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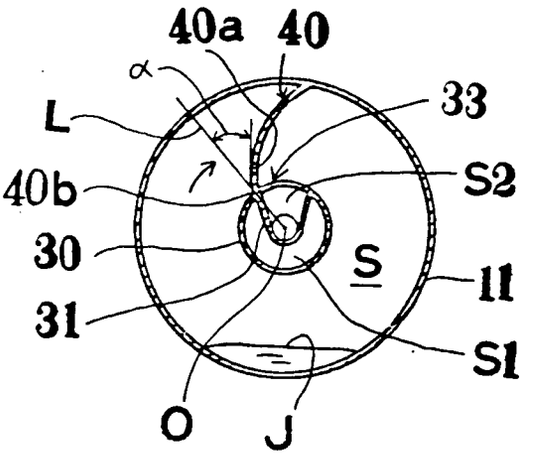
(54) Rotary disc-type dryer.

(57) The dryer comprises a) a hollow drum (30) through which steam can be circulated, b) means rotatably mounting the hollow drum within an outer casing (10), c) a plurality of hollow rotary discs (11) mounted on the outer peripheral surface of the hollow drum, d) first partition means (31) dividing the interior of the hollow drum into a steam injection chamber (S1) and a steam discharging chamber (S2), e) a steam injection aperture (32) for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam injection chamber (S1) and a steam discharging aperture (33) for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam discharging chamber (S2), whereby the steam injection and discharging chamber each communicate with the inner space (S) of the hollow rotary discs, f) second partition means (40) within each of the hollow rotary disc between the steam injection aperture and the steam discharging aperture thereof for directing steam from the steam injection aperture to steam discharging aperture, g) spray means (12) for spraying slurry-like material onto both surfaces of said hollow rotary discs, and h) scraper means (G) for scraping off the dryed solid material from the surface of respective hollow rotary discs, the improvement being characterized in that the second partition means (40) is made of a plate which extends between the hollow drum and the outer surface of the rotary disc (11), and the plate defines an angle (α) in a drum rotating direction between the radially inner portion (40a) thereof and an extension of a line (L) which connects the center (O) of the hollow drum (30) and the radially inner proximal end (40b) of the plate which abuts to the outer surface of the hollow rotary drum. Due to such construction, the drain water produced in the rotary discs due to the heat exchanging operation can be effectively removed.

FIG. 4



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The present invention relates to a rotary disc-type dryer.

Conventionally, there is a type of rotary disc-type dryer disclosed in U.S.P. 4,640,345 (Fig. 12 and Fig. 13 of the patented specification) which is substantially constructed as follows.

Namely, the dryer comprises a) a hollow drum through which a heating medium such as steam can be circulated, b) means rotatably mounting the hollow drum within an outer casing, inlet means for introducing fluid into said outer casing, c) an outlet means for discharging the fluid after being heated from the outer casing, d) a plurality of hollow and disc-like projections mounted on the outer peripheral surface of the hollow drum, e) first partition means dividing the interior of the hollow drum into supply and discharge passages, f) a supply port for each projection at said peripheral wall of the hollow drum communicating with the supply passage and a discharge port for each projection at the peripheral wall of the hollow drum communicating with the discharge passage, whereby the heating medium supply and discharge passages each communicate with the interior of hollow portions of the projections, g) second partition means within each of the hollow disc-like projections between a supply port and a discharge port thereof for directing fluid around the interior of the projection from the supply port to the discharge port, and h) scraper means for scraping off the dried solid material from the surface of respective projections.

Due to such construction, the heating medium can smoothly circulate within the hollow drum as well as the projections and can provide a heat exchange with heated or heating medium within the outer casing and the slurry-like material on the surface of the projections can be effectively dried and the dried material is scraped off from the surface of the projections.

The above dryer, however, has following drawbacks. Namely, the steam which is used as the heating medium is converted to the drain water as a result of the heat exchange between the steam and the slurry-like material to be dried which adhere to the both surfaces of the projections. The drain water accumulates in the inner space defined in the respective projections and considerably deteriorates the heat exchanging efficiency between the steam and the slurry-like material.

In the conventional dryer having the above construction, since the second partition means is made of a single flat straight plate which radially extends toward the outer casing, it takes a considerable time for expelling the drain water from the inner space of the respective partitions to the discharge passage.

Accordingly, the drying operation with the conventional dryer is less than optimal in view of the drying efficiency.

Accordingly, it is an object of the present device to provide a rotary disc-type dryer which can resolve the above-mentioned drawbacks of the conventional dryer.

SUMMARY OF INVENTION

In summary, the present invention discloses rotary disc-type dryer which comprises a) a hollow drum through which steam can be circulated, b) means rotatably mounting the hollow drum within an outer casing, c) a plurality of hollow rotary discs mounted on the outer peripheral surface of the hollow drum, d) first partition means dividing the interior of the hollow drum into a steam injection chamber and a steam discharging chamber, e) a steam injection aperture for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam injection chamber and a steam discharging aperture for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam discharging chamber, whereby the steam injection and discharging chamber each communicate with the inner space of the hollow rotary discs, g) second partition means within each of the hollow rotary discs between the steam injection aperture and the steam discharging aperture thereof for directing steam from the steam injection aperture to steam discharging aperture, h) spray means for spraying slurry-like material onto both surfaces of said hollow rotary discs, and i) scraper means for scraping off the dried solid material from the surface of respective hollow rotary discs, the improvement being characterized in that said second partition means is made of a plate which extends between the hollow drum and the casing and the plate defines an angle in a drum rotating direction between the radially inner portion thereof and an extension of a line which connects the center of the hollow drum and the radially inner proximal end of the plate which abuts to the outer surface of the hollow rotary drum.

BRIEF EXPLANATION OF THE DRAWINGS

Figure 1 is a front elevational view of the drying system incorporating the rotary disc-type dryer of the present invention.

Figure 2 is a side elevational view of the above drying system.

Figure 3 is a longitudinal cross-sectional view of the dryer.

Figure 4 is a transverse sectional view of the dryer taken on line I-I in Fig. 3.

Figure 5 is a partially-broken-away front view of the thickness leveller.

Figure 6 is a cross-sectional view of the thickness leveller taken on line II-II of Figure 5.

Figure 7 is a schematic view of the scraper.

Figure 8 is a cross-sectional view of the scraper.

Figure 8a is a cross-sectional view of the modification of the scraper.

Figure 8b is a plan view of the scraper.

Figure 8c is a plan view of the scraper blade.

Figure 9 is a schematic view of the peripheral scraper.

Figure 10 is a front enlarged view of the peripheral scraper.

Figure 11 is an explanatory view showing the manner of transferring drain water from the inner space of the hollow rotary drum to the steam discharging chamber.

