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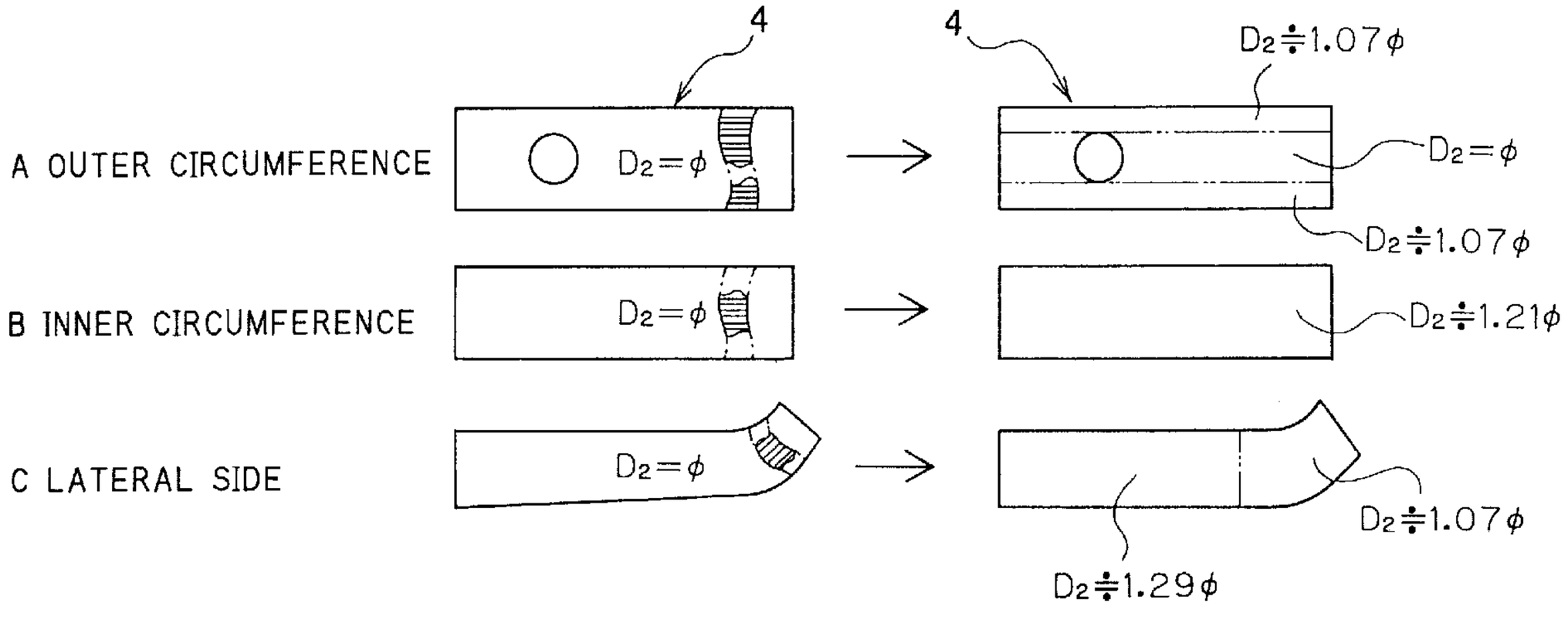
(54) Title: COOLING STRUCTURE OF COMBUSTOR TAIL TUBE



(57) Abrégé/Abstract:
To present a cooling structure of combustor tail tube capable of avoiding formation of cracks in the tail tube by lessening thermal stress and preventing thermal deformation, and extending the service life, the invention provides a cooling structure of combustor tail tube forming a multiplicity of cooling jackets (5) extending in the longitudinal direction of tail tube of a gas turbine combustor along the entire circumference of the tail tube wall, in which passage sectional area of the cooling jackets (5) is varied depending on the metal temperature of parts of the tail tube (4), for example, the passage sectional area of the cooling jackets (5) formed at the rotor side wall and the mutually opposite side walls of the adjacent tail tube is formed larger than the passage sectional area of the cooling jackets (5) formed at the casing side wall.

ABSTRACT OF THE DISCLOSURE

To present a cooling structure of combustor tail tube capable of avoiding formation of cracks in the tail tube by lessening thermal stress and preventing thermal deformation, and extending the service life, the invention provides a cooling structure of combustor tail tube forming a multiplicity of cooling jackets (5) extending in the longitudinal direction of tail tube of a gas turbine combustor along the entire circumference of the tail tube wall, in which passage sectional area of the cooling jackets (5) is varied depending on the metal temperature of parts of the tail tube (4), for example, the passage sectional area of the cooling jackets (5) formed at the rotor side wall and the mutually opposite side walls of the adjacent tail tube is formed larger than the passage sectional area of the cooling jackets (5) formed at the casing side wall.

COOLING STRUCTURE OF COMBUSTOR TAIL TUBE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a cooling structure of a combustor tail tube for gas turbine.

Description of the Related Art

As gas turbine combustor, recently, the steam cooling type combustor low in NO_x emission even in a gas turbine of 1500°C class, for example, is drawing attention. That is, by cooling the combustor wall by steam, the air hitherto used for cooling the wall can be used for combustion, and in spite of high temperature of the gas turbine, the premixed combustion temperature can be suppressed to a level of air-cooled combustor, so that low NO_x is realized.

Such steam cooling is employed in cooling of, for example as shown in Fig. 9, a tail tube 4 of a multi-nozzle type premixed combustor 3 having premixed flame forming nozzles 2 for forming and injecting a premixed gas of main fuel and combustion air, divided and disposed in plural positions around a cone 1 for forming a diffusion flame by reaction between pilot fuel and combustion air.

According to this structure, the cooling steam is first supplied into the middle part of the tail tube 4 in the longitudinal direction (see manifold 6b) from the cooling jackets 5 (see Fig. 10) and manifolds 6a, 6b, 6c formed inside the wall of the tail tube 4, and is divided into the upstream

side and downstream side of gas flow indicated by arrow in the diagram to cool the wall surface, and is collected from the inlet (see manifold 6a) and outlet (see manifold 6c) of the tail tube 4. A reverse flow of cooling steam is also known, that is, the cooling steam is first supplied from the inlet (see manifold 6a) and outlet (see manifold 6c) of the tail tube 4, and then flows into the middle part (see manifold 6b) to cool the wall surface, and is collected from the middle part.

The cooling jacket 5 is formed, as shown in Fig. 10, by processing a groove (see groove processing part "a") in width D_1 and depth D_2 in one wall 4a of the tail tube 4 of double wall structure, and brazing the groove side to other wall 4b (see brazing part "b").

In such conventional cooling structure of combustor tail tube, however, although the temperature condition generally differs locally in the elevated position of metal temperature at the inner side (rotor side) and lateral side (opposite sides of adjacent tail tubes) from the outer side (casing side) of the tail tube 4 formed in a rectangular shape at the outlet side, the size (passage sectional area) of the cooling jackets 5 is set uniformly on the entire circumference, and the flow rate distribution of cooling steam to necessary parts is set regardless of the metal temperature, and cracks are likely to be formed at four corners of the outlet of the tail tube 4 due to thermal deformation caused by increase of thermal stress by uneven metal temperature and lack of cooling in the outlet (in particular, flange) of the tail tube 4.

