Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2525346 C 2012/04/03

(11)(21) 2 525 346

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2004/09/06
(87) Date publication PCT/PCT Publication Date: 2005/03/17
(45) Date de délivrance/Issue Date: 2012/04/03
(85) Entrée phase nationale/National Entry: 2005/11/09
(86) N° demande PCT/PCT Application No.: FI 2004/000517
(87) N° publication PCT/PCT Publication No.: 2005/024127
(30) Priorité/Priority: 2003/09/09 (FI20031286)

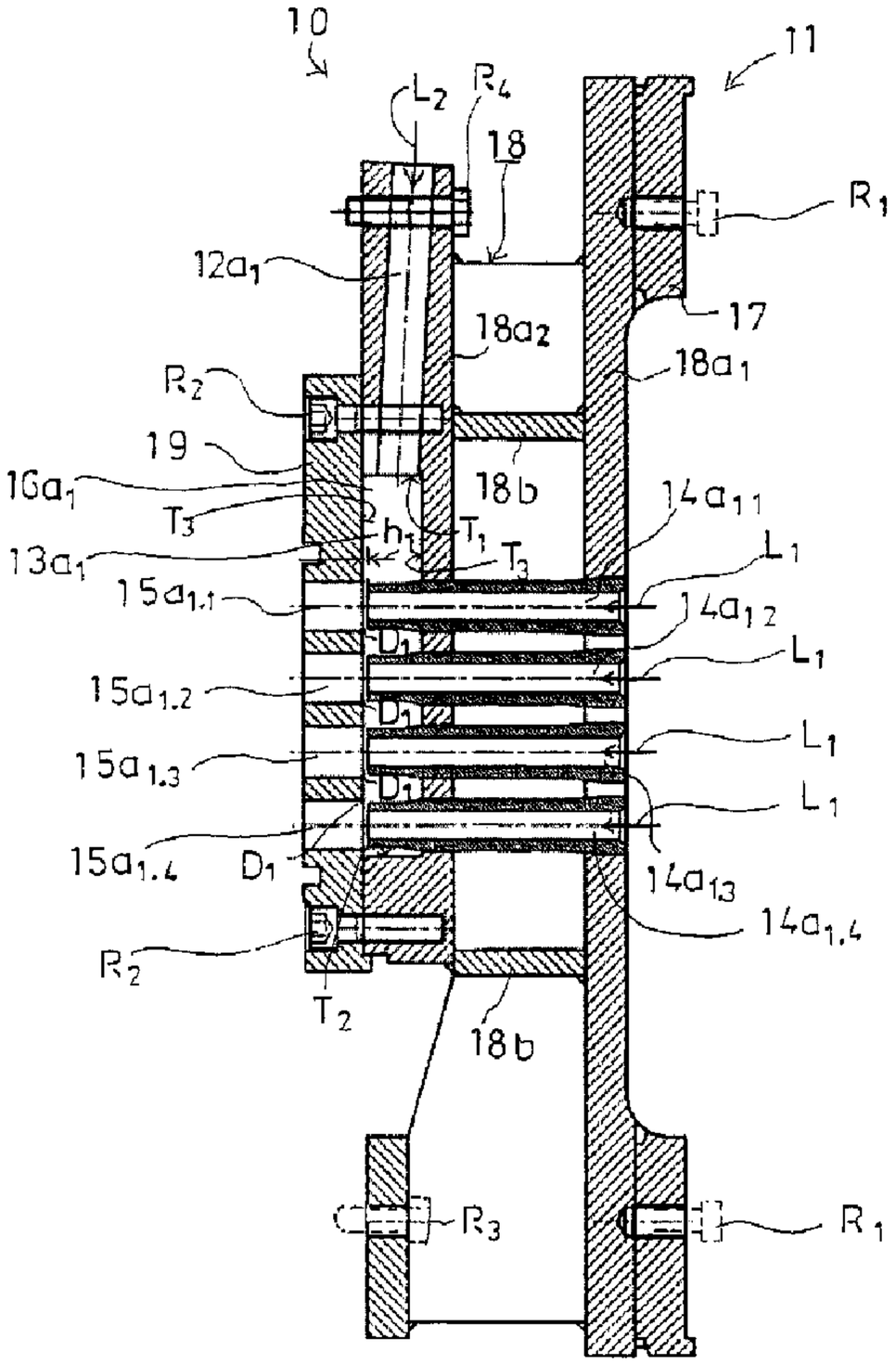
(51) Cl.Int./Int.Cl. *D21F 1/02* (2006.01), *D21F 1/06* (2006.01), *D21F 1/08* (2006.01)

(72) Inventeurs/Inventors:
KIRVESMAEKI, JARMO, FI;
KEMILAEINEN, ILKKA, FI;
TURPEINEN, HANNU, FI;
LAPPI, JANNE, FI

(73) Propriétaire/Owner:
METSO PAPER, INC., FI

(74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : APPAREIL CONNECTE A LA CAISSE D'ARRIVEE D'UNE MACHINE A PAPIER OU ANALOGUE
(54) Title: APPARATUS IN CONNECTION WITH A HEADBOX OF A PAPER MACHINE OR EQUIVALENT



(57) Abrégé/Abstract:
Headboxes of modern paper machines often include a dilution system. Older headboxes are difficult and expensive to retrofit with dilution systems, requiring heavy machinery and numerous valves. The present invention of a headbox dilution apparatus

CA 2525346 C 2012/04/03

(11)(21) 2 525 346

(13) C

(57) Abrégé(suite)/Abstract(continued):
comprises a body having a plurality of mixing chambers. Dilution water (arrow L_2) is conducted through at least two rows of ducts ($12a_1$, $12a_2$...) into each body mixing chambers ($13a_1$, $13a_2$...). Each mixing chamber ($13a_1$, $13a_2$...) is limited by vertical walls (T_1), a bottom wall (T_2) and a covering wall (T_3), and a partition wall ($16a_1$, $16a_2$...). The ducts ($14a_{1.1}$, $14a_{1.2}$...) on the inlet side of the mixing chamber extend into the mixing chamber ($13a_1$, $13a_2$...) at a distance (h_1) from the ducts ($15a_{1.1}$, $15a_{1.2}$...,$15a_{2.2}$...) on the outlet side of the mixing chamber ($13a_1$, $13a_2$...), whereby an annular gap (D_1) is left between the aligned duct ($14a_{1.1}$, $14a_{1.2}$... $14a_{2.1}$, $14a_{2.2}$...) on the inlet side and the duct ($15a_{1.1}$, $15a_{1.2}$.., $15a_{2.1}$, $15a_{2.2}$...) on the outlet side. Each mixing chamber ($13a_1$, $13a_2$...) is filled by dilution water which is conducted through the annular gap (D_1) to join the stock (m_1).

