fulfill the formula 1 below to place the dust-removed face Wa within the transitional area E.

$$[\text{formula 1}] \quad H/9 \leq S < H/6$$

[0021] And, it is preferable to set the slit width dimension S as to fulfill the formula 1 above within a range of $1\text{mm} \leq H \leq 2\text{mm}$.

[0022] Herewith function and effect are explained with test results of an embodiment and a comparison example.

[0023] First, the embodiment is having the nozzle portion 1 of Figure 2, and constructed as to fulfill the formula 1 with the parting dimension H of 1.5mm and the slit width dimension S of 0.2mm.

[0024] Next, a dust-removing apparatus, having the nozzle portion 1 of Figure 2 and not fulfilling the formula 1 with the parting dimension H of 1.5mm and the slit width dimension S of 0.4mm, (in other words, a dust-removing apparatus in which the dust-removed face Wa is on the upstream side to the end 50 of the potential core 5) is the comparison example. And, inner pressure P in the air reserve chamber 11 is administrated (regulated) to the same (14kPa) in the embodiment and the comparison example.

[0025] Removal ratio γ is measured for each of particles of which diameter is $3\text{ }\mu\text{m}$ and particles of which diameter is $1.6\text{ }\mu\text{m}$. The removal ratio γ , average velocity of the jet 3, and strength of velocity variation of the jet 3 are shown in a table of Figure 4. The method of measurement is described later.

[0026] As clearly shown in Figure 4, in the embodiment, the removal ratio γ is similar to that of the comparison example relating to the particle of $3\text{ }\mu\text{m}$, and the removal ratio γ is better than that of the comparison example relating to the particle of $1.6\text{ }\mu\text{m}$. The flowing amount remarkably decreases in the embodiment in comparison with the comparison example because the embodiment has the inner pressure P same to that of the comparison example, and the slit width dimension S of $1/2$. That is to say, in the embodiment, supplied air amount is approximately half in comparison with the comparison example, and the device to supply air to the cleaner head 9 (blower device) can be made small.

[0027] Next, with a dust-removing apparatus, having the nozzle portion 1 of Figure 2 and the slit width dimension S of 0.2mm, called first apparatus, the removal ratio γ is measured in a case that the dust-removed face Wa is gradually departed from the downstream side to the end 50 of the potential core 5.

[0028] And, the measured results of change in the removal ratio γ , in a case that the inner pressure P of the air reserve chamber 11 of the first apparatus is changed to 8kPa, 11kPa, and 14kPa, are shown in Figure 5.

[0029] As clearly shown in Figure 5, the removal ratio γ shows an inclination to decrease when H is increased. The range of H to fulfill the formula 1 is $1.2\text{mm} < H \leq 1.8\text{mm}$ because $S=0.2\text{mm}$. When H is beyond 1.8mm, the removal ratio γ rapidly decreases.

[0030] That is to say, as in the above-described comparison example, when the dust-removed face Wa is disposed within the potential core 5, the strength of velocity variation is small even if time average velocity is large, and the removal ratio becomes inferior. And, when the dust-removed face Wa is too far from the end 50 of the potential core 5 as shown in Figure 5, the average velocity of the jet 3 hitting the dust-removed face Wa becomes too low to obtain sufficient dust-removing effect (the removal ratio γ decreases).

[0031] And, when the time average velocity of the jet 3 at the dust-removed face Wa in the jetting direction (y direction) is U[m/s], its maximum value is U_{max} [m/s], the strength of velocity variation (RMS value) in the jetting direction of the jet 3 is V' [m/s], and its maximum value is V'_{max} [m/s], the dust-removing apparatus relating to the present invention is constructed as to fulfill the following formula 2 and formula 3.

$$\text{[formula 2]} \quad 110 < U_{\text{max}} < 150 \quad (\text{unit:m/s})$$

$$\text{[formula 3]} \quad 6.0 \leq (V'_{\text{max}}/U_{\text{max}}) \times 100 \leq 12$$

[0032] More preferably, the dust-removing apparatus is constructed as to fulfill the following formula 4 and formula 5.

$$\text{[formula 4]} \quad 120 < U_{\text{max}} < 150 \quad (\text{unit:m/s})$$

$$\text{[formula 5]} \quad 7.5 \leq (V'_{\text{max}}/U_{\text{max}}) \times 100 \leq 12$$

[0033] Herewith function and effect are explained with results of comparing a second apparatus, a dust-removing apparatus having a nozzle portion 1' in Figure 14, with the above-described first apparatus.

[0034] In the nozzle portion 1' in Figure 14, the first cavity portion 14, the cavity connecting portion 15, and the second cavity portion 16 of the nozzle portion 1 in Figure 2 are omitted, and the air flow-in portion 13 and the third cavity portion 17 are directly connected. Dimensions of common components such as the slit width dimension S are the same.

[0035] And, both of the first apparatus and the second apparatus, in which the slit width dimension S is 0.2mm and the parting dimension H is 1.5mm, fulfill the formula 1. And, the inner pressure P of the air reserve chamber 11 is changed to 8kPa, 11kPa, and 14kPa in each of the apparatuses.

[0036] The measured results of the jet 3 in each of the apparatuses are explained. As shown in Figure 3, with a central position J_0 in an outlet width direction of an outlet portion J of the jetting slit 18 as an origin, X coordinate is plotted in horizontal direction and Y coordinate is plotted in the jetting direction (vertically downward in figures).

[0037] The measured results of the maximum value U_{max} of time average velocity in the jetting direction (Y direction) of the jet 3 when $X=0\text{mm}$ and $Y=1.5\text{mm}$ in the first apparatus and the second apparatus are shown in Figure 6.

[0038] As clearly shown in Figure 6, the maximum value U_{max} of time average velocity shows an inclination to be large along with increase of the inner pressure P in both of the first apparatus and the second apparatus.

[0039] Next, the measured results of distribution of the time average velocity U in the X direction with $Y=1.5\text{mm}$ in the case of the inner pressure P of 14kPa are shown in Figure 7.

[0040] As clearly shown in Figure 7, difference between the first apparatus and the second apparatus is hardly observed. That is to say, average characteristic of the jet 3 does not change according to the difference of configurations between the nozzle portions 1 and 1' under the same inner pressure.

[0041] Next, the measured results of distribution of the strength of velocity variation V' in the jetting direction of the jet 3 in the X direction with $Y=1.5\text{mm}$ are shown in Figure 8.

[0042] As clearly shown in Figure 8, the maximum value of the strength of velocity variation reveals not on $X=0$ directly below the nozzle where the maximum value of time average velocity is measured, but on $X \approx 0.3$ where approximately half value of the maximum value of average velocity is measured. It is considered that distribution slope of the maximum

value of time average velocity is steep on this position, and large velocity change may be generated by forming a shearing layer.