The invention is devised in the light of the above background, and it is hence an object thereof to present a cooling structure of combustor tail tube capable of preventing formation of tail tube cracks by decreasing the thermal stress and preventing thermal deformation, and extending the service life.

SUMMARY OF THE INVENTION

To solve the problems, the invention presents a cooling structure of combustor tail tube forming a multiplicity of cooling jackets extending in the longitudinal direction of tail tube of a gas turbine combustor along the entire circumference of the tail tube wall, in which passage sectional area of the cooling jackets is varied depending on the metal temperature of the tail tube parts.

Preferably, the passage sectional area of the cooling jackets formed at the rotor side wall and the mutually opposite side walls of the adjacent tail tube is formed larger than the passage sectional area of the cooling jackets formed at the casing side wall of the tail tube.

Preferably, the cooling jackets are extended from the root of the flange attached to the peripheral edge of the outlet of the tail tube in the flange height direction, and are pulled back after the cooling medium is supplied in the area.

Preferably, an annular cooling passage is formed to surround the outlet in the front portion of the flange attached to the edge of the outlet of the tail tube, and the cooling medium

is directly supplied into the cooling passage without cooling the tail tube wall.

Preferably, the tail tube is formed n a double wall structure, a groove is processed in one wall, the groove side is bonded with the other wall to form a cooling jacket, and the groove side wall is disposed at the inner wall side to be exposed to combustion gas.

Preferably, the cooling medium is supplied from the combustion gas outlet of the tail tube, and the cooling medium is collected from one position at the combustion gas inlet side.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a structural explanatory diagram of a cooling jacket showing a first embodiment of the invention, in which (a) is an explanatory diagram of size of an existing cooling jacket, (b) is an explanatory diagram of size of the cooling jacket of the invention, and (c) is a partial cut-away perspective view of a tail tube;

Fig. 2 is a structural explanatory diagram of a tail tube outlet showing a second embodiment of the invention, in which (a) is a structural explanatory diagram of an existing tail tube outlet, and (b) is a structural explanatory diagram of a tail tube outlet of the invention;

Fig. 3 is an essential side view of a tail tube showing a third embodiment of the invention;

Fig. 4 is a back perspective view of the tail tube outlet;

Fig. 5 is a front view of the tail tube outlet;

Fig. 6 is a sectional view of VI-VI in Fig. 5;

Fig. 7 is a side sectional view of a gas turbine combustor showing a fourth embodiment of the invention;

Fig. 8 is a sectional view of VIII-VIII in Fig. 7;

Fig. 9 is a side sectional view around a conventional gas turbine combustor; and

Fig. 10 is a sectional view of X-X in Fig. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, preferred embodiments of the cooling structure of combustor tail tube of the invention are described in detail below.

[First Embodiment]

Fig. 1 is a structural explanatory diagram of a cooling jacket showing a first embodiment of the invention, in which (a) is an explanatory diagram of size of an existing cooling jacket, (b) is an explanatory diagram of size of the cooling jacket of the invention, and (c) is a partial cut-away perspective view of a tail tube. Also in (a), the passage of cooling jacket is shown in a partially cut-away view.

As shown in Fig. 1, in this embodiment, the cooling jacket (see reference numeral 5 in Fig. 10) formed inside the wall of the tail tube 4 formed in a rectangular shape at the outlet side is expanded in its passage sectional area in most parts as compared with the existing cooling jacket, and further the passage sectional area is varied, for example, in the outer

circumference (casing side) A of the tail tube 4, inner circumference (rotor side) b, and lateral side (opposite sides of adjacent tail tubes) C, depending on the metal temperature of the parts of the tail tube 4.

That is, in the existing cooling jacket, as shown in Fig. 1 (a), a uniform cooling jacket size of groove depth D_2 (see Fig. 8) = ø mm, for example, is set in all parts of the outer circumference, inner circumference, and lateral sides, but in the embodiment, as shown in Fig. 1 (b), the cooling jacket size is set at the groove depth D_2 = ø mm in the central part of the outer circumference, and groove depth D_2 = about 1.07 ø mm at both lateral parts (corners), and further the cooling jacket size is set at the groove depth D_2 = about 1.21 ø mm in the inner circumference and groove depth D_2 = about 1.29 ø mm at the upstream side of the lateral side. On the other hand, the cooling jacket size is set at the groove depth of D_2 = about 1.07 ø mm at the downstream side of the lateral side. The number of cooling jackets is same in both the existing structure and the embodiment.

Thus, in the embodiment, by varying the cooling jacket size of the parts so that the metal temperature may be uniform in the parts of the tail tube 4, the flow rate distribution of cooling steam as cooling medium is optimized, and therefore thermal deformation due to increase of thermal stress by uneven metal temperature and lack of cooling of outlet of the tail tube 4 can be effectively prevented, and crack formation at the outlet of the tail tube 4 can be avoided.

In the embodiment, instead of the groove depth D_2, the groove width D_1 may be also increased, together with the groove depth D_2, to change the cooling jacket size in various parts.

[Second Embodiment]

Fig. 2 is a structural explanatory diagram of a tail tube outlet showing a second embodiment of the invention, in which (a) is a structural explanatory diagram of an existing tail tube outlet, and (b) is a structural explanatory diagram of a tail tube outlet of the invention. The entire structure of the tail tube is shown in Fig. 9, and detailed description is omitted herein.

As shown in Fig. 2, in this embodiment, the destination of the cooling jacket 5 (see Fig. 10) for supplying cooling steam to the flange 4a projecting outward to the outlet peripheral edge (opening peripheral edge) of the tail tube 4 is changed, so that the flange 4a is cooled by steam in particular.

That is, in the existing cooling jacket 5, as shown in Fig. 2 (a), the cooling steam sent to the root of the flange 4a flows into the adjacent cooling jacket 5 at the root, and slightly returns to the upstream side, and flows into the manifold 6c through the pass hole 5a (formed at every other cooling jacket 5), whereas, in the embodiment, as shown in Fig. 2 (b), the cooling steam sent into the root of the flange 4a flows through the passage 5b extended in the height direction of the flange 4a, and flows into the manifold 6c. Therefore, the passage 5b is, unlike the pass hole 5a, is formed in every cooling jacket 5.

Thus, in the embodiment, the cooling steam is supplied into the entire flange 4a at the outlet of the tail tube 4, and cooling of the flange 4a is reinforced, so that thermal deformation due to temperature difference can be prevented, and crack formation at the outlet of the tail tube 4 can be avoided.

[Third Embodiment]

Fig. 3 is an essential side view of a tail tube showing a third embodiment of the invention, Fig. 4 is a back perspective view of the tail tube outlet, Fig. 5 is a front view of the tail tube outlet, and Fig. 6 is a sectional view of VI-VI in Fig. 5.