ABSTRACT

Headboxes of modern paper machines often include a dilution system. Older headboxes are difficult and expensive to retrofit with dilution systems, requiring heavy machinery and numerous valves. The present invention of a headbox dilution apparatus comprises a body having a plurality of mixing chambers. Dilution water (arrow L_2) is conducted through at least two rows of ducts ($12a_1$, $12a_2$...) into each body mixing chambers ($13a_1$, $13a_2$...). Each mixing chamber ($13a_1$, $13a_2$...) is limited by vertical walls (T_1), a bottom wall (T_2) and a covering wall (T_3), and a partition wall ($16a_1$, $16a_2$...). The ducts ($14a_{1.1}$, $14a_{1.2}$...) on the inlet side of the mixing chamber extend into the mixing chamber ($13a_1$, $13a_2$...) at a distance (h_1) from the ducts ($15a_{1.1}$, $15a_{1.2}$...,$15a_{2.2}$...) on the outlet side of the mixing chamber ($13a_1$, $13a_2$...), whereby an annular gap (D_1) is left between the aligned duct ($14a_{1.1}$, $14a_{1.2}$... $14a_{2.1}$, $14a_{2.2}$...) on the inlet side and the duct ($15a_{1.1}$, $15a_{1.2}$.., $15a_{2.1}$, $15a_{2.2}$...) on the outlet side. Each mixing chamber ($13a_1$, $13a_2$...) is filled by dilution water which is conducted through the annular gap (D_1) to join the stock (m_1).

Apparatus in connection with a headbox of a paper machine or equivalent

The invention concerns an apparatus in connection with the headbox of a paper machine or equivalent.

It has proved to be a problem with old headboxes that the distribution tube banks are there attached to the headbox structures in such a way that it has proved difficult to add a dilution profiling system to them. In known headboxes, the diluting profiling is done in such a way that the diluting liquid is conducted into one row of pipes formed by superimposed pipes. The number of dilution valves will hereby be high in many cases and many other mechanisms are also needed. In known device solutions, expensive machining is made in the dilution plates and thick plate dimensions have to be used. This has resulted in further increases in costs. In many cases cleaning at state-of-the-art dilution headboxes is implemented in such a way that they are equipped with an opening structure, which can be opened owing to hinging means for the time of washing. However, the solution is expensive.

The present application presents an apparatus of a new type in the web formation for mixing dilution water and the stock conducted from the inlet header of a paper machine. According to the invention, the apparatus comprises such a body, into which inlet channels for the dilution water are drawn, which are made to open into mixing chambers for the stock and dilution water, which chambers may also be called dilution water chambers in the present application. The dilution water is conducted into the top part of each mixing chamber, so that the facing end of the dilution water will open into the mixing chamber from its top wall. In the solution according to the invention, each mixing chamber comprises at least two, preferably more rows of pipes located side by side. In bringing the dilution water into the mixing chamber it is made to flow around the pipes entering the mixing chamber

and further through the flow gap between the pipe ends and the outlet pipe ends to join the stock flow and further as a joined flow of dilution water and stock $L_1 + L_2$ away from the mixing chamber. In the operating situation, the mixing chamber proper is entirely filled and pressurized by dilution water.

In the new solution there is no need to exchange the tube bank and it is also suitable for headboxes provided with a fixed tube bank. The dilution can be divided simultaneously into several pipes located side by side and on top of each other using the same valve, whereby the number of valves and the costs are reduced. It has been possible to shorten the time of standstill for installation, because the tube bank need not be exchanged. The structure is a light sleeve structure and the parts can be made without any manual grinding.

In the solution according to the invention, washing of the mixing chamber can be carried out in the following manner. A duct opens into each washing chamber from the lower part of the washing chamber. The duct in question can be connected to a system of supply ducts for the washing liquid. Thus, by supplying the washing liquid from below upwards into the mixing chamber, washing liquid is made to flow in a direction opposite to the dilution water and also in a direction opposite to the stock from the stock inlet header. In this way the washing operation is made even more effective.

In the apparatus solution, the device may comprise a closing spindle, in which holes are made by boring at mixing chamber spacing. Using the spindle, the system of washing ducts can be opened and closed by a rotating or linear motion of the spindle. The closing spindle may have a circular or rectangular cross-sectional shape. The closing spindle may extend over the entire width of the headbox or it may be, so to speak, modulated in the CD direction, whereby the closing spindle extends into the area of certain mixing chambers and several closing spindles are used side by side. In the structure, the closing spindle may be placed in a groove made as a part of the body plate of the apparatus structure.

The concerned system of washing ducts allows washing the mixing chambers the lower way and individually, for example, using a pressure washer, or alternatively all mixing chambers may be connected to the same system of washing ducts, whereby supply of the washing water takes place simultaneously into all mixing chambers. Since in the washing situation the direction of flow inside the mixing chamber is changing from normal to the opposite due to the washing pipe fitting located in the lower part, cleaning of the areas soiled in the running situation becomes more effective.

The apparatus according to the invention in connection with the headbox of a paper machine or equivalent is characterised by the features presented in the claims.

The invention is presented in the following with reference to some advantageous embodiments shown in the figures of the accompanying drawings. However, the invention is not limited to these only.

Figure 1A is a side view and longitudinal cross-section of the headbox in a paper machine.

Figure 1B shows the target area of the invention, an arrangement for supplying dilution water to join stock conducted from a stock inlet header. The figure shows target area X_1 from Figure 1A.

Figure 1C is a sectional side view along the line I-I in Figure 1B.

Figure 2 shows on an enlarged scale a mixing chamber and the structures associated with it.

Figure 3 is an axonometric view of the formation of a mixing chamber structure.

Figure 4A is an example in principle of an arrangement for washing mixing chambers.

Figure 4B shows washing modules on an enlarged scale.

Figure 1A shows the so-called dilution headbox 100 of a paper machine.

Figure 1B shows the area X_1 of Figure 1A on an enlarged scale.

Figure 1C shows the apparatus as a partial view from the front and as a sectional view along the line I-I in Figure 1B.

Dilution headbox 100 comprises a stock inlet header J_1, from which stock m_1 is conducted as shown by arrow L_1 into mixing chambers $13a_1$, $13a_2$... of an apparatus 10 according to the invention, which chambers may also be called dilution water chambers in this application. The dilution water is conducted from a dilution water inlet header J_2 through ducts $12a_1$, $12a_2$.. and valves V_1, V_2.. regulating the flow L_2 into mixing chambers $13a_1$, $13a_2$... The ducts $14a_{1.1}$, ducts $14a_{1.2}$ lead from the stock inlet header J_1 into the mixing chambers $13a_1$, $13a_2$... From the mixing chambers $13a_1$, $13a_2$.. there are ducts $15a_{1.1}$, $15a_{1.2}$..., $15a_{2.1}$, $15a_{2.2}$... for the dilution water and stock mixture $L_1 + L_2$ to be conducted away.