[0043] And, the strength of velocity variation of the first apparatus resulted to be larger than that of the second apparatus. It is considered that the effect of construction of the nozzle portion 1 in Figure 2 having the first cavity portion 14 and the second cavity portion 16 of which cross sections are triangular becomes remarkable.

[0044] Next, the relationship between the maximum value V' max of the strength of velocity variation and the inner pressure P of the air reserve chamber 11 is shown in Figure 9.

[0045] As clearly shown in Figure 9, similar to the maximum value U_{max} of the time average velocity, there is an inclination that V' max increases along with the increase of the inner pressure of the air reserve chamber 11. And, V' max of the first apparatus is larger than V' max of the second apparatus. Although not shown in figures, pressure change has similar inclination of the result for the velocity change.

[0046] And, graphs, comparing velocity change spectral distribution in each of inner pressures P of the first apparatus and the second apparatus, are shown in Figure 10 through Figure 12.

[0047] As clearly shown in Figure 10 through Figure 12, in each of inner pressures P of 8kPa, 11kPa, and 14kPa, the first apparatus remarkably surpasses the second apparatus in spectral strength in a high frequency zone of 10 to 20kHz and contributes to the difference of the strength of velocity variation. That is to say, it is considered that the first cavity portion 14 and the second cavity portion 16 work effectively.

[0048] And, the maximum value of the time average velocity U_{max} at the dust-removed face W_a in the jetting direction and the maximum value V' max of the strength of velocity variation in the jetting direction resulted as follows.

[0049] In the first apparatus, $U_{max}=116\text{m/s}$, and V' max=7.3m/s in the case of the inner pressure P of 8kPa. In the case of the inner pressure P of 11kPa, $U_{max}=123\text{m/s}$, and V' max=10.4m/s. And in the case of the inner pressure P of 14kPa, $U_{max}=135\text{m/s}$, and V' max=12.3m/s.

[0050] In the second apparatus, $U_{max}=111\text{m/s}$, and V' max=5.0m/s in the case of the inner pressure P of 8kPa. In the case of the inner pressure P of 11kPa, $U_{max}=123.5\text{m/s}$, and V' max=5.5m/s. And in the case of the inner pressure P of 14kPa, $U_{max}=132\text{m/s}$, and V' max=6.0m/s.

[0051] As clearly shown by the results above, the first apparatus has the construction which fulfills the formula 2 and formula 3, and the second apparatus has the construction which does not fulfill the formula 2 and formula 3.

[0052] Next, the measured results of the removal ratio γ of silica-acrylic compound particles of which diameter is 3 μm with the first apparatus and the second apparatus are shown in Figure 13.

[0053] As clearly shown in Figure 13, the removal ratio γ of particles becomes high along with the increase of the inner pressure P . In other words, the removal ratio γ is improved as the time average velocity becomes large. And, the removal ratio γ of the first apparatus surpasses the removal ratio γ of the second apparatus.

[0054] In the time average velocity of the first apparatus and the second apparatus under the same inner pressure, difference is hardly observed in value and distributional configuration. However, difference is observed in the strength of velocity variation. That is to say, when the time average velocity is the same, the removal ratio γ corresponds to the inclination of the strength of velocity variation. Adding to largeness of the time average velocity of the jet 3, largeness of the strength of velocity variation is important to remove the particles, and the construction fulfilling the formula 2 and formula 3 generates the jet 3 of well-balanced time average velocity and strength of velocity variation (optimum for dust removal).

[0055] Even if the maximum value U_{max} of the time average velocity of the first apparatus is smaller than the maximum value U_{max} of the time average velocity of the second apparatus (in comparison with the case that the inner pressure P of the first apparatus is 11kPa and the inner pressure P of the second apparatus is 14kPa), the first apparatus (fulfilling the formula 2 and formula 3) has the removal ratio γ better than that of the second apparatus (not fulfilling the formula 2 and formula 3), sufficient dust-removing effect is obtained with small consumed energy.

[0056] And, in the first apparatus, the case that the inner pressure P is 8kPa does not fulfill the formula 4 and formula 5, and the case that the inner pressure P is 11kPa or 14kPa fulfills the formula 4 and formula 5.

[0057] As clearly shown in Figure 13, the constructions which fulfill the formula 4 and formula 5 show quite excellent dust-removing effect with the removal ratio γ over 99%. That is to say, fulfilling the formula 4 and formula 5, the jet 3 optimum for dust removal is generated. For example, the construction fulfilling the formula 4 and formula 5 can be obtained by setting the slit width dimension S and regulating (setting) the inner pressure P of the air reserve chamber 11.

[0058] The measuring method of the time average velocity and the velocity variation is that a hot wire anemometer of I type is set on a position apart from the central position J_0 in the outlet width direction of the jetting slit 18 for 1.5mm ($Y=1.5\text{mm}$), output of the hot wire anemometer of I type is recorded by a digital oscilloscope, the strength of velocity variation is obtained with calculation of the time average velocity. The measurement is conducted with an interval of 0.02mm in the X direction.

[0059] And, in the measuring method of the removal ratio γ , a glass base with chrome film, of which thickness is 0.7mm and of which surface area is 300mm $\times$ 400mm, is used as the work W .

[0060] Test particles are uniformly diffused by a syringe onto the dust-removed face W_a of the work W sufficiently

cleaned in advance. The work W is fixed to an adsorption table, and cleaning (dust-removing test) is conducted on the whole surface of the dust-removed face Wa by the cleaner head 9 transferred with a speed of 100mm/sec. Number of stuck particles n_0 before the diffusion of the particles, number of particles n_1 after the diffusion, and number of remaining stuck particles n_2 after the cleaning (dust-removing test), are measured. The particle removal ratio (dust-removal ratio) γ % is obtained by the formula 6 below. And, a surface test apparatus (GI4830 produced by Hitachi High-Technologies Corporation) is used for counting the numbers of stuck particles in a class 100 clean room. Three or more times of measurement are conducted under the same test conditions, and the average value is adopted as the dust-removal ratio.

$$[\text{formula 6}] \quad \gamma = \{100 (n_1 - n_2)\} / (n_1 - n_0)$$

[0061] In the present invention, being modifiable, the cavity portion, not restricted to the cross sectional configuration in Figure 2, may be laterally long (long width) rectangular or triangular diminishing downward. The work W, not particularly restricted, may be a sheet body of paper, film, metal foil, etc., or a panel body of plastic base, glass base, etc. And, the apparatus may be constructed as to conduct the dust removal with the nozzle portion 1 relatively moved. For example, the apparatus may be constructed that the cleaner head 9 is fixed and the work W is transferred by a transferring device to conduct the dust removal, or, the work W is fixed and the cleaner head 9 is moved to conduct the dust removal as in the removal test, or, both of the cleaner head 9 and the work W are moved to conduct the dust removal.