As shown in Fig. 3 to Fig. 6, in this embodiment, aside from the cooling jackets (see reference numeral 5 in Fig. 10) formed inside the wall of the tail tube 4 formed in a rectangular shape at the outlet side, bypass steam jackets 10a to 10d are formed, and the cooling steam not cooling the wall of the tail tube 4 is supplied through the bypass steam jackets 10a to 10d into an annular cooling passage 11 formed at the front side of the flange 4a at the outlet of the tail tube 4, so that the flange 4a is cooled by steam in particular.

That is, the bypass steam jackets 10a to 10d are branched into four lines in the peripheral direction along the outer circumference of the tail tube 4 from the manifold 6b, and communicate with steam sumps 12a to 12d formed at four corners at the outlet of the tail tube 4. The steam sumps 12a to 12d communicate with the cooling passage 11 through pass holes 13a to 13d and groove passages 14a to 14d formed at four corners

of the rectangular flange 4a. From the cooling passage 11, the cooling steam is guided into the manifold 6c through tiny hole groups 15a to 15d formed at four peripheral positions, and it is mixed with the cooling steam from the cooling jackets 5 herein, and collected. Reference numeral 16 in the drawing is a cover plate for closing the cooling passage 11 and groove passages 14a to 14d after processing the grooves.

In the embodiment, therefore, the flange 4a at the outlet of the tail tube 4 is cooled entirely by the steam by the cooling steam at low temperature supplied into the annular cooling passage 11 without heat exchange from the manifold 6b by way of the bypass steam jackets 10a to 10d, steam sumps 12a to 12d, pass holes 13a to 13d, and groove passages 14a to 14d, and a sufficient cooling effect is obtained, and thermal deformation due to temperature difference is prevented, and formation of cracks at the outlet of the tail tube 4 is avoided.

[Fourth Embodiment]

Fig. 7 is a side sectional view of a gas turbine combustor showing a fourth embodiment of the invention, and Fig. 8 is a sectional view of VIII-VIII in Fig. 7. In these diagrams, same reference numerals are given to the parts and members same as in Fig. 9 and Fig. 10, and detailed description is omitted.

As shown in Fig. 7, the invention is applied to steam cooling of a tail tube 4 of a multi-nozzle type premixed combustor 3 having premixed flame forming nozzles 2 for forming and injecting a premixed gas of main fuel and combustion air, divided and disposed in plural positions around a cone 1 for

forming a diffusion flame by reaction between pilot fuel and combustion air.

In this embodiment, the cooling steam is first supplied into the outlet (see manifold 6c) of the tail tube 4 from the cooling jackets 5A (see Fig. 8) and manifolds 6a, 6c formed in the wall of the tail tube 4, and flows in the upstream side of the gas flow as indicated by arrow to cool the wall surface, and is collected from one position at the inlet (see manifold 6a) of the tail tube 4.

The cooling jacket 5A is formed, as shown in Fig. 8, by processing a groove (see groove processing part "a") in $D_1 < D_2$ in one wall 4a of the tail tube 4 of double wall structure, and brazing the groove side to other wall 4b (see brazing part "b"), and the groove side wall 4a is disposed at the inner wall side to be exposed to the combustion gas.

Further in the embodiment, the other wall 4b at the outer wall side is formed slightly thicker than in the prior art in consideration of the strength in the bending process. The wall 4a is also considerably thicker than in the prior art in order to prevent lowering of strength in the brazing part "b" by equalizing the itch of the cooling jackets 5A, and to increase the passage sectional area by increasing the groove depth D_2.

Thus, in the embodiment, since the groove side wall 4a is disposed at the inner wall side exposed to the combustion gas, the brazing part "b" of the cooling jacket 5A can be set apart from the combustion gas as far as possible, so that temperature elevation due to combustion gas can be prevented.

It hence avoids peeling phenomenon of the brazing part "b" due to elevated thermal stress, and the service life of the combustor wall can be extended. In addition, by the long groove of the cooling jacket 5A, a flexible wall structure is realized, and the thermal stress can be much lowered, and the heating surface area is increased at the same time, and the amount of steam (or air may be used in the invention) as the cooling medium can be decreased, so that the performance of the plant may be enhanced.

In the embodiment, by the cooling jackets 5A and manifolds 6a, 6c, steam cooling is executed in one pass from the outlet to the inlet of the tail tube 4, so that the outlet of the tail tube can be cooled by the steam (or air in the invention) before temperature elevation by heat exchange.

As a result, the metal temperature is lowered, low cycle fatigue life is extended, and formation of cracks at four corners of the outlet of the tail tube 4 due to elevation of thermal stress as in prior art can be avoided. Further, by increasing the groove depth D_2 and increasing the passage sectional area, lowering of strength of brazing part "b" can be prevented while the same steam flow rate is maintained. In addition by one-pass steam cooling, the number of jackets and manifolds can be decreased, and the structure may be simplified.

The invention is not limited to these illustrated embodiments alone, but it must be noted that the invention may be changed or modified within the scope not departing from the true spirit thereof by, for example, using air as cooling medium,

or executing the first to fourth embodiments simultaneously. Still more, the cooling jacket structure as shown in Fig. 8 may be applied to the steam cooling of two-position collection system as shown in Fig. 9.

Thus, as explained specifically in relation to the embodiments, in the cooling structure of combustor tail tube forming a multiplicity of cooling jackets extending in the longitudinal direction of tail tube of a gas turbine combustor along the entire circumference of the tail tube wall, the passage sectional area of the cooling jackets is varied depending on the metal temperature of the tail tube parts, and therefore the flow rate distribution of cooling medium is optimized, and thermal deformation due to increase of thermal stress by uneven metal temperature and lack of cooling at the tail tube outlet can be effectively prevented, and crack formation at the outlet of the tail tube can be avoided.

What is claimed is:

1. A cooling structure of combustor tail tube forming a multiplicity of cooling jackets extending in the longitudinal direction of tail tube of a gas turbine combustor along the entire circumference of the tail tube wall, wherein passage sectional area of the cooling jackets is varied depending on the metal temperature of the tail tube parts.

2. The cooling structure of combustor tail tube of claim 1, wherein the passage sectional area of the cooling jackets formed at the rotor side wall and the mutually opposite side walls of the adjacent tail tube is formed larger than the passage sectional area of the cooling jackets formed at the casing side wall of the tail tube.

3. The cooling structure of combustor tail tube of claim 1, wherein the cooling jackets are extended from the root of the flange attached to the peripheral edge of the outlet of the tail tube in the flange height direction, and are pulled back after the cooling medium is supplied in the area.

4. The cooling structure of combustor tail tube of claim 1, wherein an annular cooling passage is formed to surround the outlet in the front portion of the flange attached to the edge of the outlet of the tail tube, and the cooling medium is directly supplied into the cooling passage without cooling the tail tube wall.

5. The cooling structure of combustor tail tube of claim 1, wherein the tail tube is formed n a double wall structure,

a groove is processed in one wall, the groove side is bonded with the other wall to form a cooling jacket, and the groove side wall is disposed at the inner wall side to be exposed to combustion gas.