Ducts $12a_1$, $12a_2$.. lead to mixing chambers $13a_1$, $13a_2$... located in various width positions of the paper machine's headbox. The dilution water is used to control the consistency of the stock m_1 and thus the web's basis weight across the width of the web to be the desired ones by adjusting valves V_1, V_2... Thus, the dilution valves V_1 are used to control the dilution water flow L_2 to the desired places across the headbox width and thus to control the basis weight of the paper web or equivalent across the width of the web. The dilution water flow L_2 arrives in each mixing chamber $13a_1$, $13a_2$... at the desired place across the width in the desired quantity and the dilution water is mixed with the stock flow L_1 conducted from

the inlet header J_1 at the concerned place over the width into the mixing chamber $13a_1$, $13a_2$... The combined flow $L_1 + L_2$ is conducted further as shown in Figure 1A into a tube bank P and further into an intermediate chamber E and further into a turbulence generator G and further through a slice cone K on to a forming wire H_1.

Figure 2 shows a mixing chamber $13a_1$ and the relating structures on an enlarged scale. The view is a longitudinal sectional view in the machine direction. As is shown in Figure 2, the apparatus 10 comprises the following structural parts for mixing a flow of dilution liquid, preferably dilution water (arrow L_2), and stock m_1 conducted (arrow L_1) from the stock inlet header J_1 of the headbox. The apparatus 10 according to the invention for mixing dilution water and stock m_1 comprises a body part 11, which is connected in a module-like manner. It can be connected in between the stock inlet header J_1 and the tube bank P, for example, into old headboxes.

From an inlet header J_2 for the dilution water the dilution water is conducted into ducts $12a_1$, $12a_2$, $12a_3$.., each of which comprises a valve V_1, V_2... The valves V_1, V_2... are used to control the flow of dilution water; the rate of flow through the ducts $12a_1$, $12a_2$.., preferably through hoses or pipes to join the flow L_1 of stock m_1 conducted from the stock inlet header J_1. The ducts $12a_1$, $12a_2$.. for the dilution water are drawn to the various headbox width positions, and by controlling the inlet of dilution water joining the flow L_1 of stock m_1 the dilution is controlled and thus also the consistency of the stock at each place across the width of the headbox and thus the basis weight of the web, such as a paper web, at each position over the web width.

According to the invention, the dilution water ducts $12a_1$, $12a_2$.. open into the mixing chambers $13a_1$, $13a_2$, $13a_3$... for stock m_1 and dilution water. The ducts $12a_1$, $12a_2$.. open into the top part of the mixing chambers $13a_1$, $13a_2$... They do not extend into the mixing chambers $13a_1$, $13a_2$.. proper, but open from the cover-

ing wall T_1 of the mixing chambers $13a_1$, $13a_2$.. directly into the mixing chamber $13a_1$, $13a_2$...

Each mixing chamber $13a_1$, $13a_2$.. comprises pipes $14a_{1.1}$, $14a_{1.2}$ .. , which are drawn to the mixing chamber from a stock inlet header J_1 and in such a way that into each mixing chamber extend at least two duct rows, preferably pipe rows $14a_{1.1}$, $14a_{1.2}$ .. ; $14a_{2.1}$, $14a_{2.2}$... The ducts, preferably pipes $14a_{1.1}$, $14a_{1.2}$ .. ; $14a_{2.1}$, $14a_{2.2}$.., are adapted to open into the mixing chamber $13a_1$, $13a_2$.. in such a way that the ends of the pipes $14a_{1.1}$, $14a_{1.2}$ .. are at a short distance h_1 from the outlet ducts, for example, pipes or, as in the figure, preferably plate borings $15a_{1.1}$, $15a_{1.2}$ .. ; $15a_{2.1}$, $15a_{2.2}$..., which outlet ducts open into the mixing chamber $13a_1$, $13a_2$... and face the ends of the pipes. Under these circumstances, an annular gap D_1 is left between the ducts $14a_{1.1}$, $14a_{1.2}$ .. for the stock flow and the ducts $15a_{1.1}$, $15a_{1.2}$ on the outlet side for the stock m_1 and the dilution liquid conducted thereto. The width h_1 of the annular gap D_1 is within a range of 2 – 8 mm, preferably 3 – 5 mm. Thus, the dilution water flow and the stock flow are mixed together in the space between the end of ducts $14a_{1.1}$, $14a_{1.2}$ .. and the ends of the ducts $15a_{1.1}$, $15a_{1.2}$ on the outlet side. Thus, the term mixing chamber is used. Outside the mixing point proper the mixing chamber is filled by dilution water. The pressure of the dilution water exceeds the pressure existing in the stock flow, whereby the direction of flow of the dilution water is from the mixing chamber $13a_1$, $13a_2$.. into the ducts $15a_{1.1}$, $15a_{1.2}$.

Under these circumstances, the dilution water is conducted from the ducts, such as pipes $12a_1$, $12a_2$.. , into the mixing chambers $13a_1$, $13a_2$.. located side by side, which in the present application may also be called dilution water chambers, and it will flow into each mixing chamber $13a_1$, $13a_2$.. from above downwards and around the ducts $14a_{1.1}$, $14a_{1.2}$.. on the inlet side of the mixing chamber $13a_1$, $13a_2$... for the stock m_1, and further through the annular gaps D_1 into each duct $15a_{1.1}$, $15a_{1.2}$ .. ; $15a_{2.1}$, $15a_{2.2}$.. on the outlet side of the mixing chamber $13a_1$, $13a_2$.. as a flow $L_2 + L_1$. The dilution water fills the mixing chambers $13a_1$, $13a_2$..,

and the actual mixing together of the dilution water and the stock m_1 takes place in the space between the ducts $14a_{1.1}$, $14a_{1.2}$.. on the inlet side and the ducts $15a_{1.1}$, $15a_{1.2}$ .. on the outlet side.

Thus, each mixing chamber $13a_1$, $13a_2$.. is a free space, which is limited only by the mixing chamber's covering wall T_1 and bottom wall T_2 and vertical walls T_3 and by the partition walls $16a_1$, $16a_2$.. separating the mixing chambers $13a_1$, $13a_2$... Into the concerned free internal space of the mixing chamber $13a_1$, $13a_2$.. extend the ducts for the stock m_1 drawn from the stock m_1 inlet header J_1, such as pipes $14a_{1.1}$, $14a_{1.2}$.., and in such a way that there are inlet ducts into each mixing chamber $13a_1$, $13a_2$.. in at least two adjacent rows, preferably in three or even in more rows. The ducts, such as pipes $14a_{1.1}$, $14a_{1.2}$.., in each row, and correspondingly the outlet ducts $15a_{1.1}$, $15a_{1.2}$ .., may be in non-linear rows superimposed in a zigzag fashion.

The body 11 of the device according to the invention with its parts mentioned above can easily be connected in between the stock inlet header J_1 and the tube bank P of old headboxes, and thus the old headbox structure is easily changed afterwards and made into a dilution headbox. According to the invention, the partition walls $16a_1$, $16a_2$.. may be designed as curved structures and, in addition, according to the invention, adjacent duct rows or pipe rows may be staggered in relation to each other in a zigzag-like manner, whereby marking of the web is avoided.

The device body 11 comprises a first facing plate 17. The facing plate 17 is joined by screws R_1 to the basic body 18, to its plate $18a_1$. Another facing plate 19 is further joined to a plate $18a_2$ by screws R_2. The plates $18a_1$ and $18a_2$ are connected by ribs 18b. The apparatus 10 is connected by screws R_1, R_3 and R_4 to the tube bank P and to the stock inlet header J_1 and, for example, to an old headbox.