DETAILED DESCRIPTION OF THE PREFFERED EMBODIMENT

(GENERAL CONSTRUCTION OF THE DRYING SYSTEM)

A drying system which incorporates a rotary disc-type dryer according to the present invention will be described hereinafter in conjunction with the accompanying drawings.

Firstly, the entire construction of the drying system is explained in view of Fig. 1 and Fig. 2.

A rotary disc-type dryer A comprises a casing 10 in which a hollow drum 30 which is provided with a plurality of rotary discs 11 on the outer surface thereof is rotatably disposed in the casing 10. The rotary discs 11 are charged with heating medium such as steam by way of the hollow drum 30. A spray pipe 12 is disposed in the casing 10 for spraying slurry-like material onto the surface of the rotary discs 11.

The rotary disc-type dryer A is also provided with a thickness leveller F for levelling the thickness of the slurry-like material sprayed onto the surface of the rotary discs 11, a scraper G for scraping off the dried material from the rotary discs 11 and a peripheral scraper H for scraping off the slurry-like material on the periphery of the rotary discs 11.

A slurry collecting tank B is disposed right below the casing 10 for collecting slurry-like material fallen from the surface of the rotary discs 11.

A slurry circulation line C connects the slurry collecting tank B with the spray pipe 12 and the line C is provided with a pump 13 for feeding the slurry-like material to the spray pipe 12 from the slurry collecting tank B under pressure.

A slurry storage tank D for storing the material to be dried in a slurry form is disposed adjacent to the dryer A and a main slurry supply line E connects the slurry storage tank D with the slurry collecting tank B. The material to be dried may be any kind of liquid including industrial waste or residue from various plants such as food processing plant, mining plant, steel refining plant, pharmaceutical plant, porcelain or ceramics manufacturing plant.

The main slurry supply line E is provided with a pump 14 for feeding the slurry-like material into the slurry collecting tank B from the slurry storage tank D.

(CONSTRUCTION OF EACH DEVICES OR PARTS)

The construction of each devices or parts of the drying system A is explained in detail in conjunction with Fig. 1 and Fig. 2.

rotary disc-type dryer A

The casing 10 of the rotary disc-type dryer A is mounted on a frame structure 20 which includes a plurality of vertical struts 21a.

The casing 10 is provided with an upper door 10a and a lower door 10b which enable the access to the inside of the casing 10 at the time of maintenance.

The casing 10 is also provided with a duct 10c which communicates the inside of the casing 10 with a dust collector 10d mounted on the floor.

The hollow drum 30 of the rotary disc-type dryer A has both end journaling portions 21,22 thereof connected with a steam supply pipe 23 and a steam drain pipe 24 respectively by way of rotary joints 25,26.

The steam drain pipe 24 is provided with a steam trap for discharging drain water while preventing the discharge of steam.

To the bottom portion of the casing 10, a material collecting hopper 27 is attached and the slurry collecting tank B is disposed right below the material collecting hopper 27.

As shown in Fig. 2, the rotary disc-type dryer A is also provided with a power-operated motor 36 mounted on the frame structure 20 and a sprocket wheel 37 mounted on the output shaft of the motor 36 is connected with a sprocket wheel 38 mounted on the journaling portion 21 of the hollow drum 30.

As shown in Fig. 1 and Fig. 2, the hollow drum 30 is concentrically and rotatably disposed in the casing 10.

As shown in Fig. 3 and Fig. 4, a plurality of hollow rotary discs 11 are concentrically mounted on the hollow drum 30 while these discs 11 are axially spaced apart from each other.

A partition wall 31 is disposed in the hollow drum 30 axially in a slanted manner dividing the

inner space of the hollow drum 30 into a steam injection chamber S1 and a steam discharging chamber S2.

The steam injection chamber S1 is communicated with the inner space S of the hollow rotary discs 11 by way of a plurality of steam injection apertures 32 formed in the wall of the hollow drum 30, while the steam discharging chamber S2 is communicated with the inner space S of the hollow rotary discs 11 by way of a plurality of steam discharging apertures 33 formed in the wall of the hollow drum 30.

The hollow drum 30 is provided with a steam injection opening 34 and a steam discharging opening 35 on the respective ends thereof, wherein the steam injection opening 34 is communicated with the steam injection chamber S1 and the steam discharging opening 35 is communicated with the steam discharging space S2.

The steam injection opening 34 and steam discharging opening 35 are formed in the journaling portions 21, 22 of the hollow drum 30.

Due to such construction, the steam which enters the steam injection chamber S1 by way of the steam supply pipe 23 is fed into the inner space S of the rotary discs 11 through the steam injection apertures 32. Then the steam enters the steam discharging chamber S2 through the steam discharging apertures 33 from the inner space S of the rotary discs 11. Finally the steam is discharged into the steam drain pipe 24.

During the above flow of the steam in the dryer A, the disc surface 11a of the rotary discs 11 is heated at a temperature of 100 °C to 150 °C to dry the slurry-like material on the surface of the rotary discs 11.

In the above flow of the steam in the dryer A, a drain water J is produced during the heat exchanging operation and the water J tends to be accumulated in the inner space S of the rotary discs 11. The accumulation of the drain water ill-affects the heat transfer.

For facilitating the discharge of this drain water J from the rotary discs 11, as shown in Fig. 4, a partition plate 40 is provided between the inner surface of the hollow rotary drum 30 and the outer surface of the rotary disc 11 and such partition plate 40 defines an acute angle α in a drum rotating direction between the radially inner portion 40a thereof and an extension of a line L which connects the center O of the hollow drum 30 and the radially inner proximal end 40b of the partition plate 40 which abuts to the outer surface of the hollow rotary drum 30.

The steam discharging aperture 33 is formed in the hollow rotary drum 30 at a position where the inner proximal end 40b of the partition plate 40 merges to the U-shaped partition wall 31.

Due to such a construction, as the rotary disc 11 is rotated as shown in Fig. 11 (a) to (d), the partition plate 40 scoops the drain water accumulated in the bottom portion of the rotary disc 11 and subsequently makes the drain water J smoothly enter into the steam discharging chamber S2 through the steam discharging aperture 33.