6. The cooling structure of combustor tail tube of claim 1, wherein the cooling medium is supplied from the combustion gas outlet of the tail tube, and the cooling medium is collected from one position at the combustion gas inlet side.

Fig.1(a)

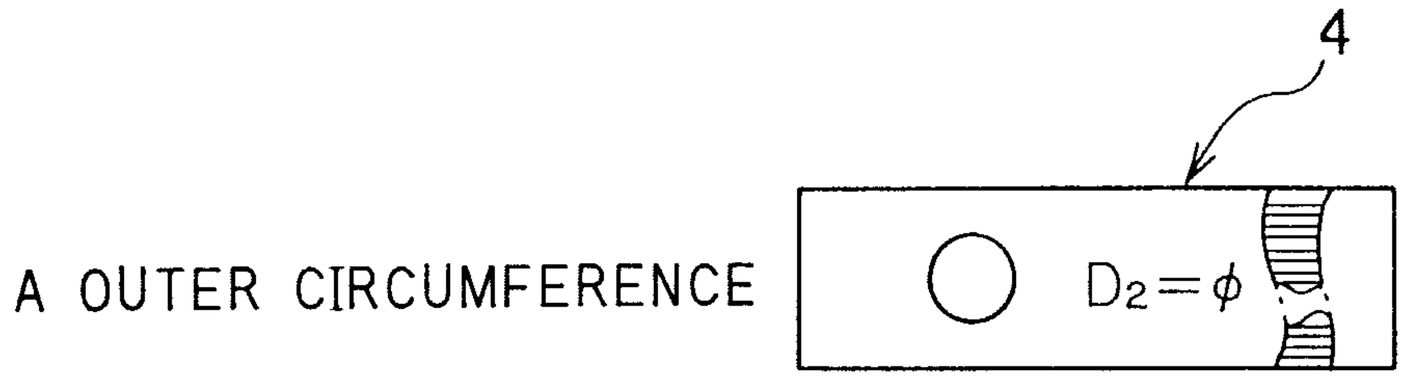


Fig.1(b)

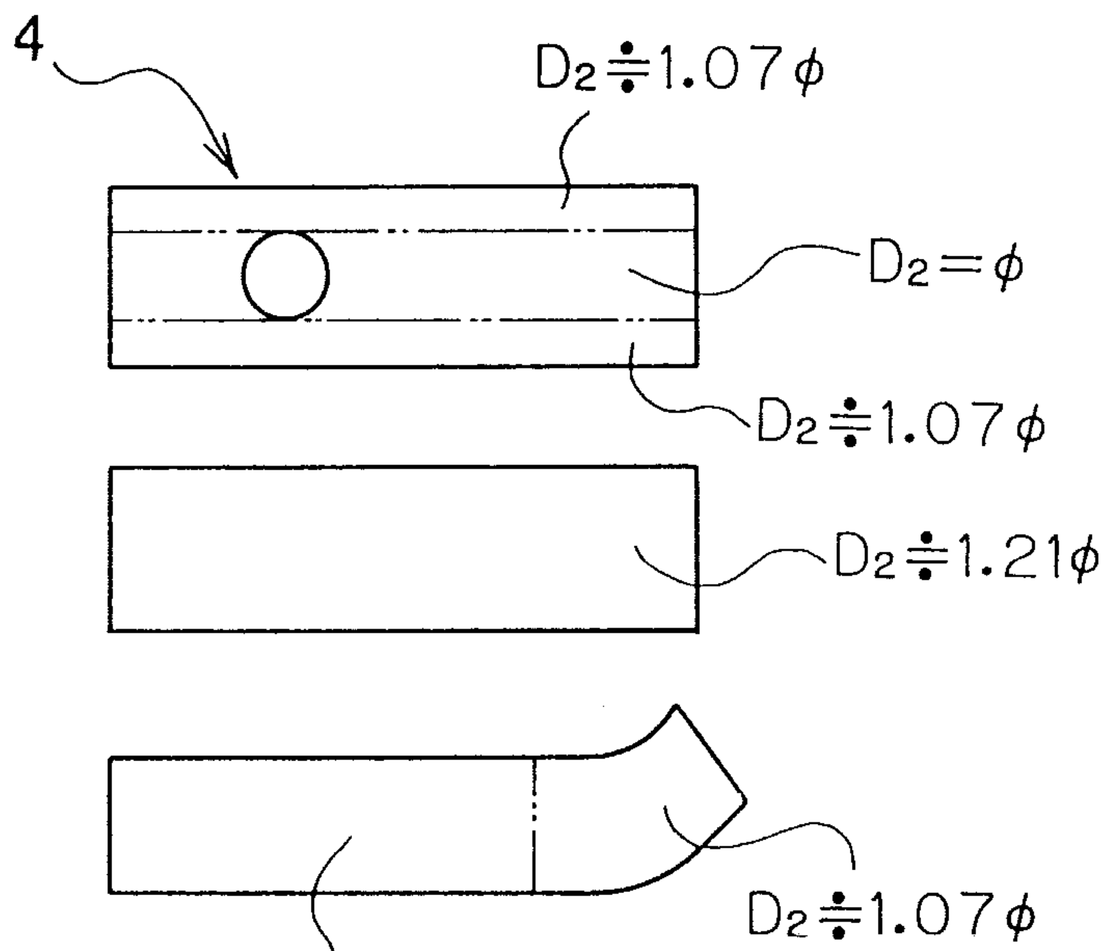


Fig.1(c)

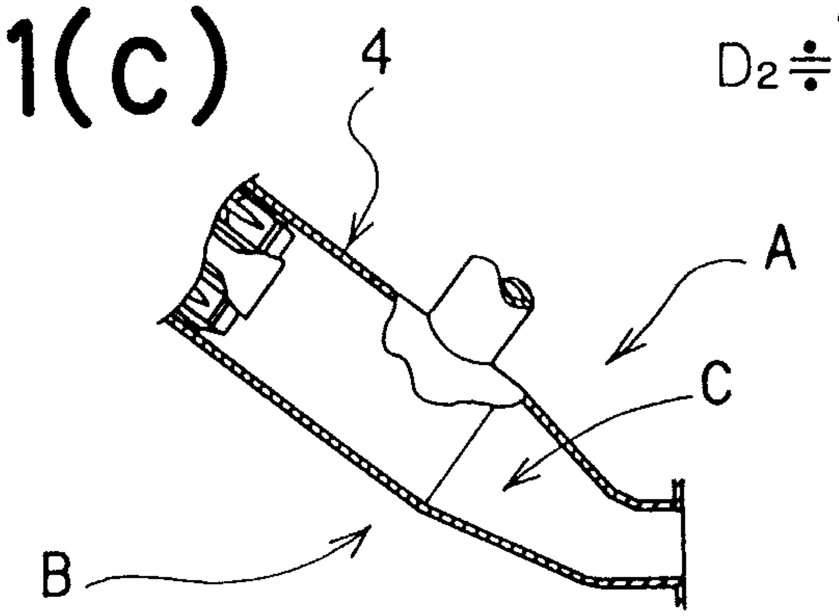


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Fig.2(a)