Figure 3 is an illustrating axonometric view of the apparatus 10 according to the invention separately from the tube bank P before it is joined to the tube bank P. The embodiment is otherwise like the structure shown in the other figures, but each vertical row comprises only three ducts $14a_{1.1}$, $14a_{1.2}$, $14a_{1.3}$... $15a_{1.1}$, $15a_{1.2}$, $15a_{1.3}$; $14a_{2.1}$, $14a_{2.2}$, $14a_{2.3}$... $15a_{2.1}$, $15a_{2.2}$, $15a_{2.3}$.

Figures 4A and 4B show washing of the mixing chambers $13a_1$, $13a_2$.. and ducts $14a_{1.1}$, $14a_{1.2}$ ..., $15a_{1.1}$, $15a_{1.2}$. Washing of the mixing chamber $13a_1$, $13a_2$.. may be performed efficiently by joining the inlet duct 20 for washing liquid to each washing liquid duct $21a_1$, $21a_2$.. opening into each mixing chamber $13a_1$, $13a_2$... Thus, washing of the mixing chamber $13a_1$, $13a_2$.. can be performed by making the washing liquid flow from below upwards from the bottom part of the mixing chamber $13a_1$, $13a_2$.. to its top part and out through the inlet ducts $12a_1$, $12a_2$.. for dilution water and the ducts $14a_{1.1}$, $14a_{1.2}$ ..., $15a_{1.1}$, $15a_{1.2}$. For efficient washing, washing should be done in the direction opposite to the direction of flow during operation.

The inlet duct 20 for washing liquid is connected to each mixing chamber $13a_1$, $13a_2$... As is shown in Figure 4A, the washing duct 20 is branched into branch ducts $20a_1$, $20a_2$, $20a_3$, which join a washing module $21a_1$. Correspondingly, branch ducts $20a_4$, $20a_5$, $20a_6$ join another washing module $21a_2$. The washing module $21a_1$ has an adjusting or closing spindle $21b_1$ and the washing module $21a_2$ has an adjusting or closing spindle $21b_2$. In the embodiment shown in the figure, the adjusting spindle is turned to align the perforations C_1, C_2.. of the adjusting spindle with the ducts $20a_1$, $20a_2$, $20a_3$... and with ducts e_1, e_2... opening into the mixing chambers $13a_1$, $13a_2$.. , and in this way a connection can be opened to each mixing chamber $13a_1$, $13a_2$...

A paper machine or equivalent means paper, board and tissue machines as well as pulp drying machines.

CLAIMS

1. A headbox of a paper machine comprises

a stock inlet header (J_1), a tube bank (P), an intermediate chamber (E), a turbulence generator (G) and a slice cone (K), wherein stock is conducted from the stock inlet header (J_1) through the tube bank (P) into the intermediate chamber (E) and further through the turbulence generator (G) into the slice cone (K),

the headbox (100) further comprises

a plurality of mixing chambers (13a), which are located across the width of the headbox (100) and into which stock is conducted from the stock inlet header (J_1), and a plurality of dilution liquid ducts (12a) for conducting dilution liquid into the mixing chambers (13a), wherein each dilution liquid duct (12a) opens into one of the mixing chambers (13a) and is provided with a valve (V) for controlling the rate of flow of dilution liquid through the dilution liquid duct (12a),

wherein a module-like apparatus (10) is connected between the stock inlet header (J_1) and the tube bank (P),

the apparatus (10) comprises a body (11) having a first facing plate (17) connected to the stock inlet header (J_1) and a second facing plate (19) connected to the tube bank (P),

the mixing chambers (13a) are formed in the body (11) of the apparatus (10), and

the apparatus (10) comprises a plurality of inlet ducts (14a) for conducting the stock from the stock inlet header (J_1) into the mixing chambers (13a),

wherein the inlet ducts (14a) are arranged in adjacent vertical duct rows and at least two duct rows open into the mixing chamber (13a).

2. The headbox according to claim 1, wherein each mixing chamber (13a) is limited by a covering wall (T_1), a bottom wall (T_2), side walls (T_3) and a partition wall (16a) separating the mixing chambers (13a) from each other, and the inlet ducts (14a) extend into each mixing chamber (13a) such that their ends are located at a distance from outlet ducts (15a) on the outlet side of the mixing chamber (13a), whereby an annular gap (D_1) is left between each aligned inlet duct (14a) and outlet duct (15a) and the dilution liquid conducted into the mixing chamber (13a) is conducted through the annular gap (D_1) to join the stock conducted into the mixing chamber (13a) through the inlet duct (14a).

3. The headbox according to claim 2, wherein the width (h_1) of the annular gaps (D_1) is within a range of 2 mm to 8 mm.

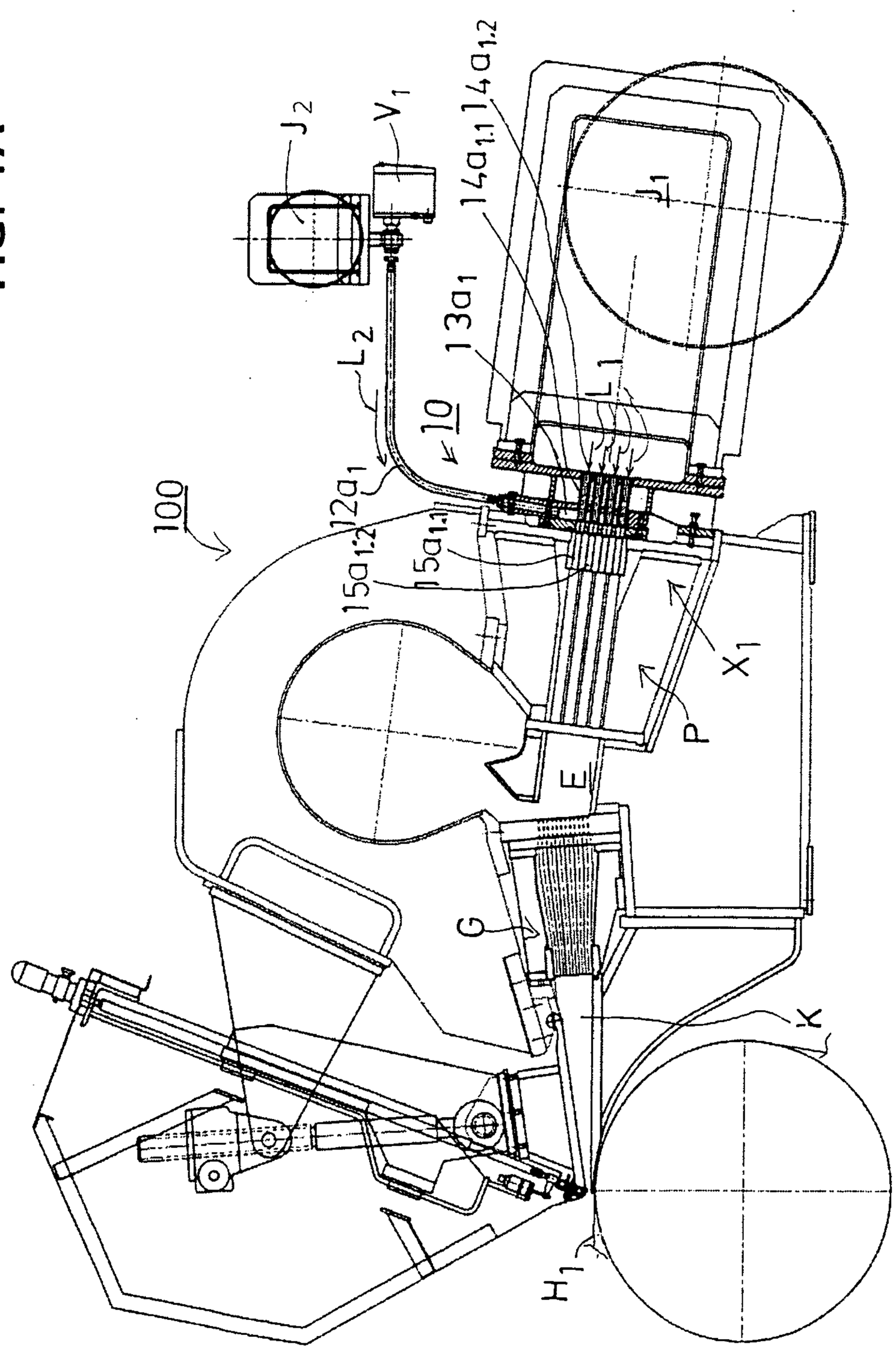
4. The headbox according to claim 3, wherein the width of the annular gaps is in the range of 3 mm to 5 mm.