If the partition plate 40 is formed on the extension of the line L, the drain water accumulates at the corner defined by the inner surface of the casing 10 and the outermost end of the partition plate 40 so that the rotary disc 11 has to rotate a considerable angle to complete the transfer of the drain water from the inner space S to the steam discharging chamber S2 and accordingly the efficiency of the heat trasfer from the rotary disc 11 to the material to be dried is deteriorated.

slurry collecting tank B

The slurry collecting tank B is provided with a float switch or a level sensor 10e which transmits an operating signal to the power-operated motor of the pump 14 for stopping or starting the operation of the pump 14 so as to maintain the level of the slurry-like material in the slurry collecting tank B constantly at a suitable level range.

spray pipe 12

The sprayer or the spray pipe 12 is hereinafter explained in details. As shown in Fig. 2, the spray pipe 12 is parallelly disposed at the lower portion of the hollow drum 30. The spray pipe 12 is capable of spraying any kind of material in either slurry or liquid form onto the disc surfaces 11a of the discs 11. While the rotary discs 11 are being rotated, the material sprayed on the disc surfaces 11a is dried by the heat of the steam which passes through the rotary discs 11.

scraper G

In Fig. 7, the construction of the scraper G is disclosed, wherein the scraper G is disposed at the lower portion of the casing 10 which is opposed to the place where the spray pipe 12 is mounted.

In Fig. 8, the scraper blade 45 is biasingly made come into contact with the disc surface 11a and the scraper blade 45 has the bottom portion thereof fixedly fastened to a supprot fitting 46 by means of bolts 47. The support fitting 46, is, in turn, pivotally mounted on a mounting plate 48 by way of a pivot 47a.

Numeral 51 indicates a support plate which is symmetrically mounted on the mounting plate 48 relative to the support fitting 46 by means of bolts 52.

A compression fitting 53 made of a leaf spring bridges between the scraper blade 45 and the support plate 51. The central portion of the compression fitting 53 is connected with the mounting plate 48 by means of a contact pressure adjustment bolt 54.

In Fig. 8a to Fig. 8c, a modification of the scraper G is disclosed, wherein the modification is characterized in that the scraper blade 45 is provided with a plurality of parallelly-spaced apart slits 45a along the front periphery thereof thus forming a plurality of independently swingable blade sections 45b.

Due to such provision of the slits 45a, even when the surface 11a of the hollow rotary disc 11 is deformed by heat, the front periphery of the scraper 45 snugly comes into contact with the surface 11a of the hollow rotary disc 11 through the entire length thereof so that the dried material on the surface 11a of the hollow rotary disc 11 can be completely scraped off.

In this modification, in lieu of the support plate 51, another mounting plate 48 is symmetrically mounted on the mounting plate 48 relative to the support fitting 46 by means of bolts 52.

thickness leveller F

The thickness leveller F is explained hereinafter in view of Fig. 5 and Fig. 6.

Numeral 63 indicates a pair of contact rollers which sandwitch the rotary disc 11 for uniformly compressing the material sprayed on both disc surfaces 11a,11a of the rotary disc 11.

The contact roller 63 has the front extremity thereof tapered while the proximal end thereof rotatably journaled by in a bearing box 64 by means of bearings 65. Numeral 66 indicates a pulley, numeral 67 indicates a steel-made connecting plate which adjustably connects the bearing box 64 to a bracket 67a fixedly mounted on the frame structure 20.

Numeral 68 indicates a drive pulley while numeral 69 indicates a power transmission belt and numeral 70 indicates a power-operated motor.

The length of the contact rollers 63,63 is approximately equal to the diameter of the rotary disc 11 and is directed to the center of the rotary disc 11 from the outer periphery of the rotary disc 11.

Due to such construction, while compressing the contact rollers 63,63 onto the disc surfaces 11a, 11a of the disc 11, the rollers 63,63 are rotated so as to make the thickness of the material on the disc surfaces 11a,11a uniform.

Furthermore, the contact rollers 63,63 can efficiently expel air or bubbles from the slurry-like material so that the decrease of the heat exchanging efficiency caused by such bubbles can be eliminated effectively.

peripheral scraper H

The peripheral scraper H is explained in view of Fig. 9 and Fig. 10.

The peripheral scraper H comprises a pair of scraper plates 80,81 which are partially overlapped each other forming a scraper groove 85 in which the peripheral surface 11b of the rotary disc 11 comes into contact. The width of the scraper groove 85 is adjustable by means of the elongated apertures 82,83 and bolts 84.

(MODE OF OPERATION)

The manner in which the drying system provided with the rotary disc-type dryer of this invention is operated is hereinafter disclosed.

Firstly, the slurry-like material is continuously fed into the slurry collecting tank B by way of the main slurry supply line E.

While rotating the hollow rotary discs 11 which are heated with steam in a clockwise direction, the material to be dried is continuously or at the time of need fed to the spray pipe 12 and is sprayed onto the disc surfaces 11a of the rotary discs 11. The material sprayed onto the peripheral surface of the rotary discs 11 is scraped off from the rotary discs by means of the peripheral scrapers H.

When the material arrives at a position where thickness leveller F is disposed, the thickness of the material is being levelled by the thickness leveller F so as to facilitate the succeeding drying operation of the material as mentioned above.

Until the material arrives at a position where the scraper G is disposed, the material is completely dried by the heat exchange between the surface of the rotary discs 11 and the material.

Since the inner space of each rotary disc 11 is provided with the partition plate 40 which defines the acute angle α in a drum rotating direction between the radially inner portion 40a thereof and the extension line L, the drain water produced as the result of the heat exchange can be scooped with the partition plate 40 and subsequently is smoothly expelled from the inner space of the rotary disc 11 to the steam discharging chamber S2 along with the rotation of the rotary disc 30 with a small rotating angle. Then the dried material is scraped off from the disc surfaces 11a of the discs 11 and collected through the discharge chute.

The slurry like material which falls in the slurry collecting tank B during the slurry spraying operation is collected in the ink B and then is fed to the spray pipe 12.

In this manner, since the supply of the slurry-like material from the slurry storage tank D to the

slurry collecting tank B and the feeding of the slurry-like material from the slurry collecting tank B to the spray pipe 12 can be carried out simultaneously, the drying operation can be carried out continuously increasing the yield of the drying operation considerably while achieving high heat exchanging efficiency.

Claims

1. A rotary disc-type dryer comprising :

(a) a hollow drum (30) through which steam can be circulated,

(b) means rotatably mounting the hollow drum within an outer casing (10),

(c) a plurality of hollow rotary discs (11) mounted on the outer peripheral surface of the hollow drum,

(d) first partition means (31) dividing the interior of the hollow drum into a steam injection chamber (S1) and a steam discharging chamber (S2),

(e) a steam injection aperture (32) for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam injection chamber (S1) and a steam discharging aperture (33) for each hollow rotary disc at the peripheral wall of the hollow drum communicating with the steam discharging chamber (S2), whereby the steam injection and discharging chamber each communicate with the inner space (S) of the hollow rotary discs,

(f) second partition means (40) within each of the hollow rotary discs between the steam injection aperture and the steam discharging aperture thereof for directing steam from the steam injection aperture to steam discharging aperture,

(g) spray means (12) for spraying slurry-like material onto both surfaces of said hollow rotary discs, and

(h) scraper means (G) for scraping off the dried solid material from the surface of respective hollow rotary discs,

the improvement being characterized in that said second partition means (40) is made of a plate which extends between the hollow drum and the casing and the plate defines an angle in a drum rotating direction between the radially inner portion (40a) thereof and an extension of a line (L) which connects the center (O) of the hollow drum (30) and the radially inner proximal end (40b) of the plate (40) which abuts to the outer surface of the hollow rotary drum (30).