[0062] As described above, with the dust-removing apparatus of the present invention, the air amount jetted from the nozzle portion 1 can be reduced, and sufficient dust-removing effect can be obtained with small consumed energy (electricity) because the dust-removed face Wa of the work W is disposed within the transitional area E formed on the downstream side to the end 50 of the potential core 5 of the jet 3 from the nozzle portion 1. Or, in case that the jetted air amount is the same as the conventional apparatuses (energy consumption is the same as the conventional apparatuses), cleaning ability can be improved. Especially, very fine foreign matter of which size is 2 μm or less can be removed with high removal ratio.

[0063] And, the sufficient removal ratio γ can be obtained with small air amount, and the apparatus can contribute to reduction of running cost of the cleaning process because the slit width dimension of the jetting slit 18 of the nozzle portion 1 is S, the parting dimension between the outlet portion J of the jetting slit 18 and the dust-removed face Wa is H, and S is set as to fulfill the above-mentioned formula 1 to dispose the dust-removed face Wa within the transitional area E.

[0064] And, even when the velocity and the inner pressure are low (lower in comparison with the conventional apparatuses), sufficient dust-removing effect can be obtained because the maximum value of time average velocity of the jet 3 in jetting direction at the dust-removed face Wa is U_{max} , the maximum value of strength of velocity variation in the jetting direction of the jet 3 is V'_{max} , and they fulfill the above-mentioned formula 2 and formula 3. Or, in case that the average velocity (the inner pressure P of the air reserve chamber 11) is the same as the conventional apparatuses, the removal ratio γ better than that of the conventional apparatuses can be obtained.

Claims

1. A dust-removing apparatus **characterized by** that a dust-removed face (Wa) of a work (W) is disposed within a transitional area (E) formed on a downstream side to an end (50) of a potential core (5) of jet (3) from a nozzle portion (1).
2. The dust-removing apparatus as set forth in claim 1, wherein a slit width dimension of a jetting slit (18) of the nozzle portion (1) is S, a parting dimension between an outlet portion (J) of the jetting slit (18) and the dust-removed face (Wa) is H, and S is set as to fulfill a formula 1 below to dispose the dust-removed face (Wa) within the transitional area (E).

$$[\text{formula 1}] \quad H/9 \leq S < H/6$$

3. The dust-removing apparatus as set forth in claim 2, wherein maximum value of time average velocity of the jet (3) in jetting direction at the dust-removed face (Wa) is U_{max} , maximum value of strength of velocity variation in the jetting direction of the jet (3) is V'_{max} , and they fulfill formula 2 and formula 3 below.

[formula 2] $110 < U_{\max} < 150$ (unit:m/s)