5. The headbox according to any one of claims 1 to 4, wherein the body (11) of the apparatus (10) comprises a basic body (18), which comprises plates ($18a_1$, $18a_2$) through which the inlet ducts (14a) are passed into the internal space of each mixing chamber (13a), the second facing plate (19) comprises the outlet ducts (15a), the second facing plate (19) is further connected by screws (R_2) to one of the plates of the basic body (18), and the first facing plate (17) is connected to the other of the plates of the basic body (18) by screws (R_1).

6. The headbox according to any one of claims 1 to 5, wherein the bottom part of each mixing chamber (13a) is connected a washing duct (20) in such a way that washing liquid can be supplied to the mixing chambers (13a) from below upwards.

7. The headbox according to claim 6, wherein the washing duct (20) comprises branch ducts (20a) joined to at least one washing module (21a), and the washing module (21a) comprises an adjusting spindle (21b) having flow openings (C), wherein the washing spindle (21b) can be placed in such a position that the flow openings (C) are aligned with the branch ducts (20a) and, in addition, with washing ducts (e) leading into the mixing chambers (13a), and wherein the spindle (21b) can furthermore be placed in such a position that the flow openings (C) are not aligned with the branch ducts (20a) and the washing ducts (e).

FIG. 1A


100
10
J2
V1
L2
L1
12a1
13a1
14a1
14a1.1
15a1.1
15a1.2
J1
X1
P
E
G
K
H1

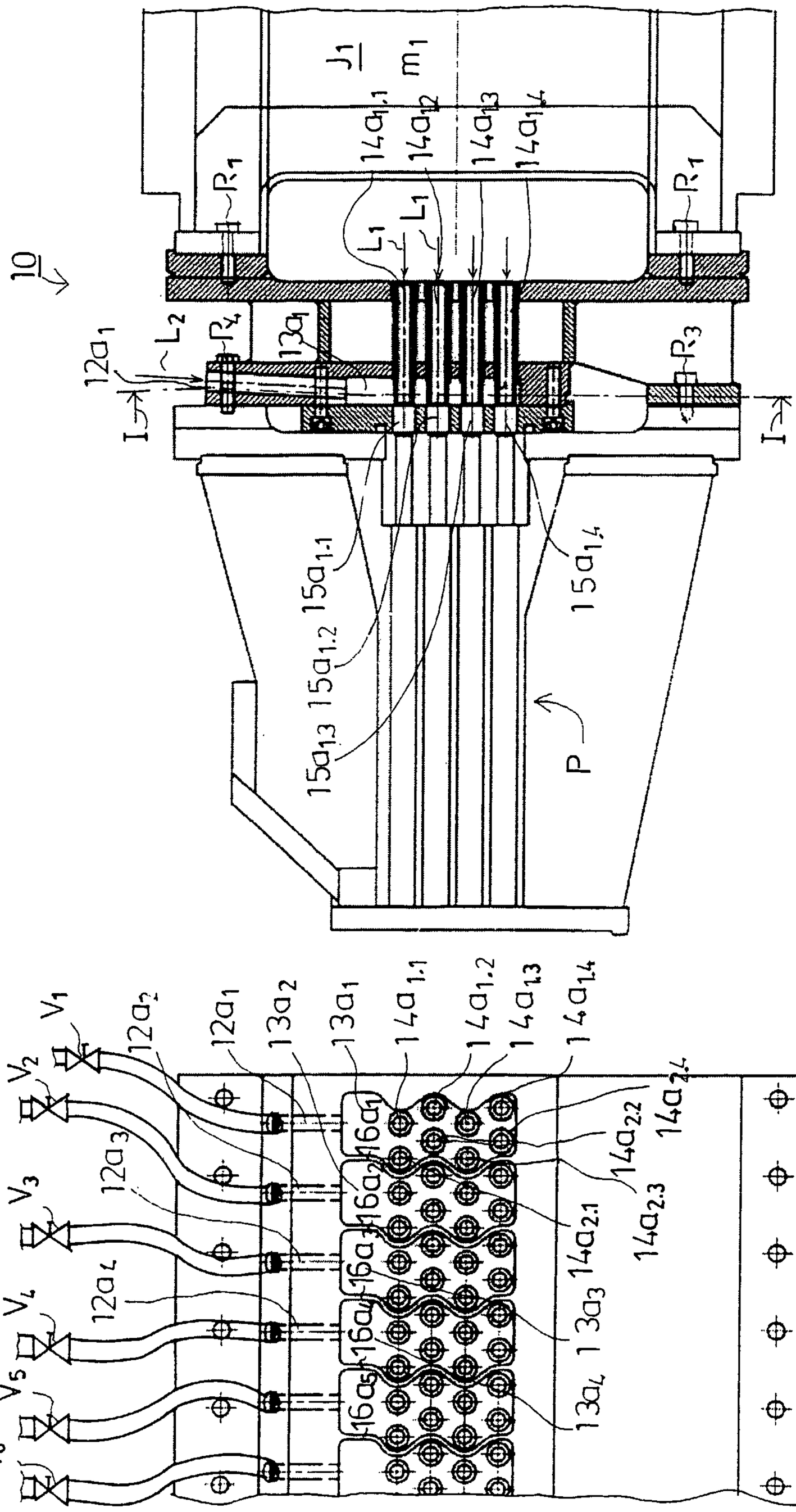

10
J1
m1
14a1.1
14a1.2
14a1.3
14a1.4
R1
R1
L1
L1
L2
R2
13a1
12a1
I
R3
I
15a1.1
15a1.2
15a1.3
15a1.4
P
V1
V2
V3
V4
V5
V6
12a2
12a3
12a4
12a1
13a2
13a1
14a1.1
14a1.2
14a1.3
14a1.4
16a1
16a2
16a3
16a4
16a5
14a2.2
14a2.3
14a2.1
14a2.4
13a4
13a3