2. A rotary disc-type dryer according to claim 1, wherein said rotary disc-type dryer includes a thickness leveller (F) which comprises a pair of rod-like contact rollers (63) which sandwitch said each hollow rotary disc (11), said contact rollers being operably connected with roller rotating means (64-68).

3. A rotary disc-type dryer according to claim 1, wherein said rotary disc-type dryer includes a scraper means (G) which comprises a scraper blade (45) which has the proximal end thereof pivotally mounted on a fixed frame (48) and the distal end thereof comes into contact with disc surface (11a) of said hollow rotary discs, and biasing means which applies a biasing force to said disc surface.

4. A rotary disc-type dryer according to claim 1, wherein said rotary disc-type dryer includes a peripheral scraper means (H) which comprises a pair of scraper plates (80,81) which are partially overlapped each other forming a scraper groove (85) in which the peripheral surface (11b) of the hollow rotary disc (11) comes into contact.

5. A rotary disc-type dryer according to claim 1, wherein said dryer further includes a) a slurry storage tank (D) for storing material to be dried in a slurry form, b) a slurry collecting tank (B) disposed below said casing, c) a main slurry supply line (E) which connects said slurry storage tank (D) with said slurry collecting tank (B), d) a slurry circulation line (C) which connects said slurry collecting tank (B) with said spray pipe (12), e) pump means (14) mounted on said main slurry pipe (E) for supplying said slurry-like material into said slurry collecting tank (B), and f) pump means (13) mounted on said slurry circulation line (C) which connects said slurry collecting tank (B) with said slurry spray pipe (12).

FIG. 2

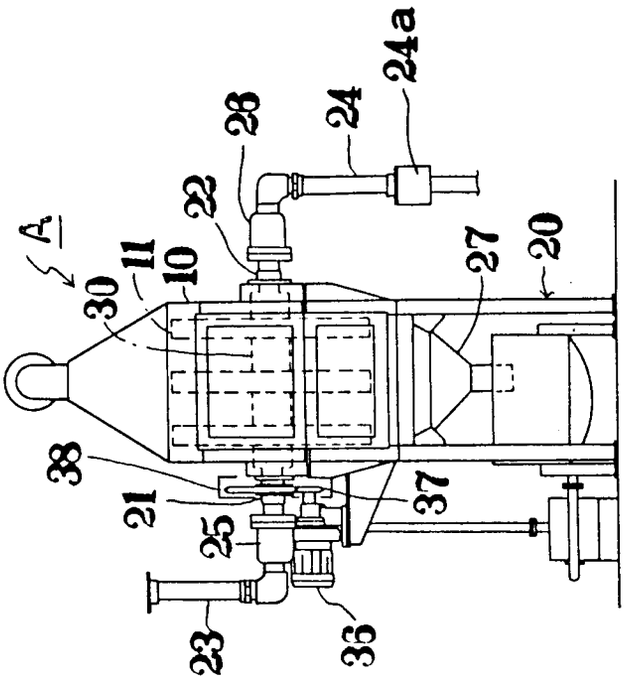
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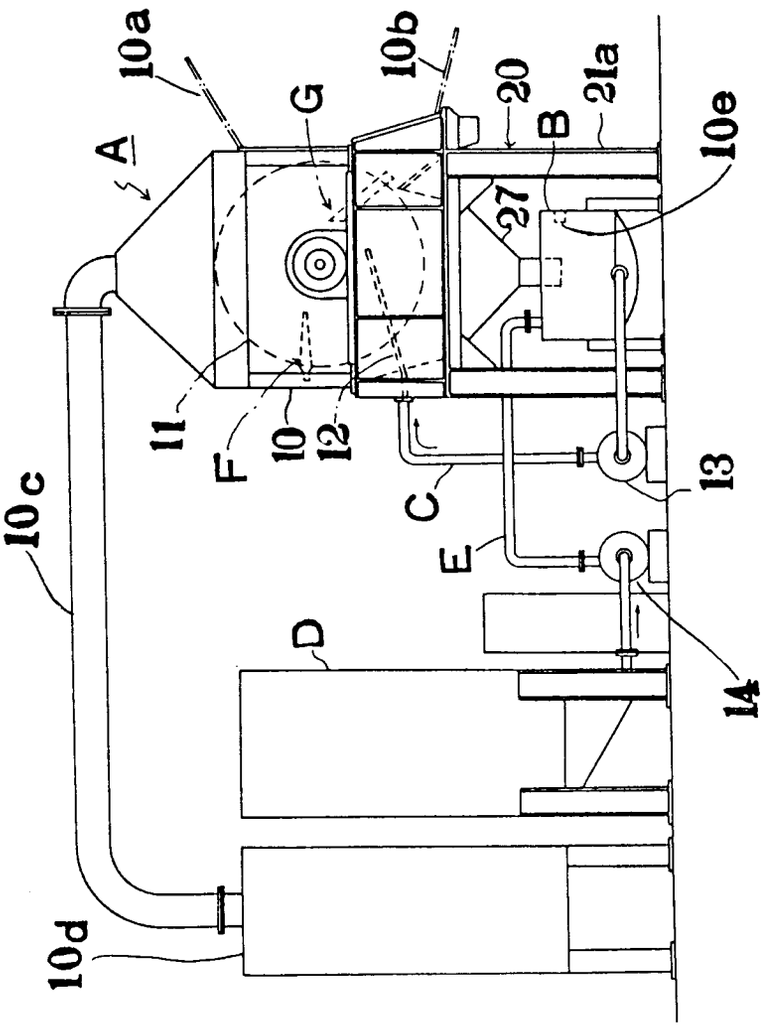
FIG. 1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10b
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FIG.3