5

[formula 3] $6.0 \leq (V'_{\max}/U_{\max}) \times 100 \leq 12$

10

15

20

25

30

35

40

45

50

55

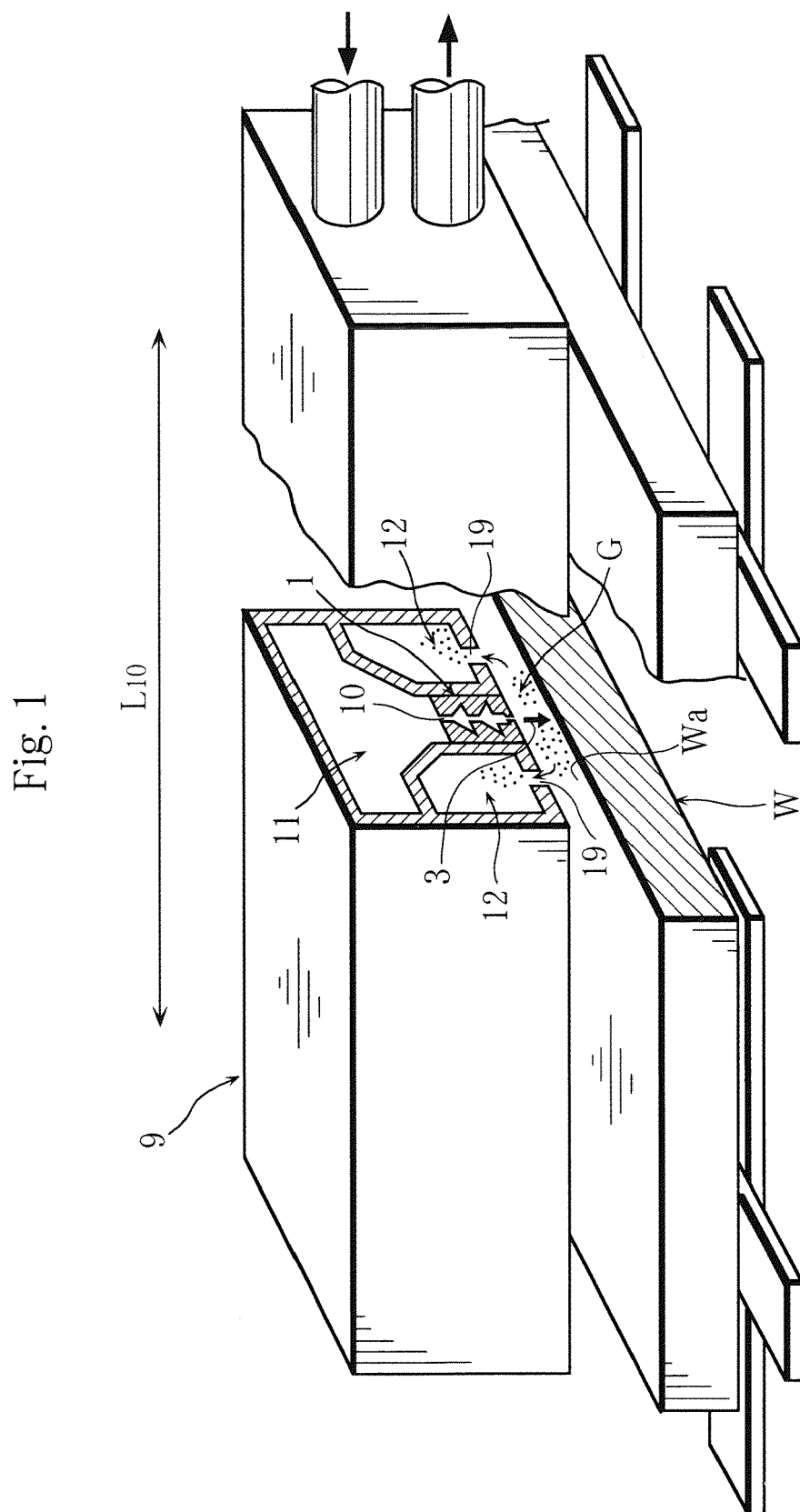


Fig. 2

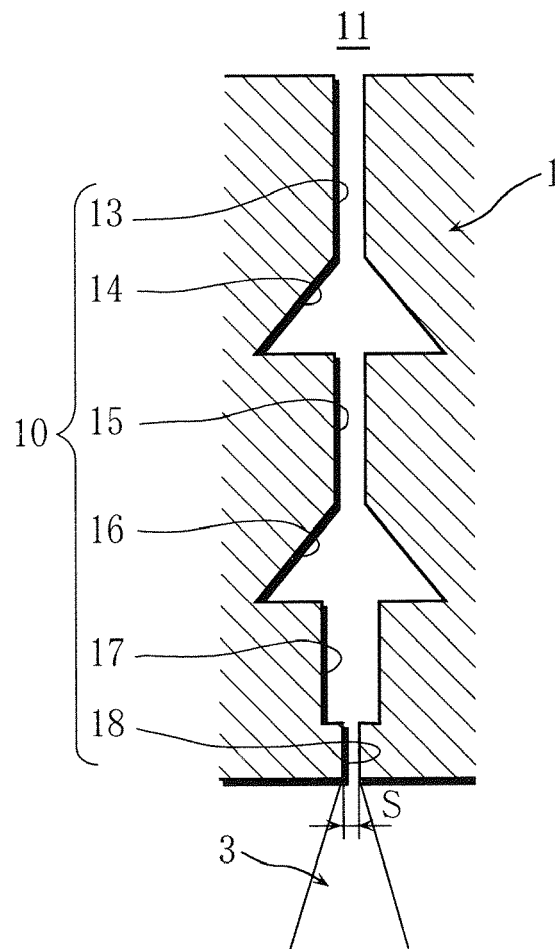


Fig. 3

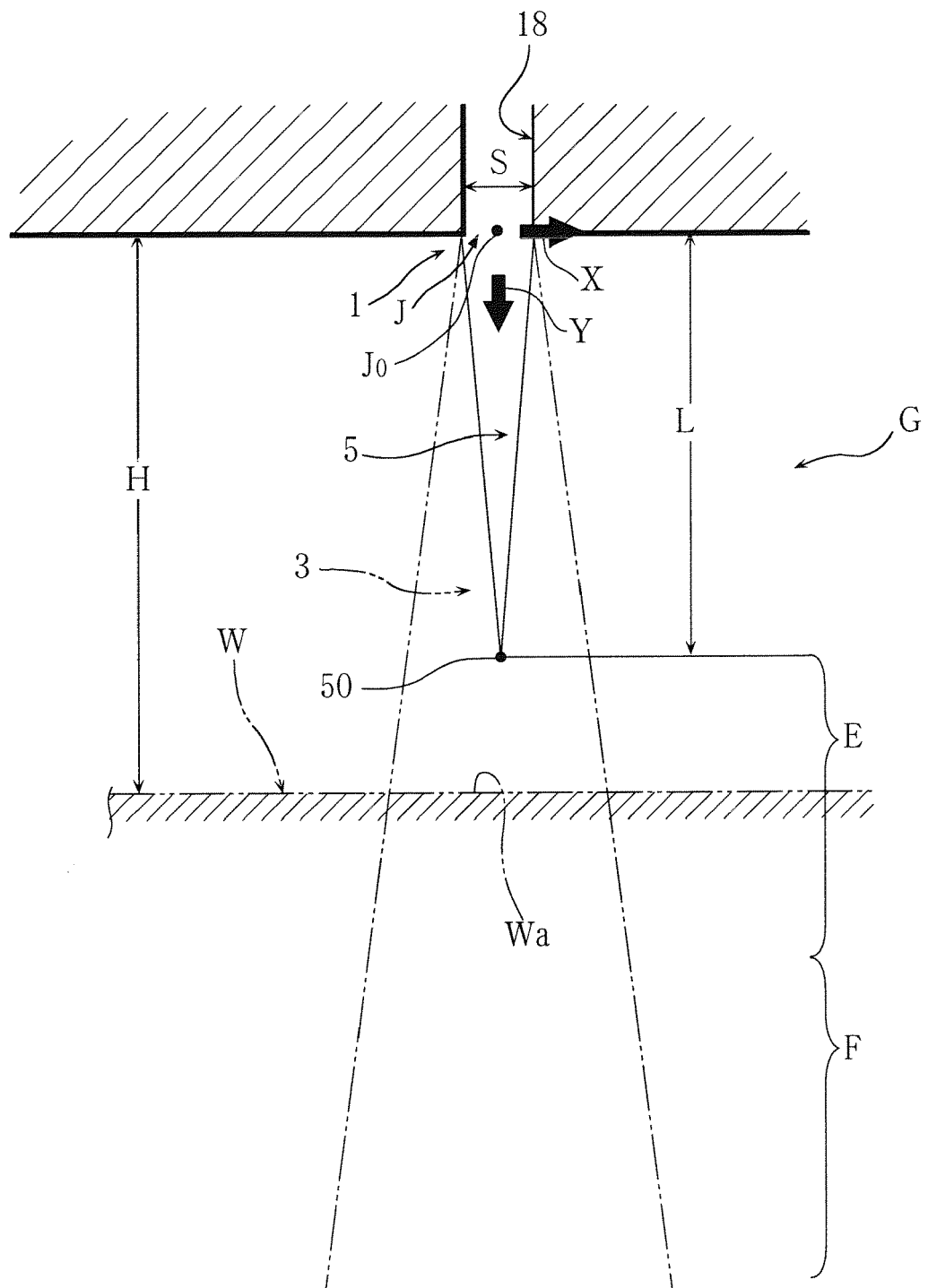


Fig. 4

	Embodiment	Comparison Example
Slit width dimension (mm)	0.2	0.4
Maximum value of time average velocity (m/s)	135	162
Maximum value of strength of velocity variation (m/s)	12.3	11
Removal ratio of $3\mu\text{m}$ particles (%)	99.20	99.00
Removal ratio of $1.6\mu\text{m}$ particles (%)	99.70	98.00