FIG. 1B

FIG. 1C

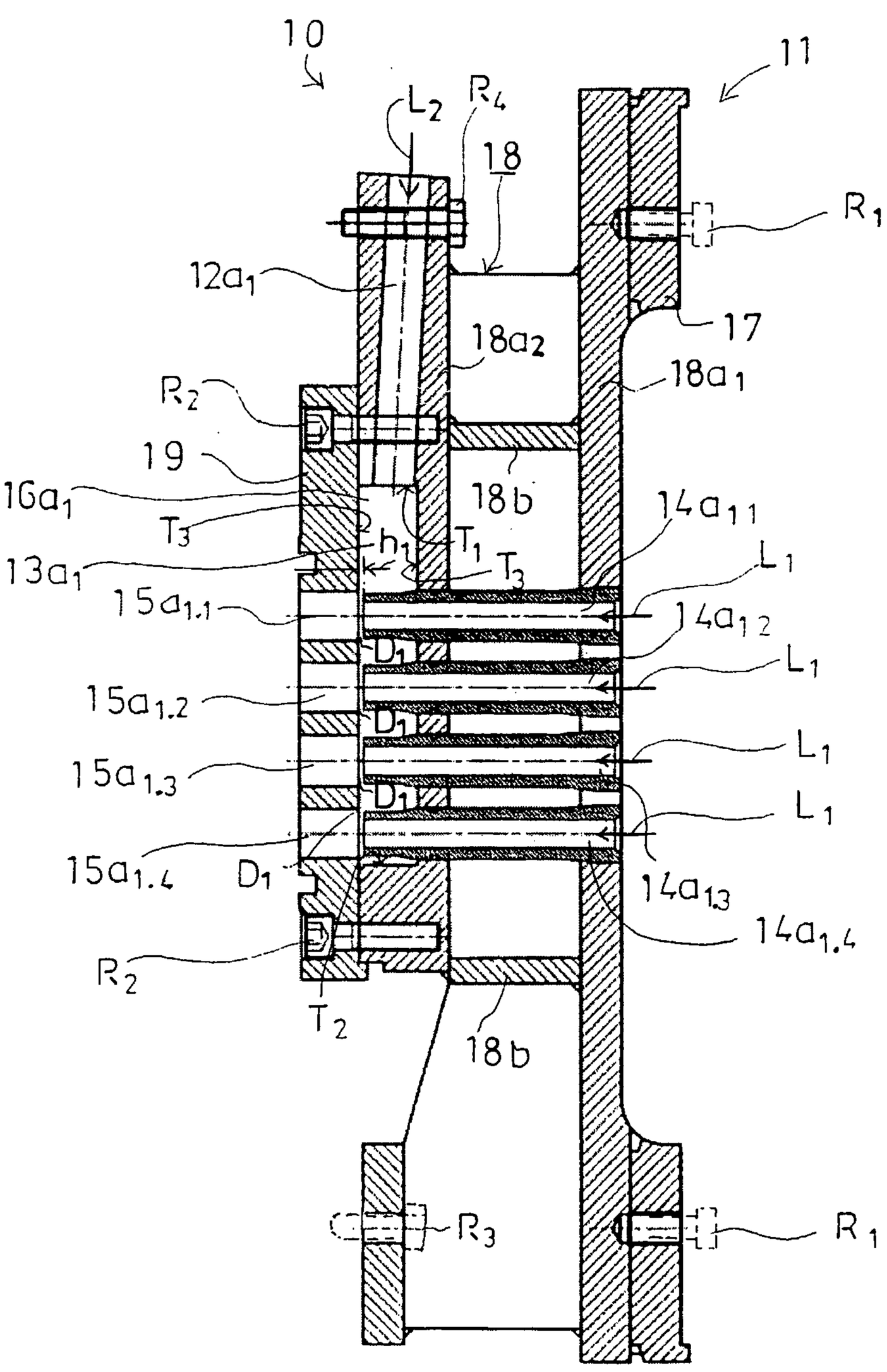
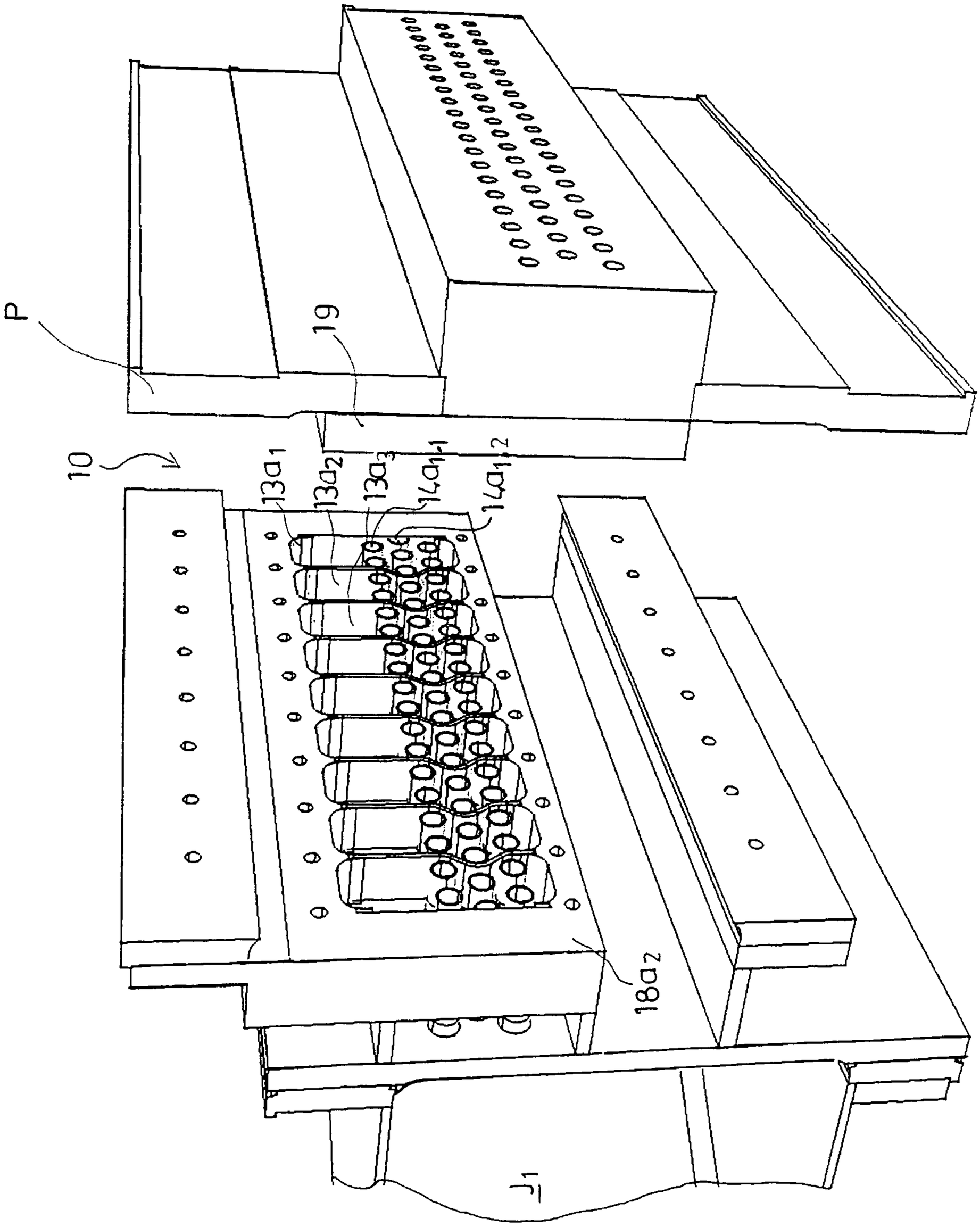