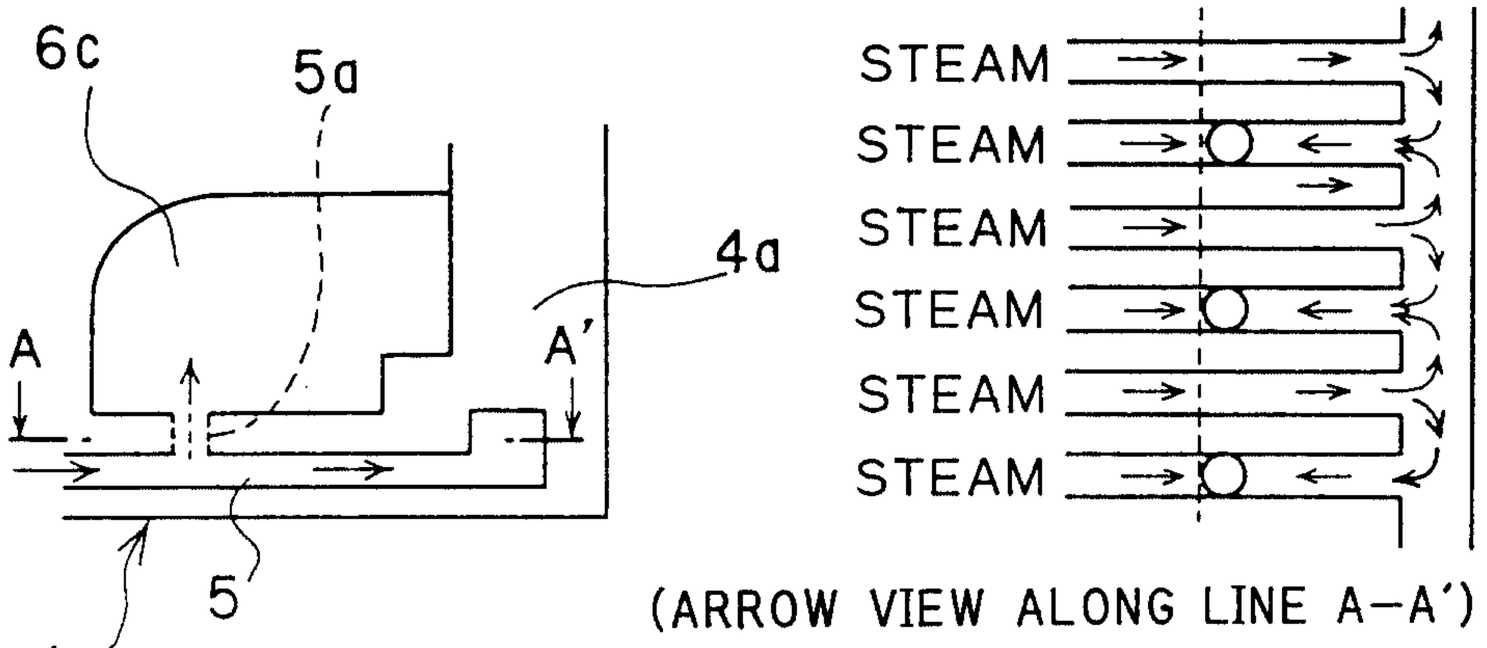

6c
5a
4a
A
A'
5
4
STEAM
STEAM
STEAM
STEAM
STEAM
STEAM
(ARROW VIEW ALONG LINE A–A')

Fig.2(b)

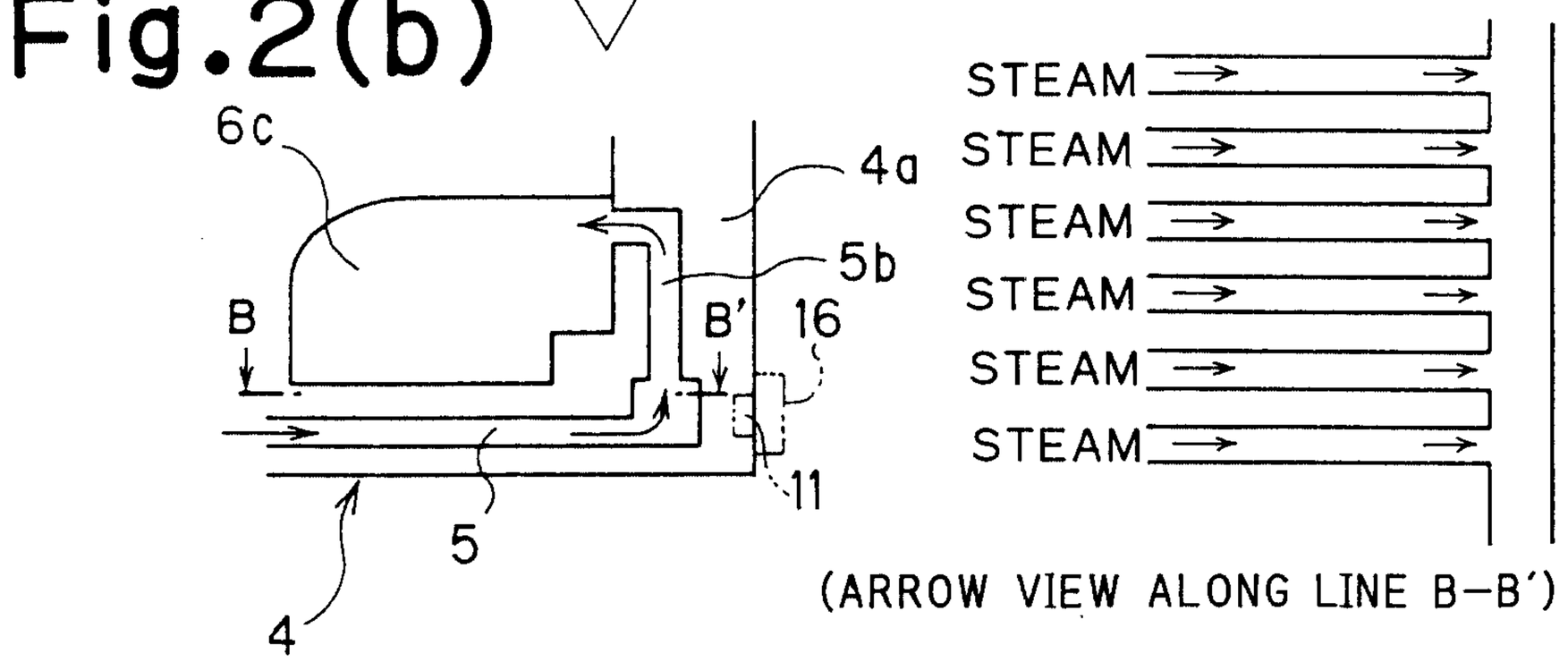

6c
4a
5b
B
B'
16
11
5
4
STEAM
STEAM
STEAM
STEAM
STEAM
STEAM
(ARROW VIEW ALONG LINE B–B')