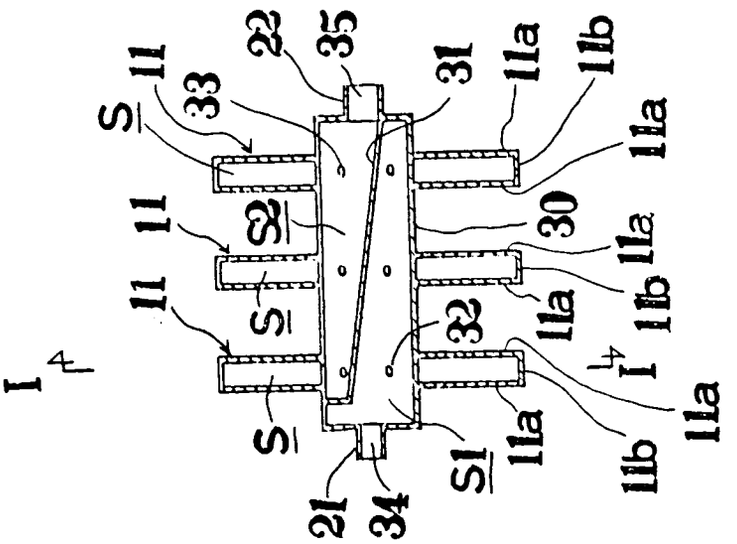
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FIG.4

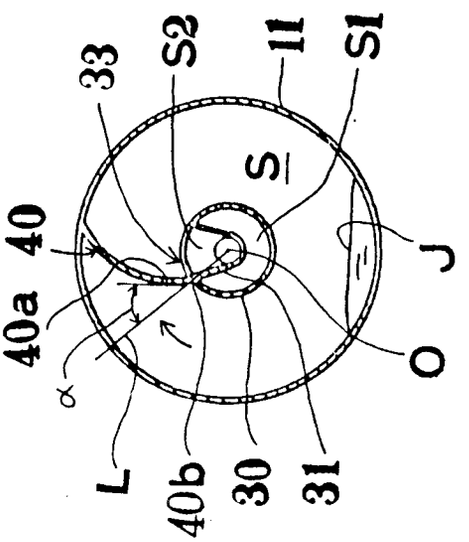
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FIG.5