10
11
L2
R4
18
R1
12a1
18a2
17
R2
18a1
19
18b
16a1
14a11
T3
h1
T1
T3
13a1
L1
15a1.1
14a12
D1
L1
15a1.2
D1
L1
15a1.3
D1
L1
15a1.4
D1
14a13
14a1.4
R2
T2
18b
R3
R1

FIG. 2

FIG. 3



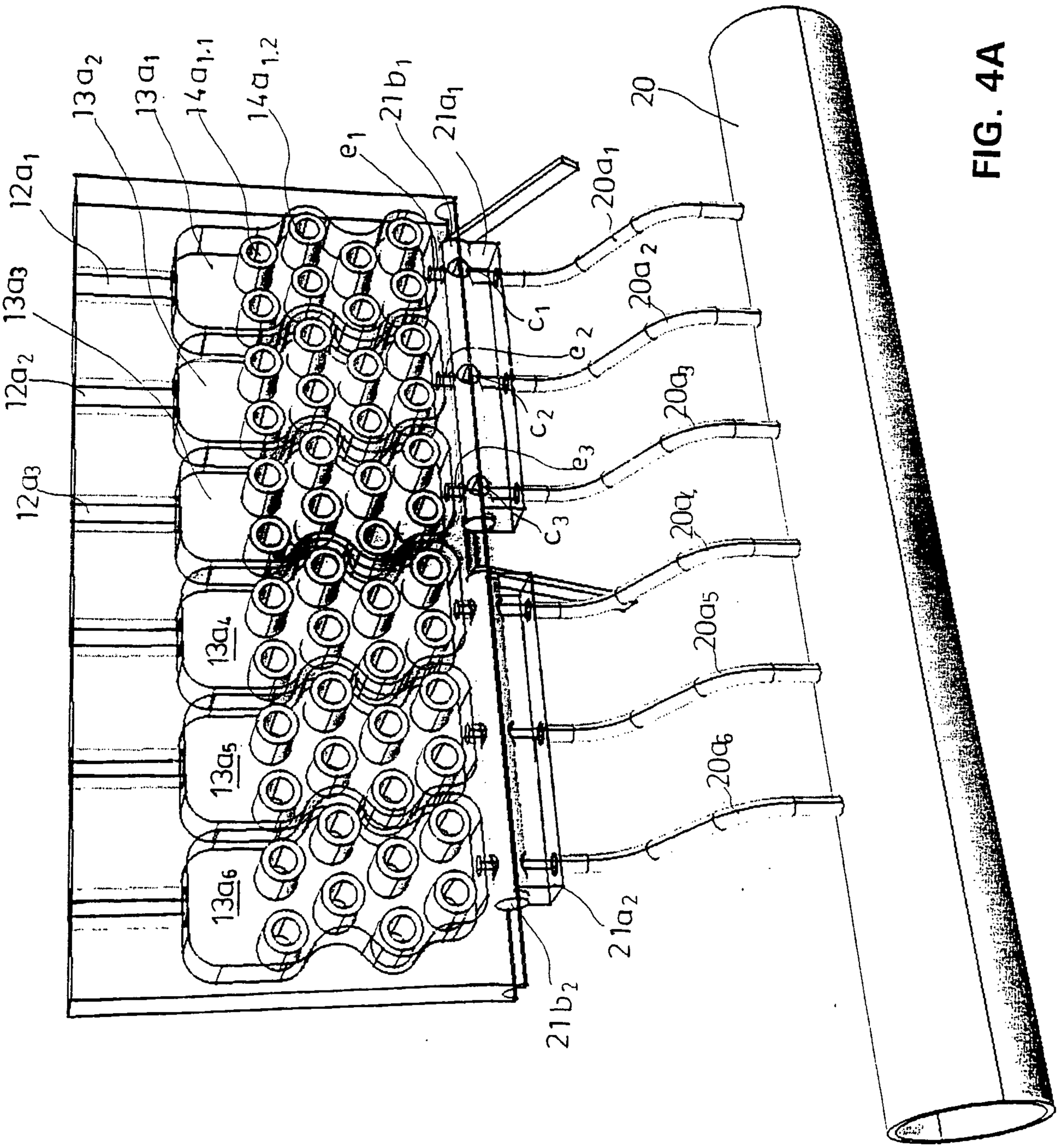

12a1
13a2
13a1
14a1.1
14a1.2
e1
21b1
21a1
20
20a1
12a2
13a3
20a2
c1
e2
c2
12a3
20a3
e3
c3
20a4
13a4
20a5
13a5
20a6
13a6
21a2
21b2