Fig.3

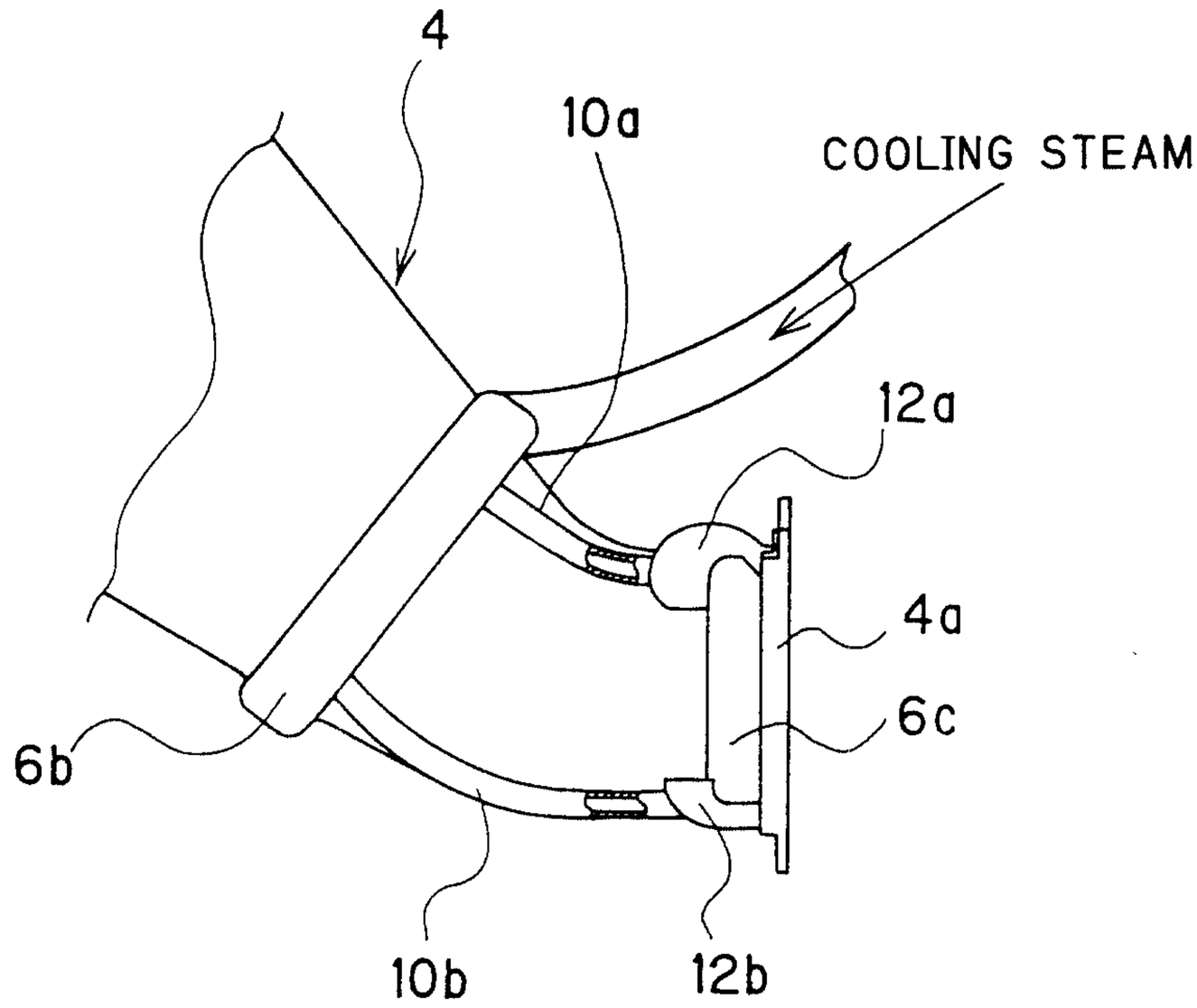


Fig.4

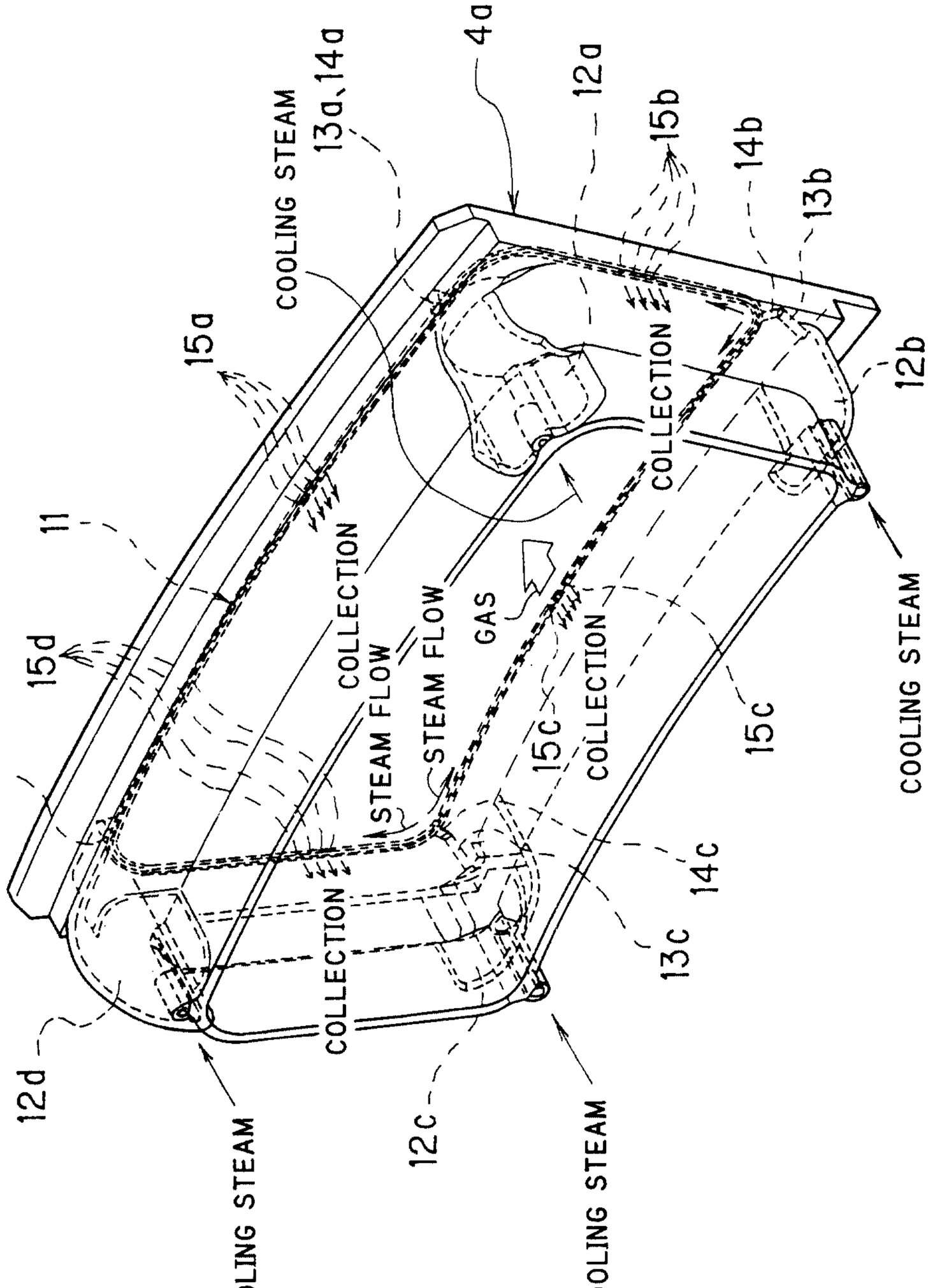

COOLING STEAM
13a、14a
4
12a
15b
14b
13b
15a
11
12b
COLLECTION
STEAM FLOW
GAS
15d
13d、14d
COLLECTION