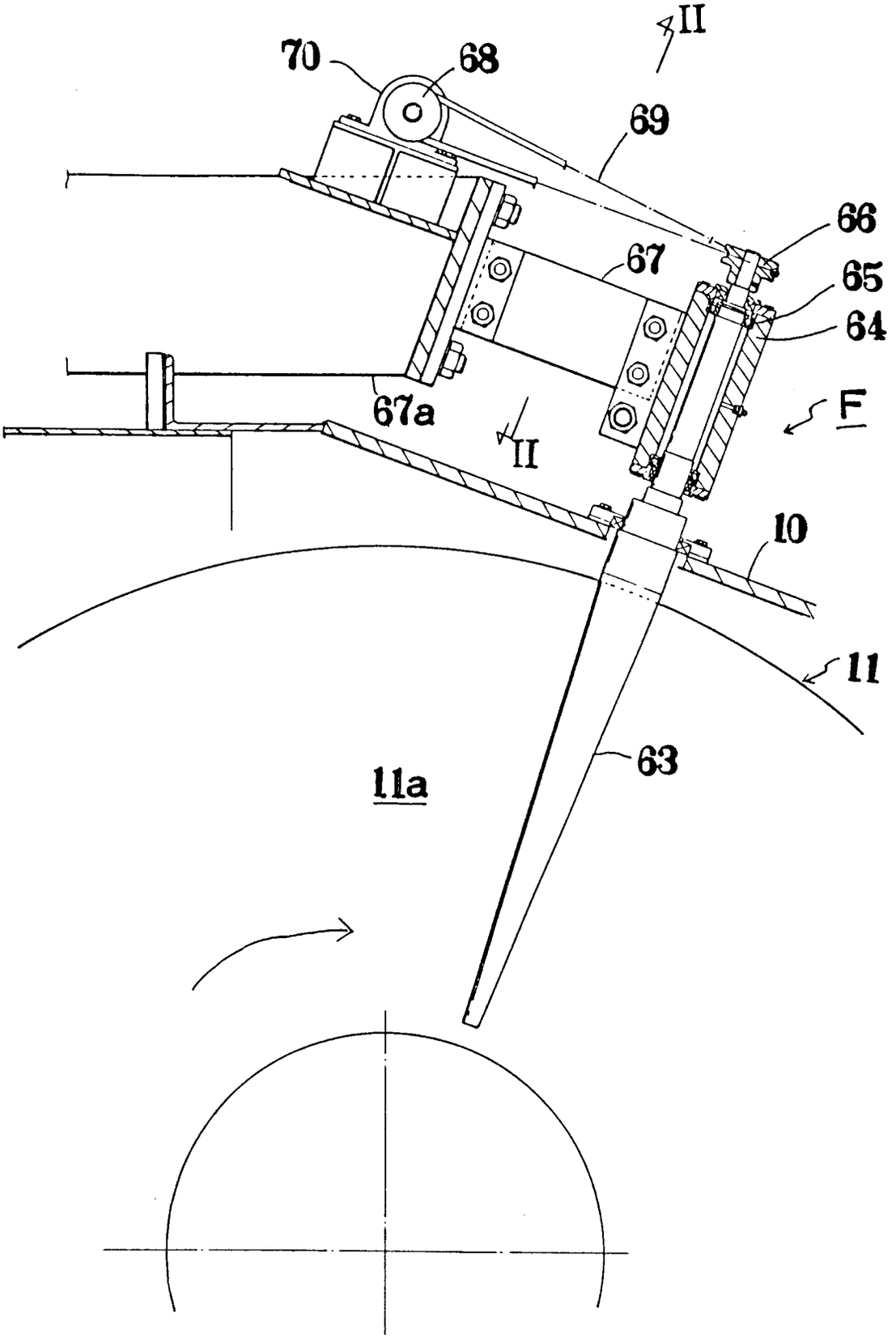

FIG.8

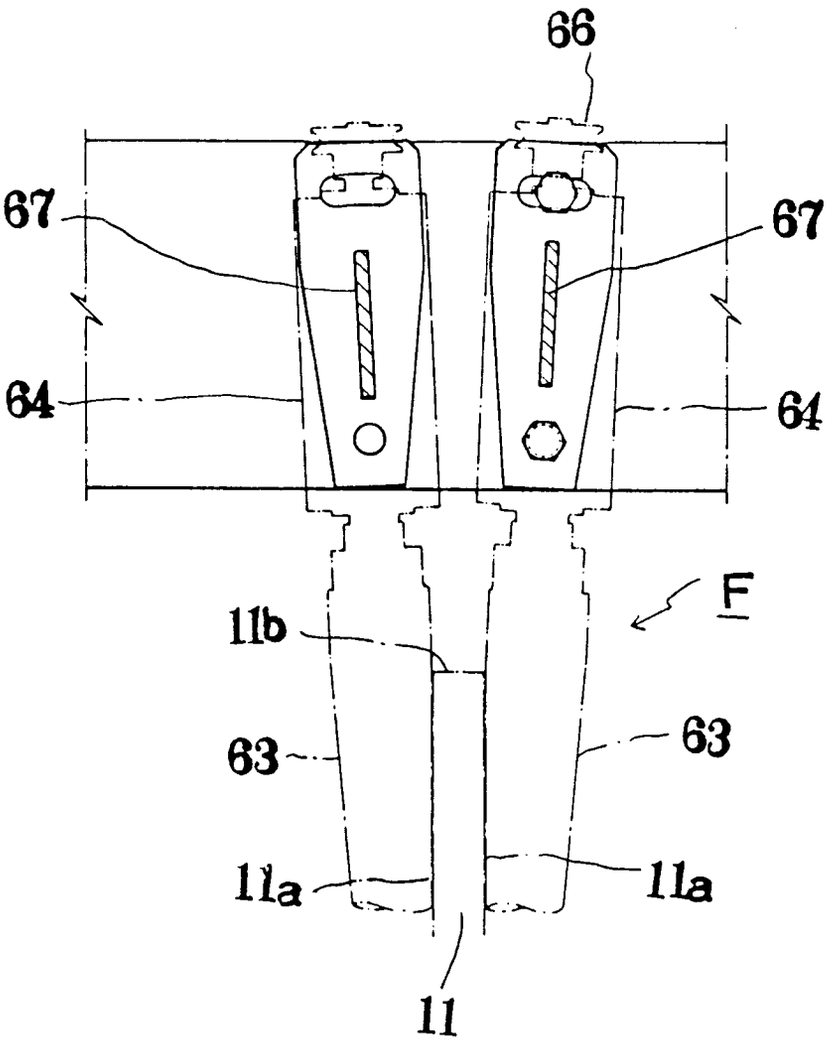

FIG.7

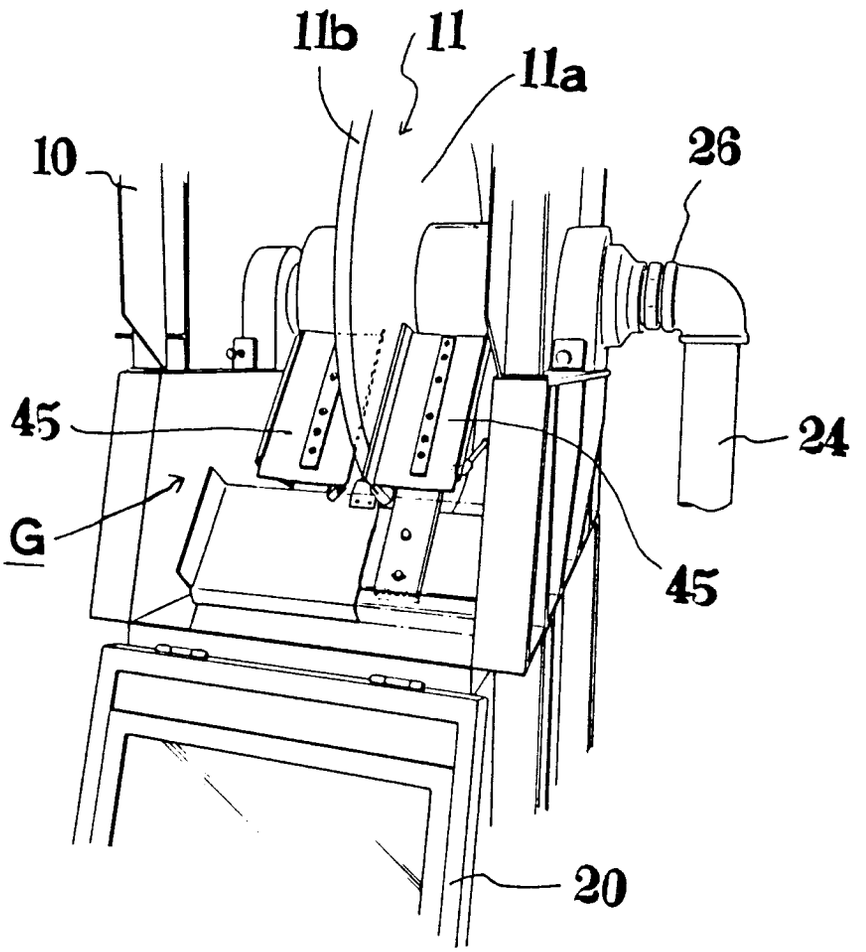

FIG.8