Fig. 5

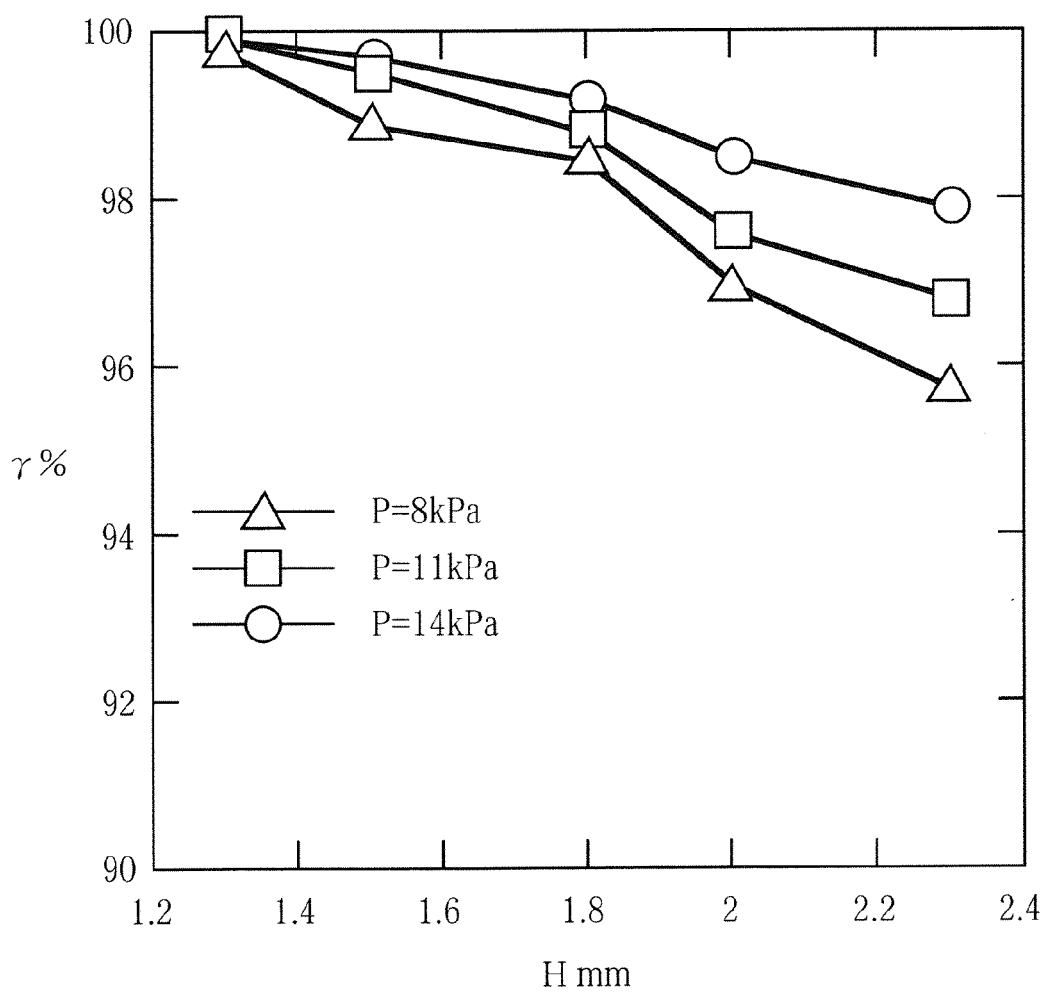


Fig. 6

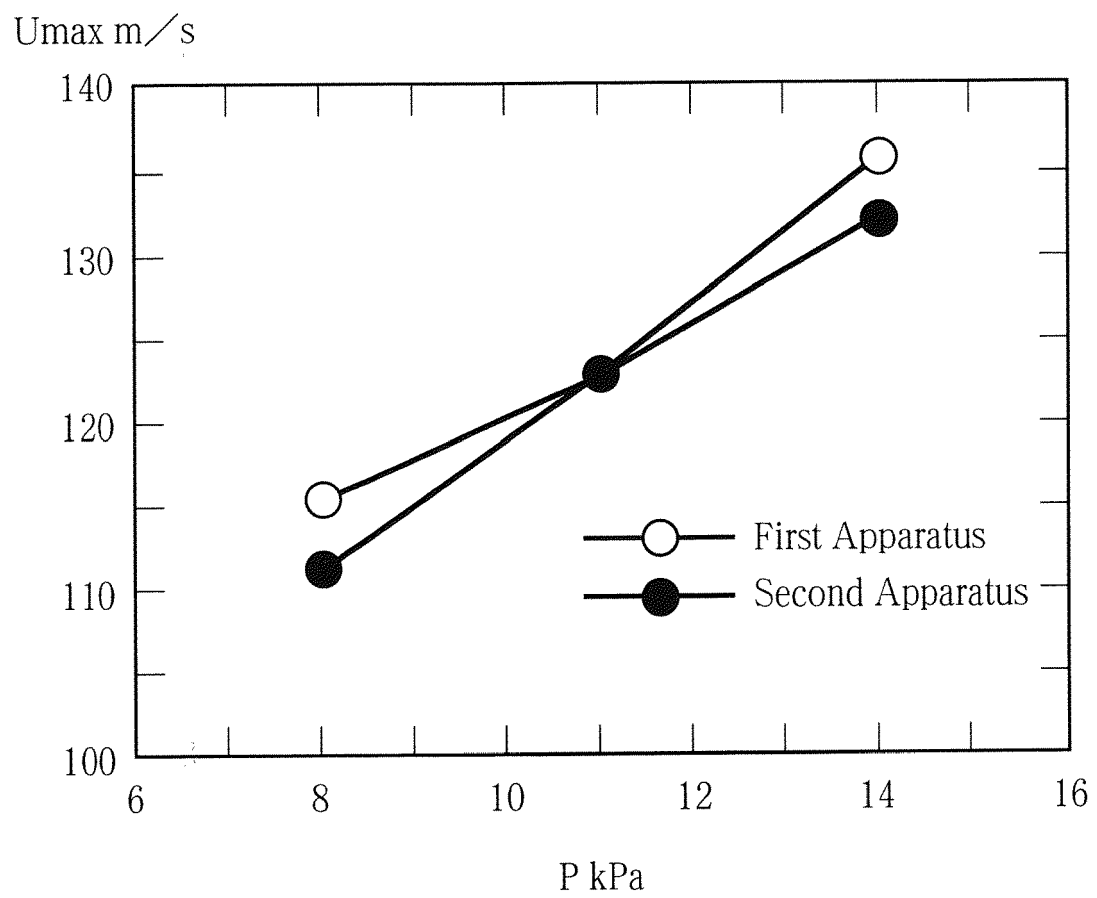


Fig. 7

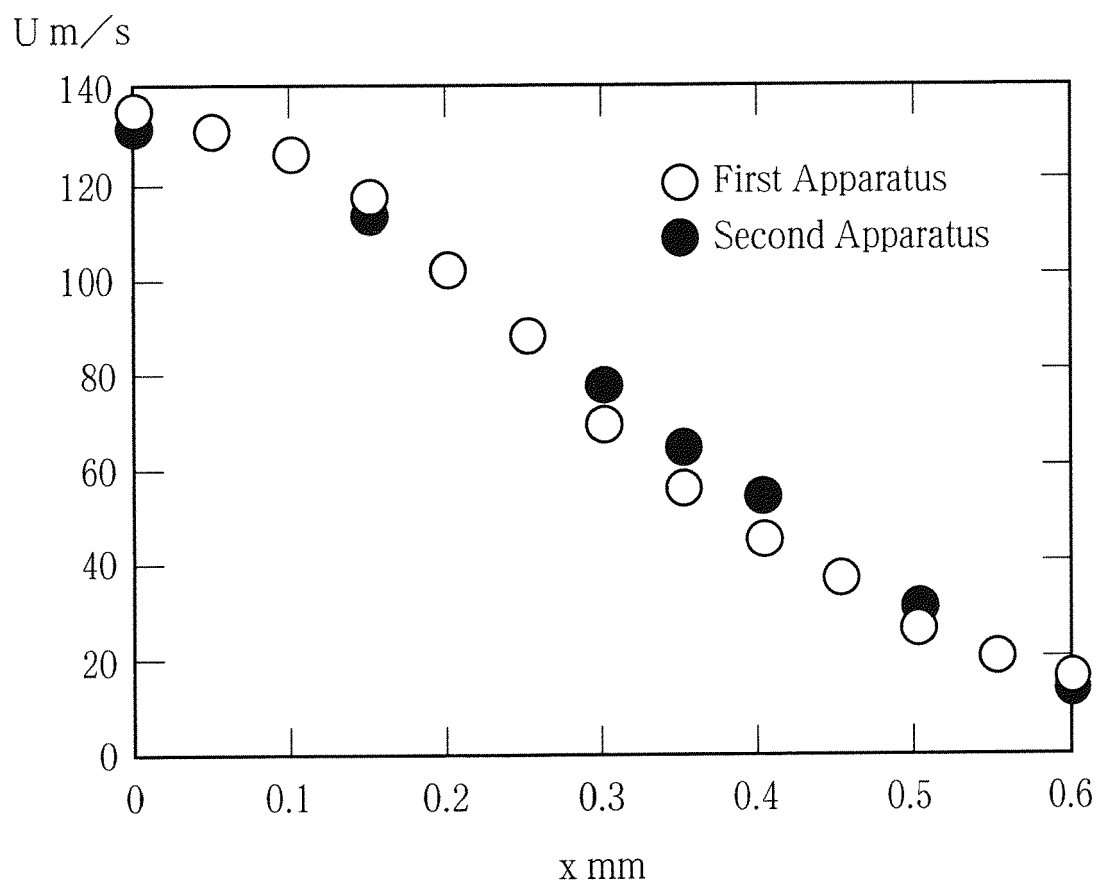


Fig. 8

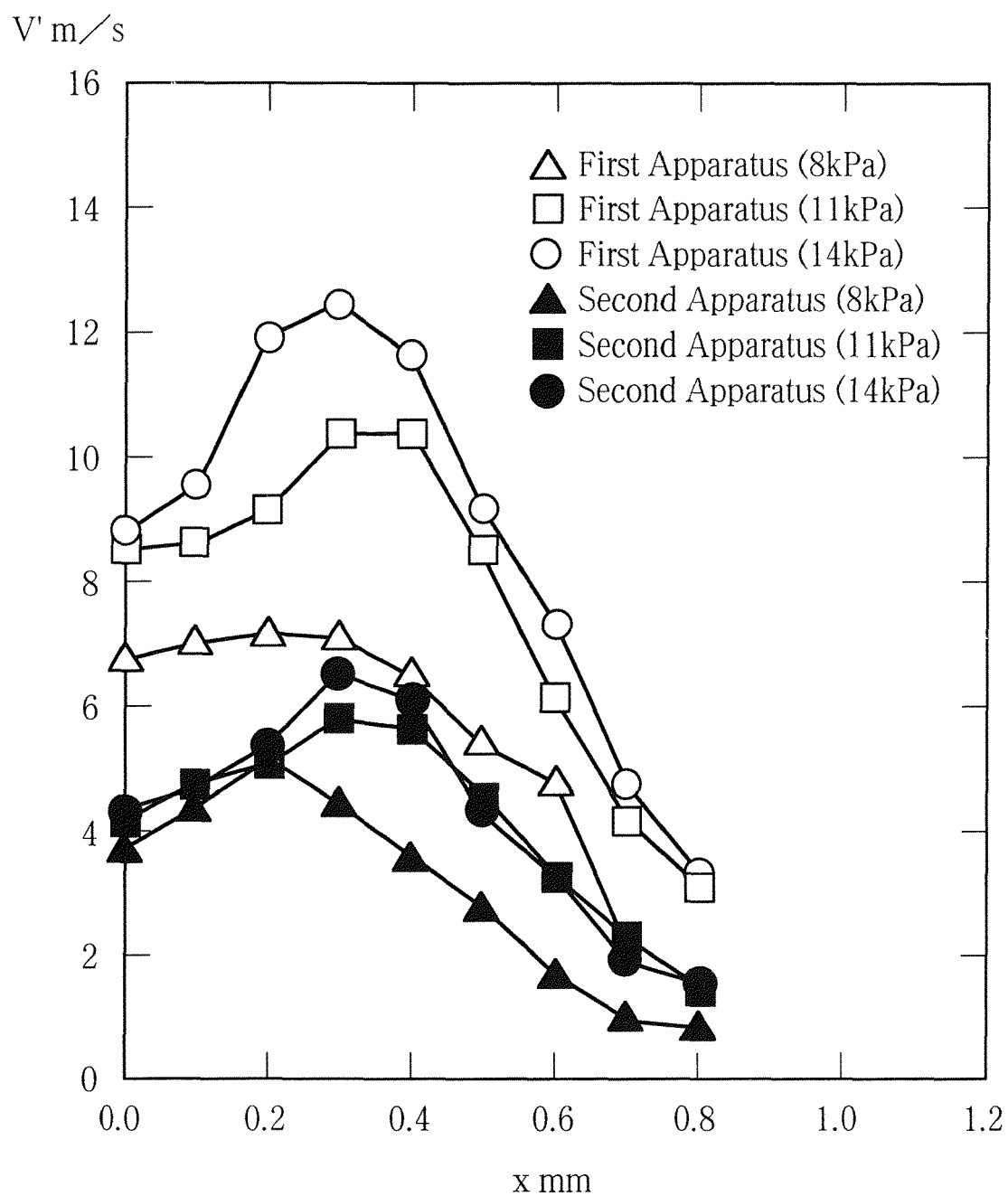


Fig. 9

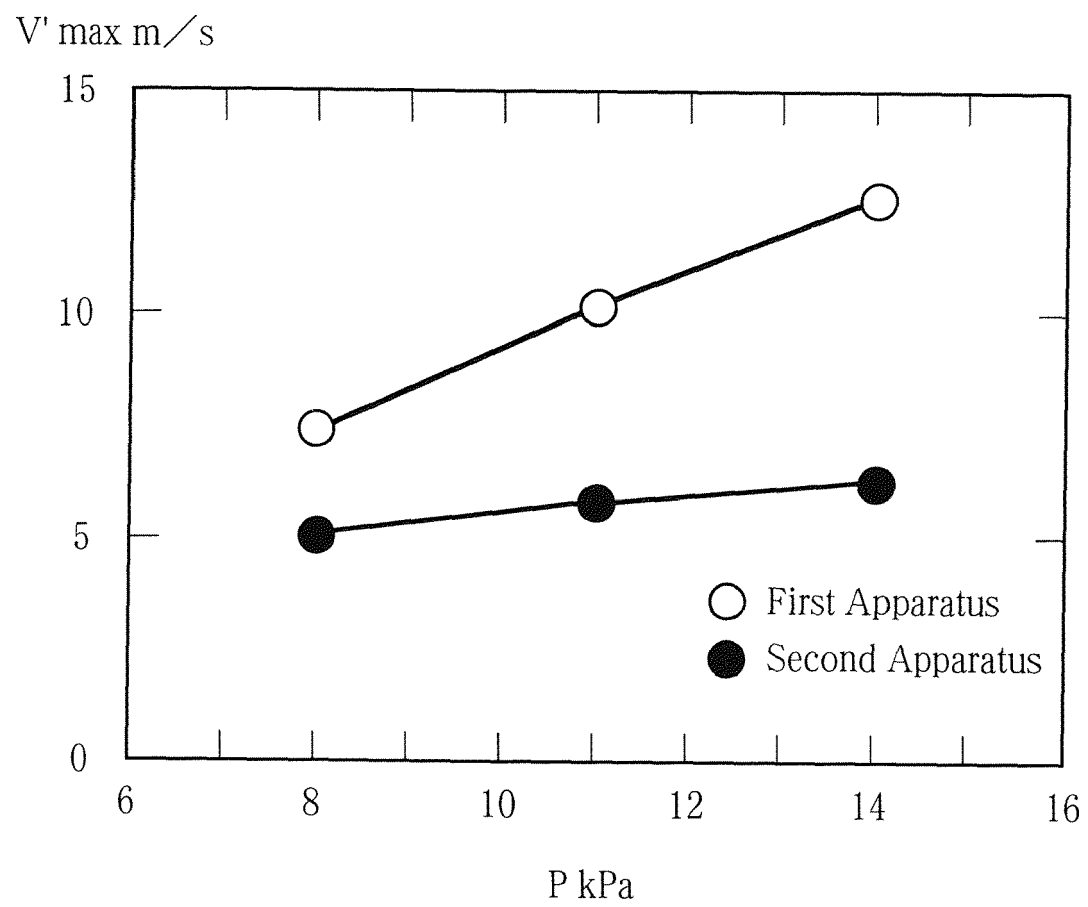


Fig. 10

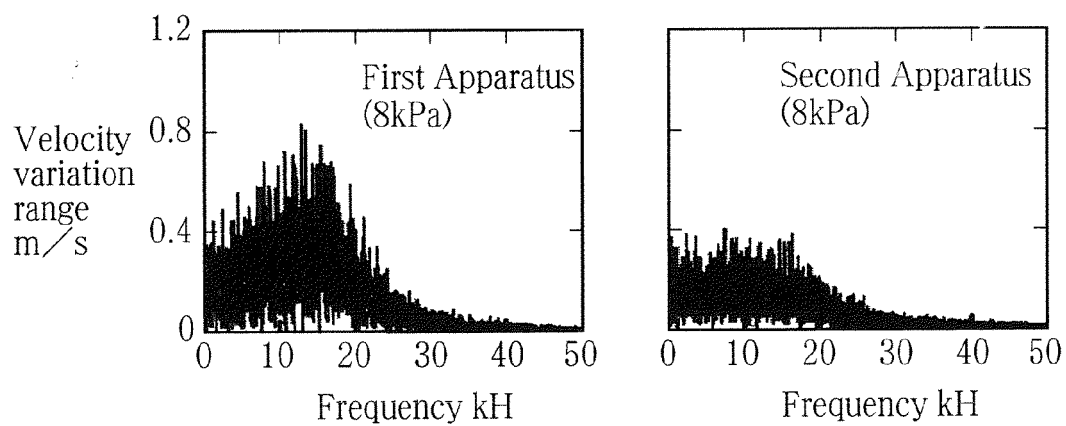


Fig. 11

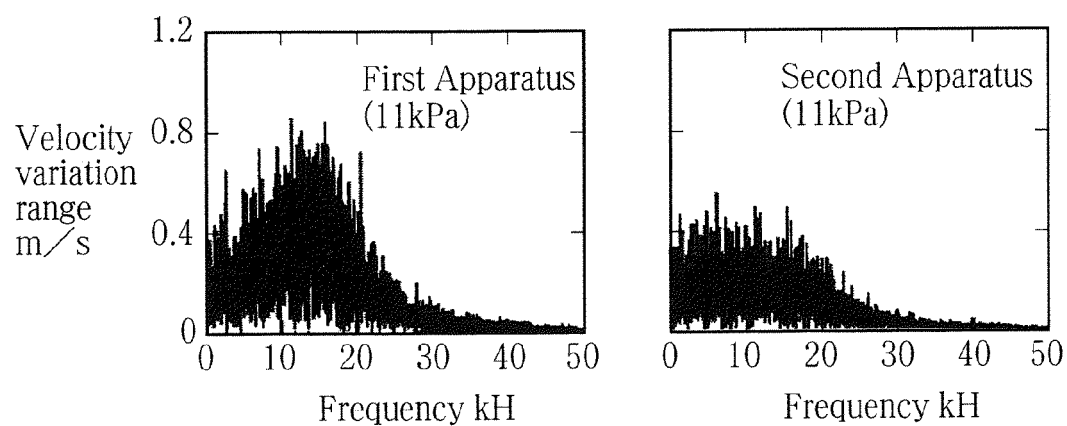


Fig. 12

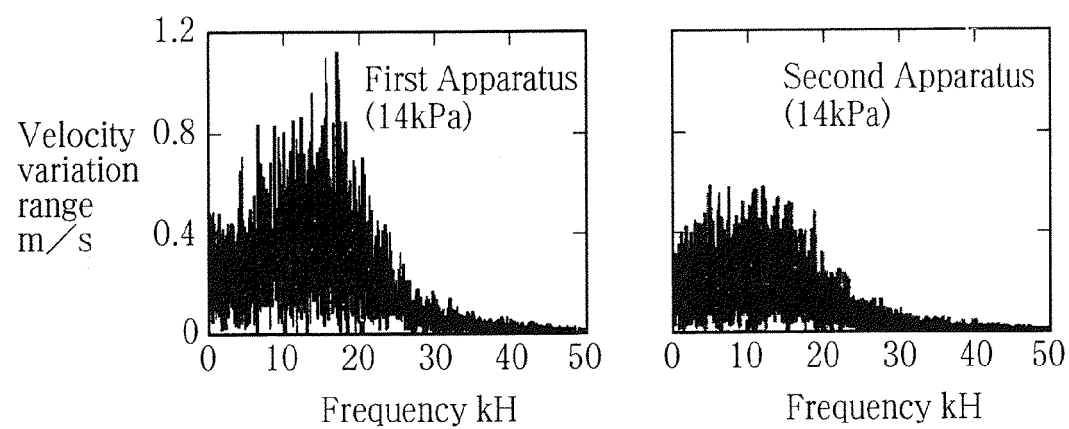


Fig. 13

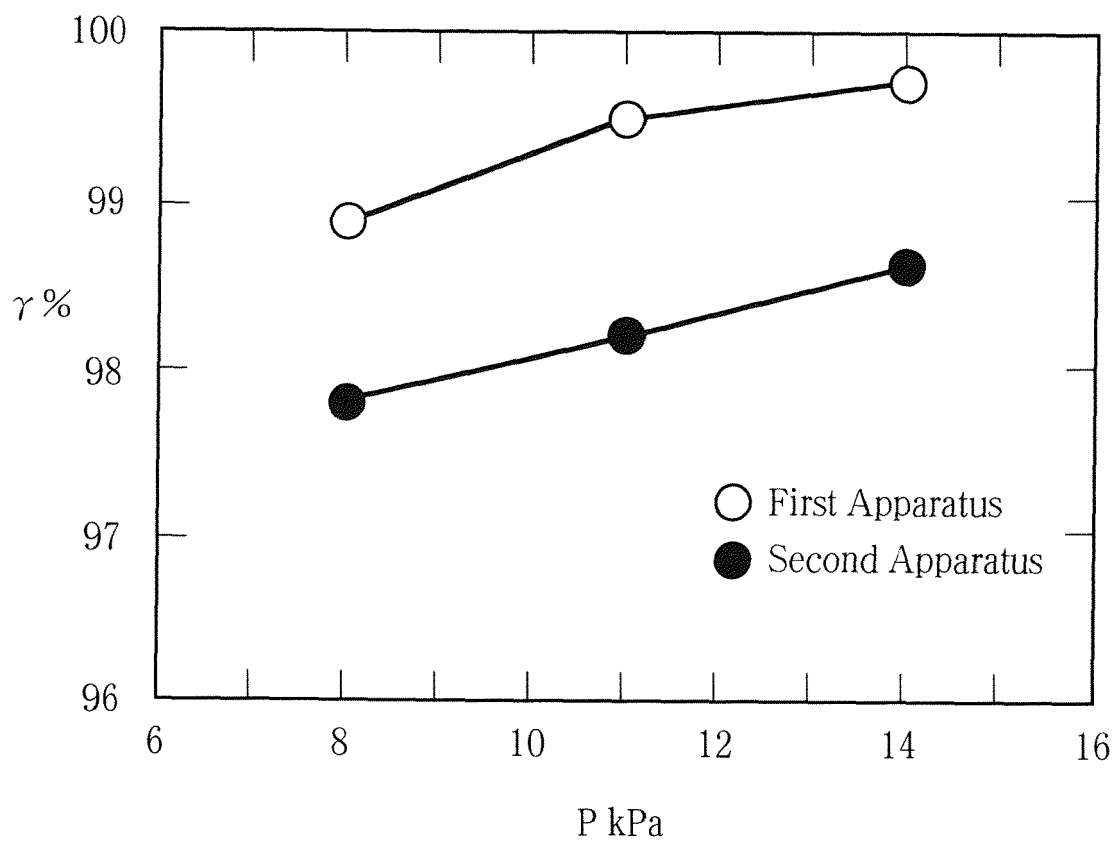
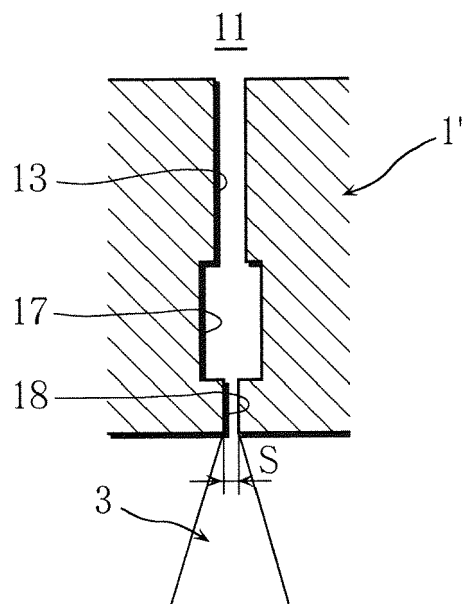