STEAM FLOW
15c
COLLECTION
12d
12c
13c
14c
COOLING STEAM
COOLING STEAM

Fig.5

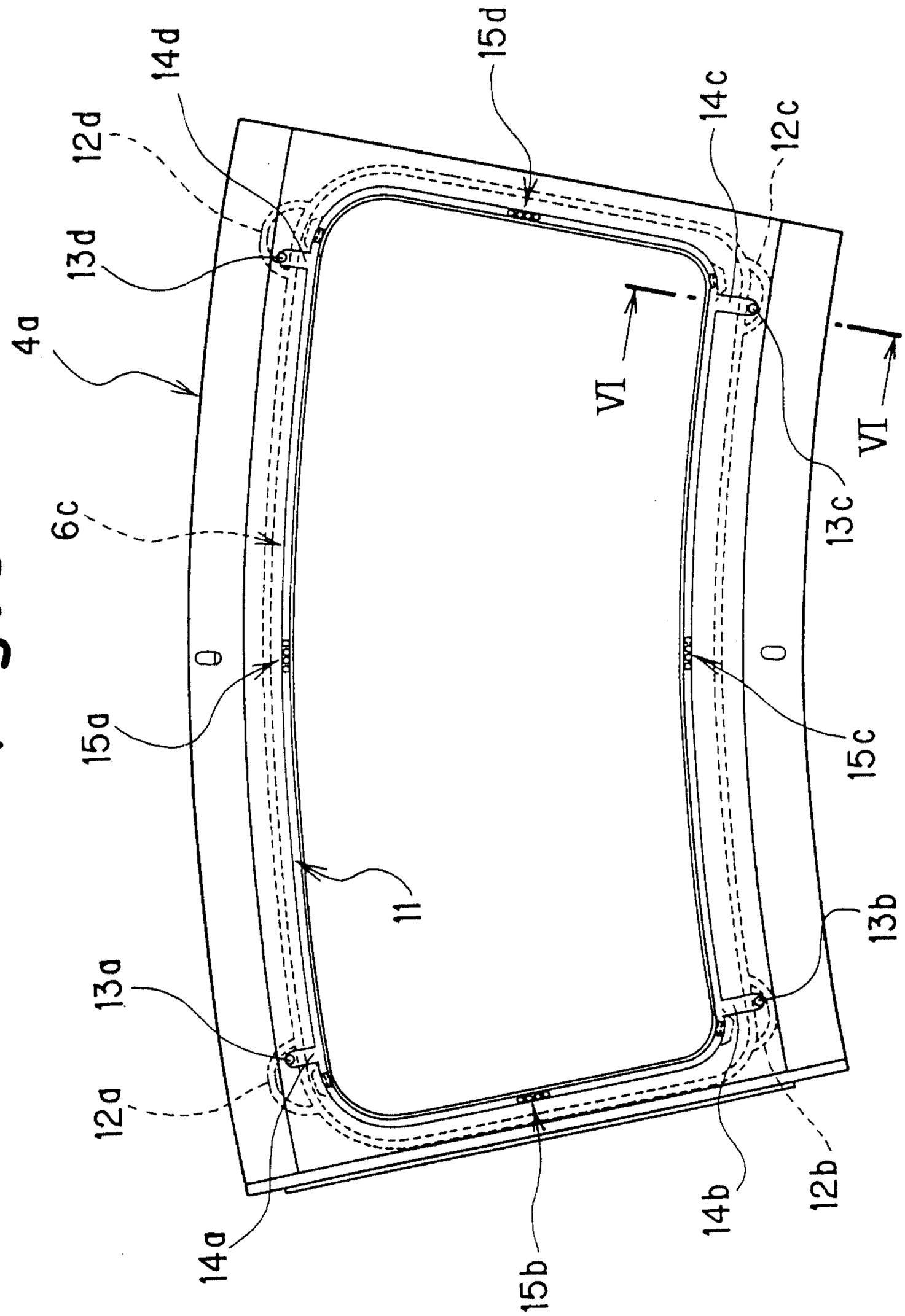

14d
15
12d
14c
12c
13d
4a
VI
VI
6c
13c
θ
θ
15a
15c
11
13b
13a
12a
12b
14a
15b
14b