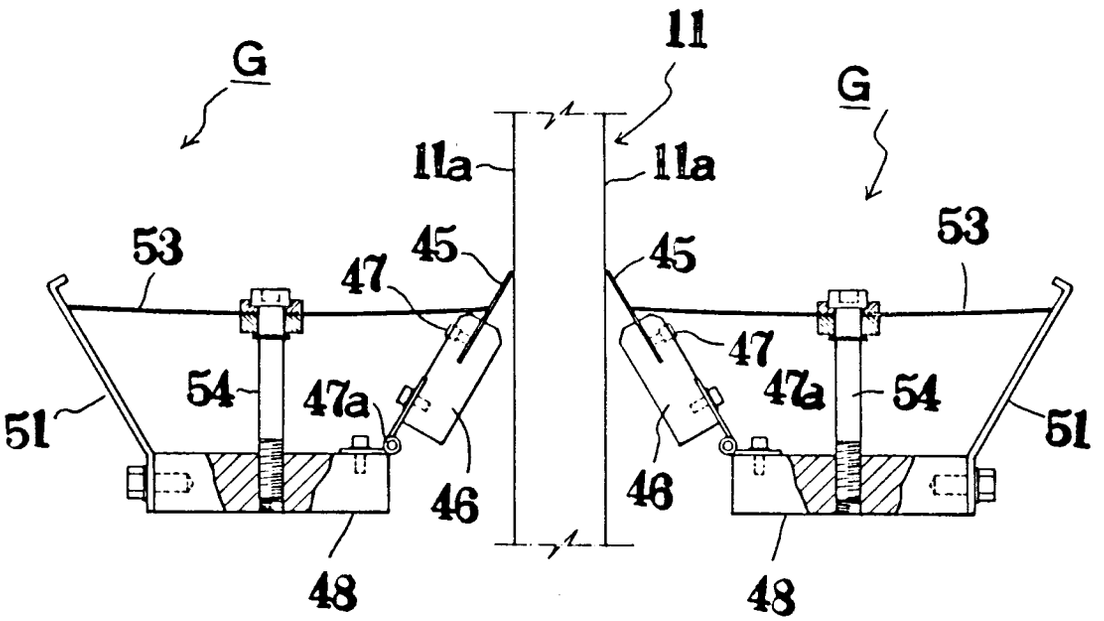

FIG. 8a

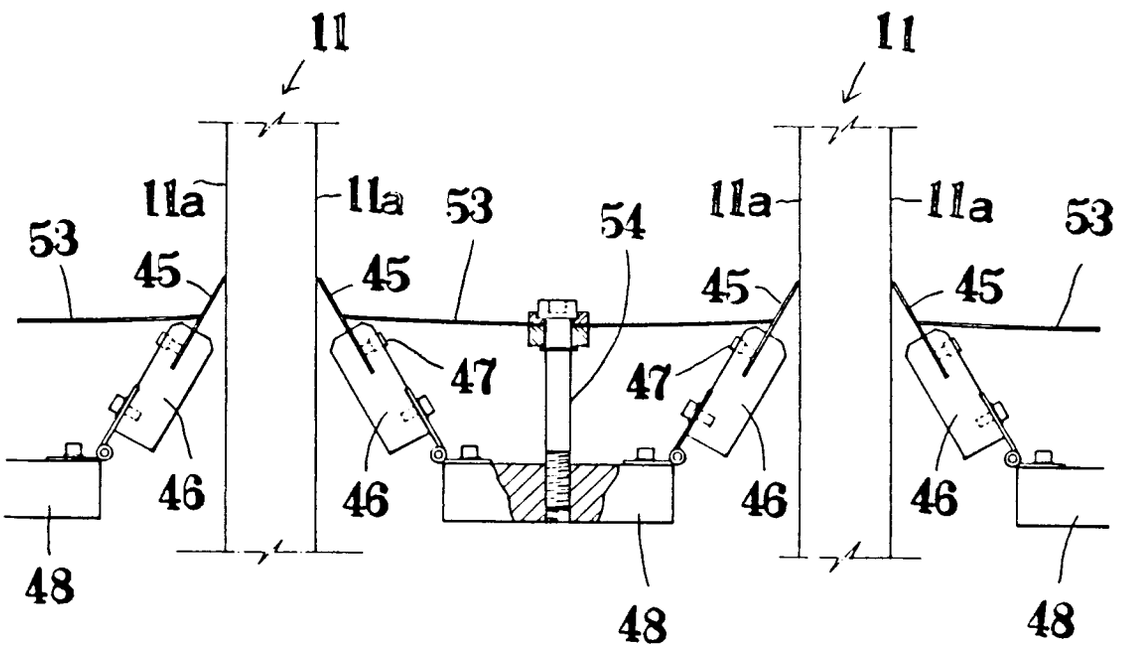
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FIG. 8c