FIG. 4A

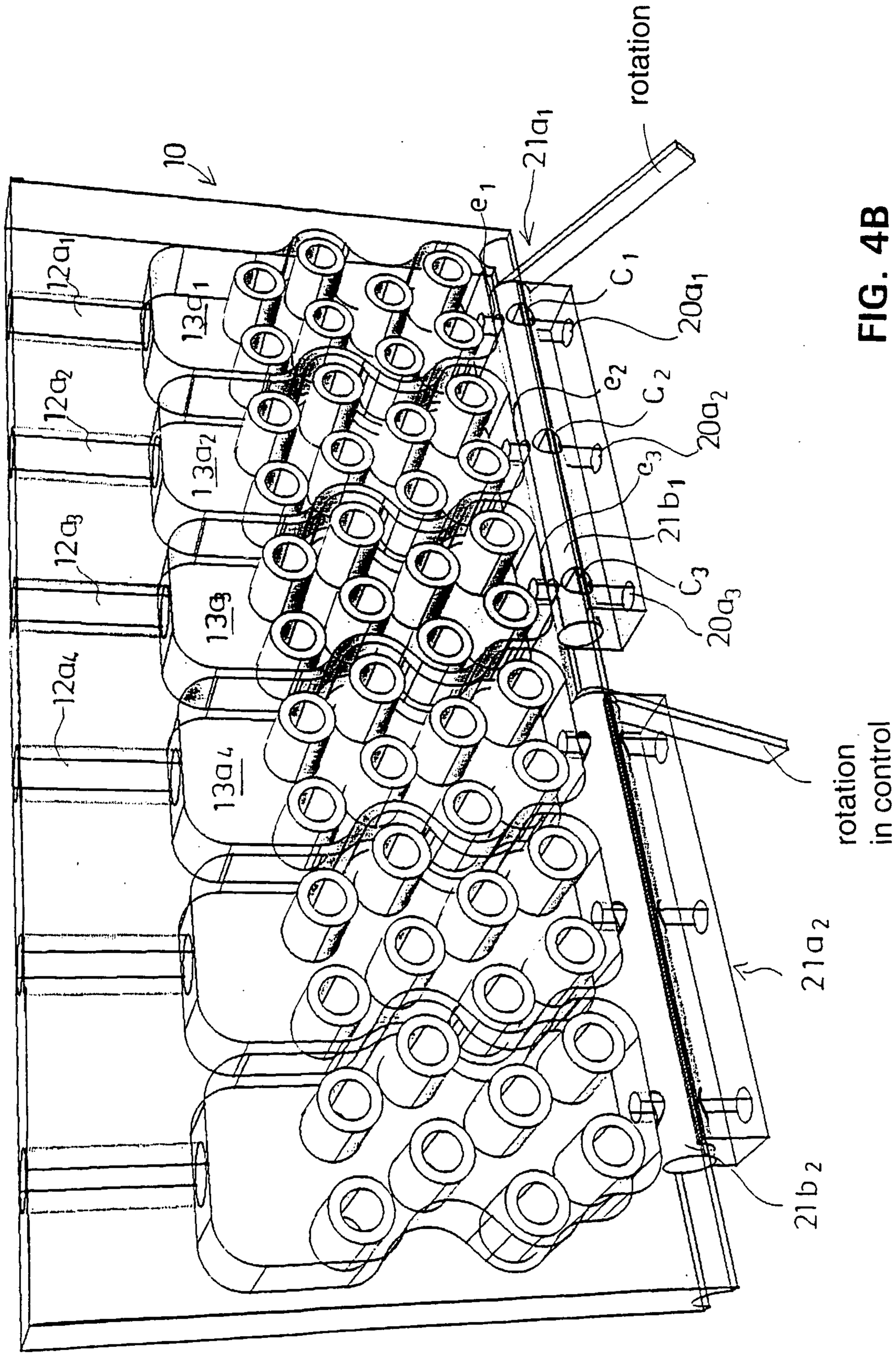
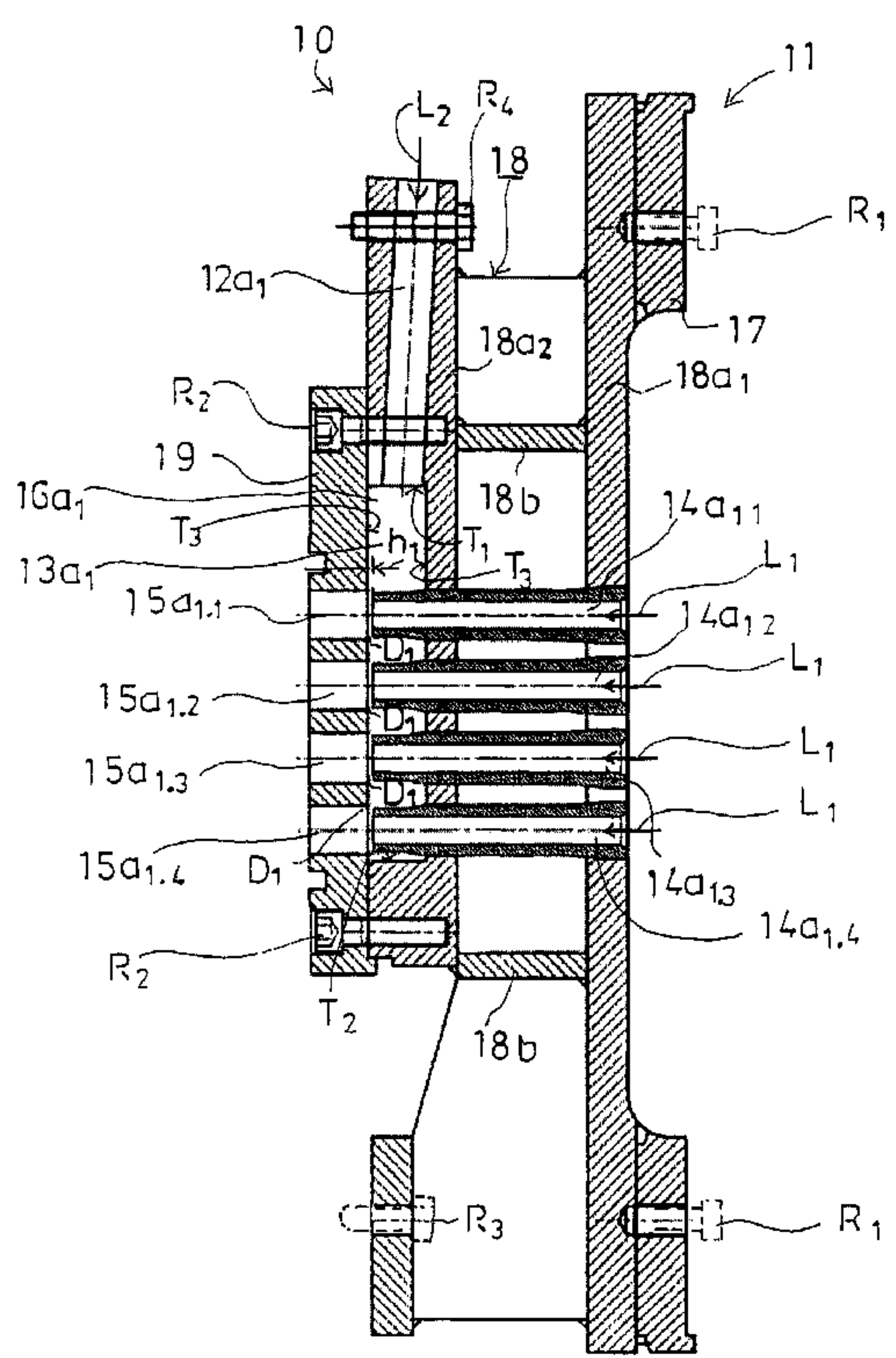

10
12a1
12a2
12a3
12a4
13d1
13a2
13a3
13a4
e1
e2
e3
C1
C2
C3
21c1
21b1
21a1
20a1
20a2
20a3
rotation
rotation
in control
21a2
21b2

FIG. 4B


10
11
L2
R4
18
R1
12a1
17
18a2
18a1
R2
19
18b
16a1
14a11
T3
h1
T1
T3
13a1
L1
15a1.1
14a12
D1
L1
15a1.2
D1
L1
15a1.3
D1
L1
15a1.4
D1
14a13
14a1.4
R2
T2
18b
R3
R1