Fig. 14





EUROPEAN SEARCH REPORT

Application Number
EP 13 18 8448

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 682 992 A2 (VALMET PAPER MACHINERY INC [FI]) 22 November 1995 (1995-11-22) * page 4, column 5, line 31 - line 41; claims 1,4,7,9 *	1-3	INV. B08B5/02 B08B5/04
X	EP 0 565 811 A1 (SHINKO KK [JP]) 20 October 1993 (1993-10-20) * claims 1,7,12 * * page 3, column 4, line 27 - line 28 * * page 4, column 6, line 21 - line 25 *	1-3	
X	EP 0 513 632 A1 (SUNDWIGER EISEN MASCHINEN [DE]) 19 November 1992 (1992-11-19) * page 2, column 1, line 41 - line 55; claim 1 *	1-3	
			TECHNICAL FIELDS SEARCHED (IPC)
			B08B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 23 January 2014	Examiner Lang, Xavier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 13 18 8448

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

23-01-2014

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0682992	A2	22-11-1995	CA 2149344 A1	17-11-1995
			EP 0682992 A2	22-11-1995
			JP H07323208 A	12-12-1995

EP 0565811	A1	20-10-1993	DE 69305405 D1	21-11-1996
			DE 69305405 T2	27-03-1997
			EP 0565811 A1	20-10-1993
			JP 2567191 Y2	30-03-1998
			JP H0580573 U	02-11-1993
			US 5388304 A	14-02-1995

EP 0513632	A1	19-11-1992	DE 4215602 A1	19-11-1992
			EP 0513632 A1	19-11-1992
			ES 2077284 T3	16-11-1995
			JP 3431181 B2	28-07-2003
			JP H05200374 A	10-08-1993
			US 5313685 A	24-05-1994

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP H11235559 B [0002]