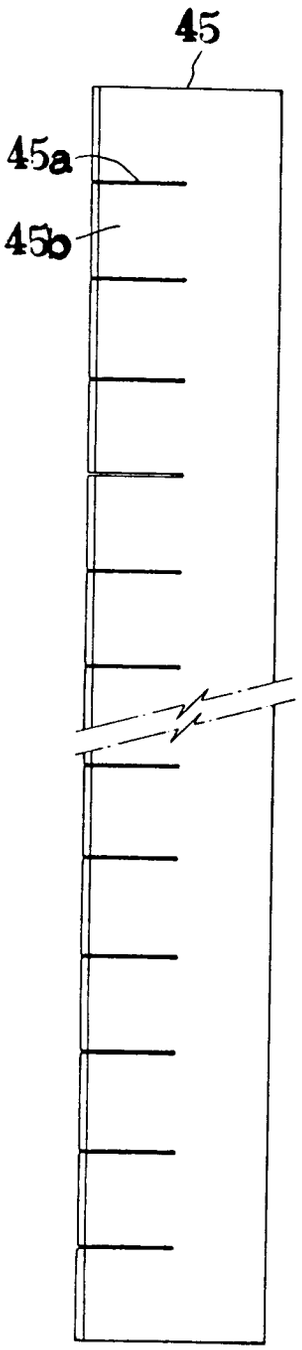


FIG. 8b

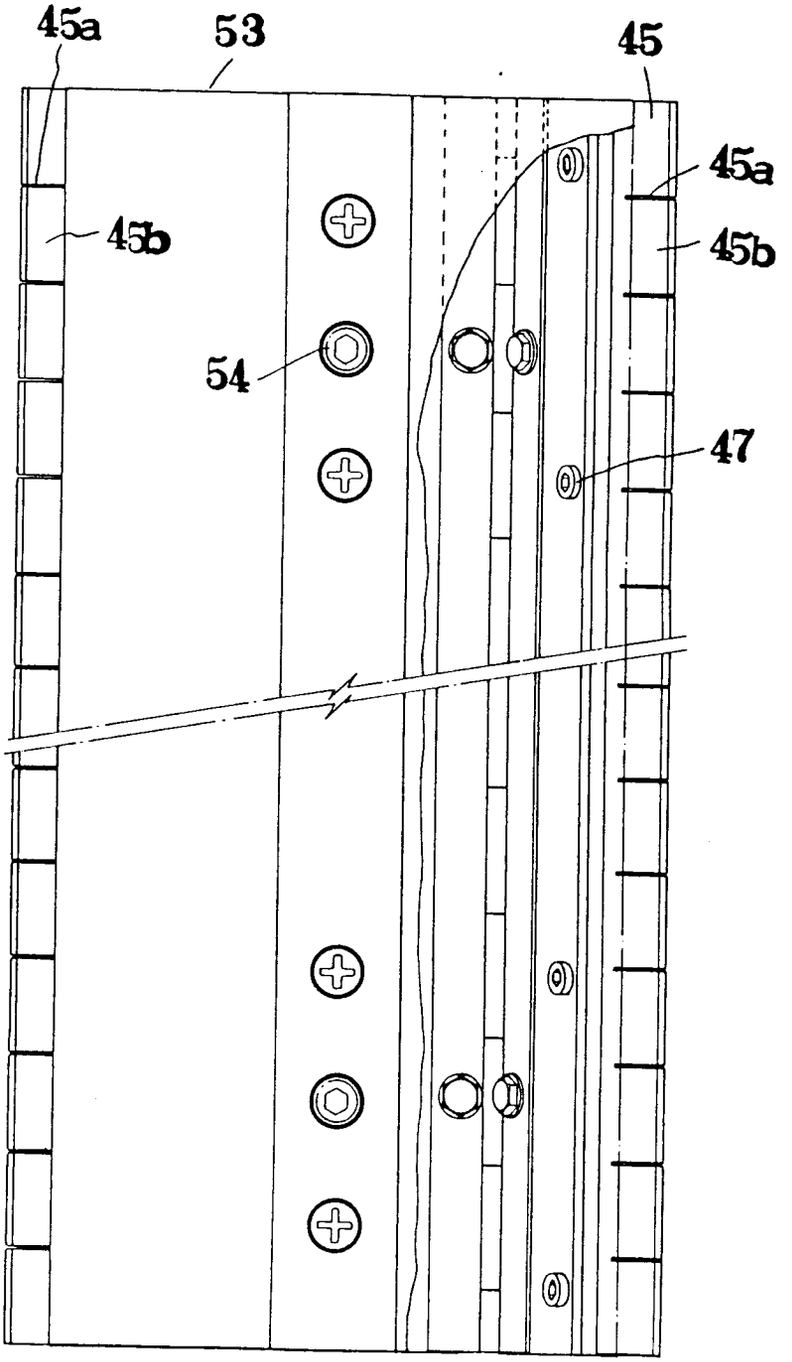


FIG.9

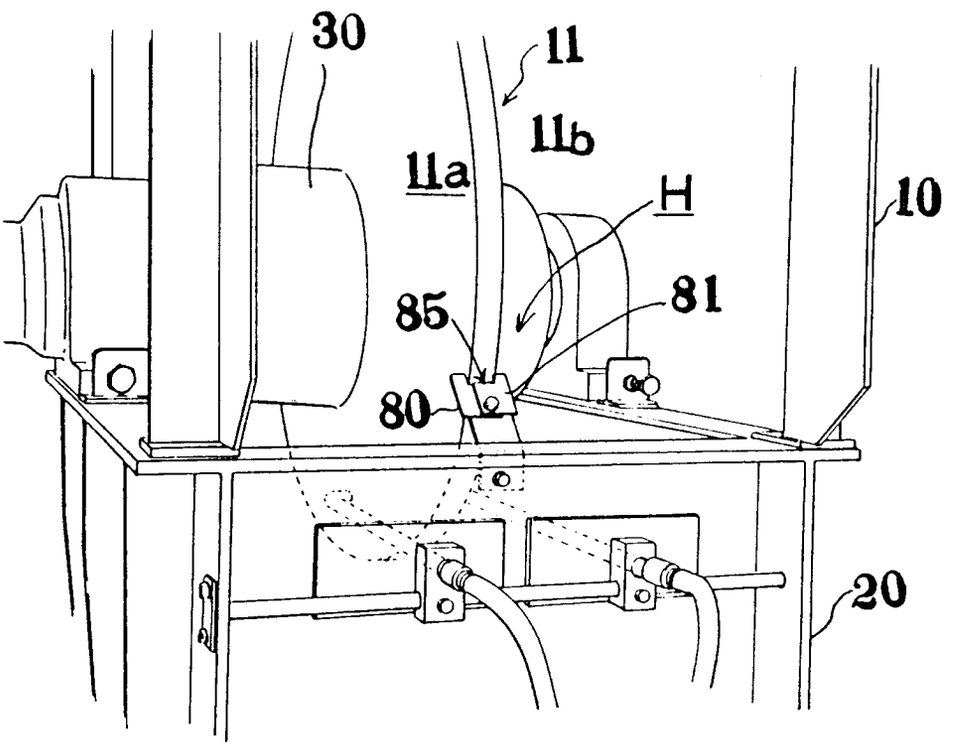
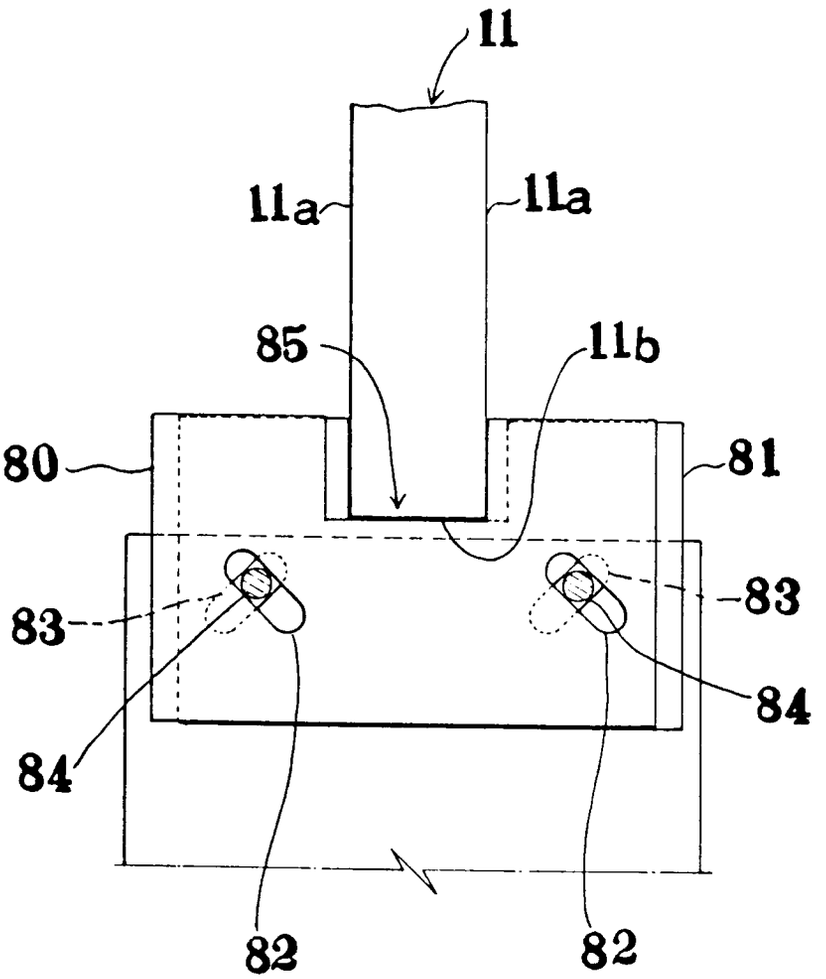


FIG.10



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 40 1727

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	US-A-4 640 345 (NISHIMURA) * the whole document *	1,2,4	F26B17/28
A	DE-A-2 807 725 (LUTHER-WERKE LUTHER GMBH & CO.) * the whole document *	1,3	
A	DE-A-3 043 166 (ADALBERT KLEIN, APPARATEBAU) * the whole document *	1,3	
A	US-A-3 800 865 (ONARHEIM ET AL) * the whole document *	1	
A	DE-C-310 353 (HUWILER) * the whole document *	1	
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A	GB-A-278 882 (LEATHER) * figures 11-14 *	1	
A	FR-A-2 251 795 (FELDMÜHLE ANLAGEN-UND PRODUKTIONSGESELLSCHAFT M.B.H.) * the whole document *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5) F26B F28D
A	DE-A-1 604 929 (HACKENBERG) * the whole document *	4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 FEBRUARY 1992	SILVIS H.

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