Fig.6

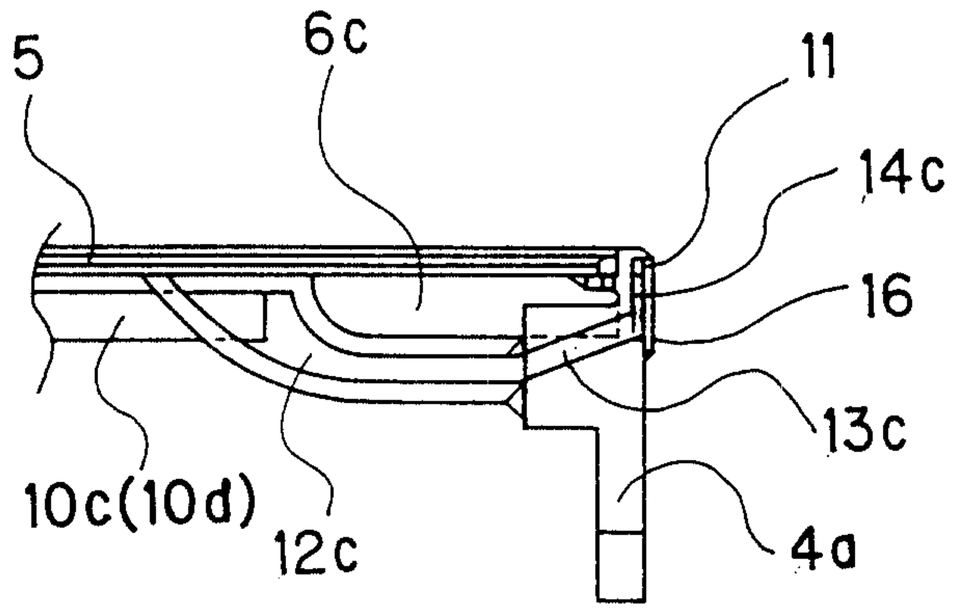


Fig.7

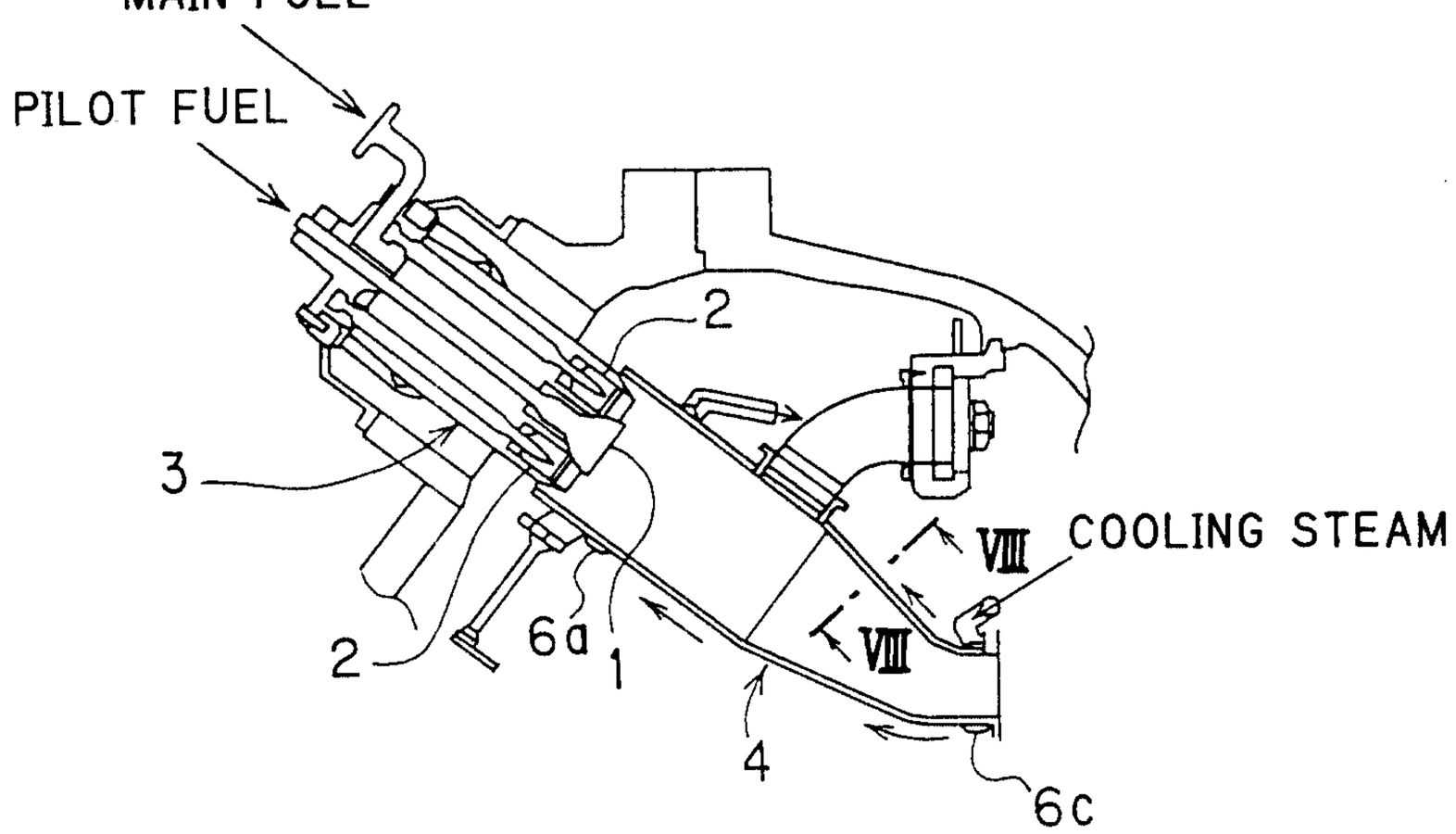

MAIN FUEL
PILOT FUEL
2
3
2
6a
1
4
6c
VIII
VIII
COOLING STEAM

Fig.8

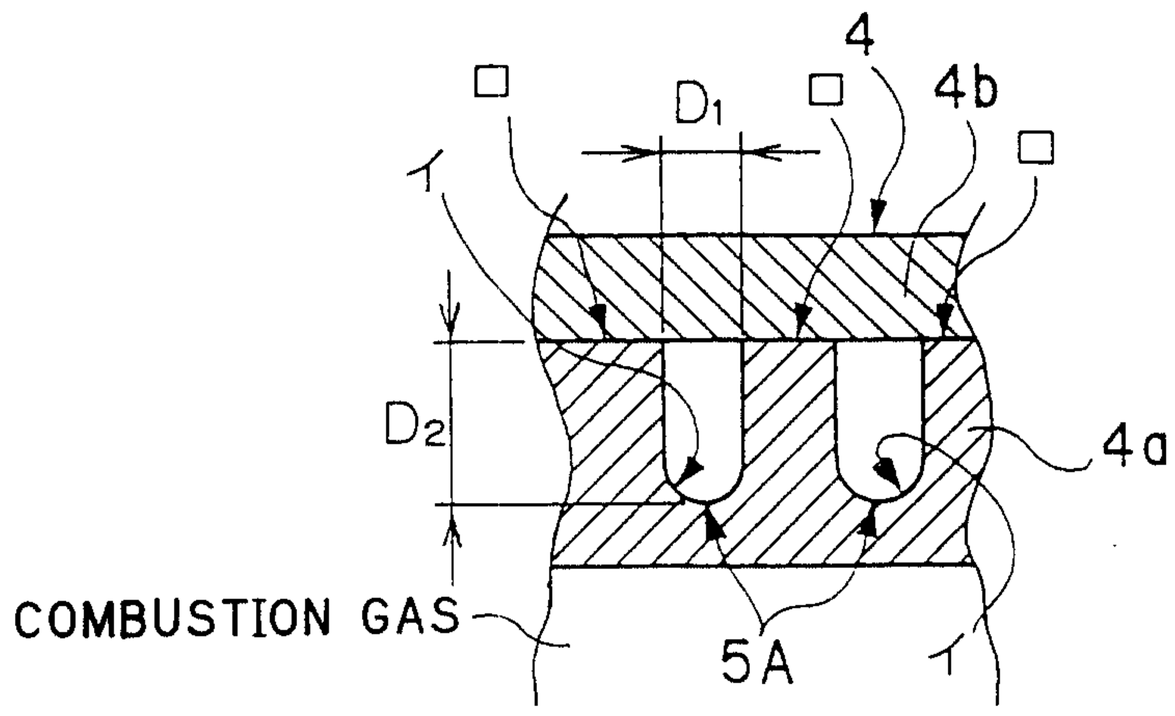

4
4b
D1
1
D2
4a
COMBUSTION GAS
5A
1

Fig.9

RELATED ART

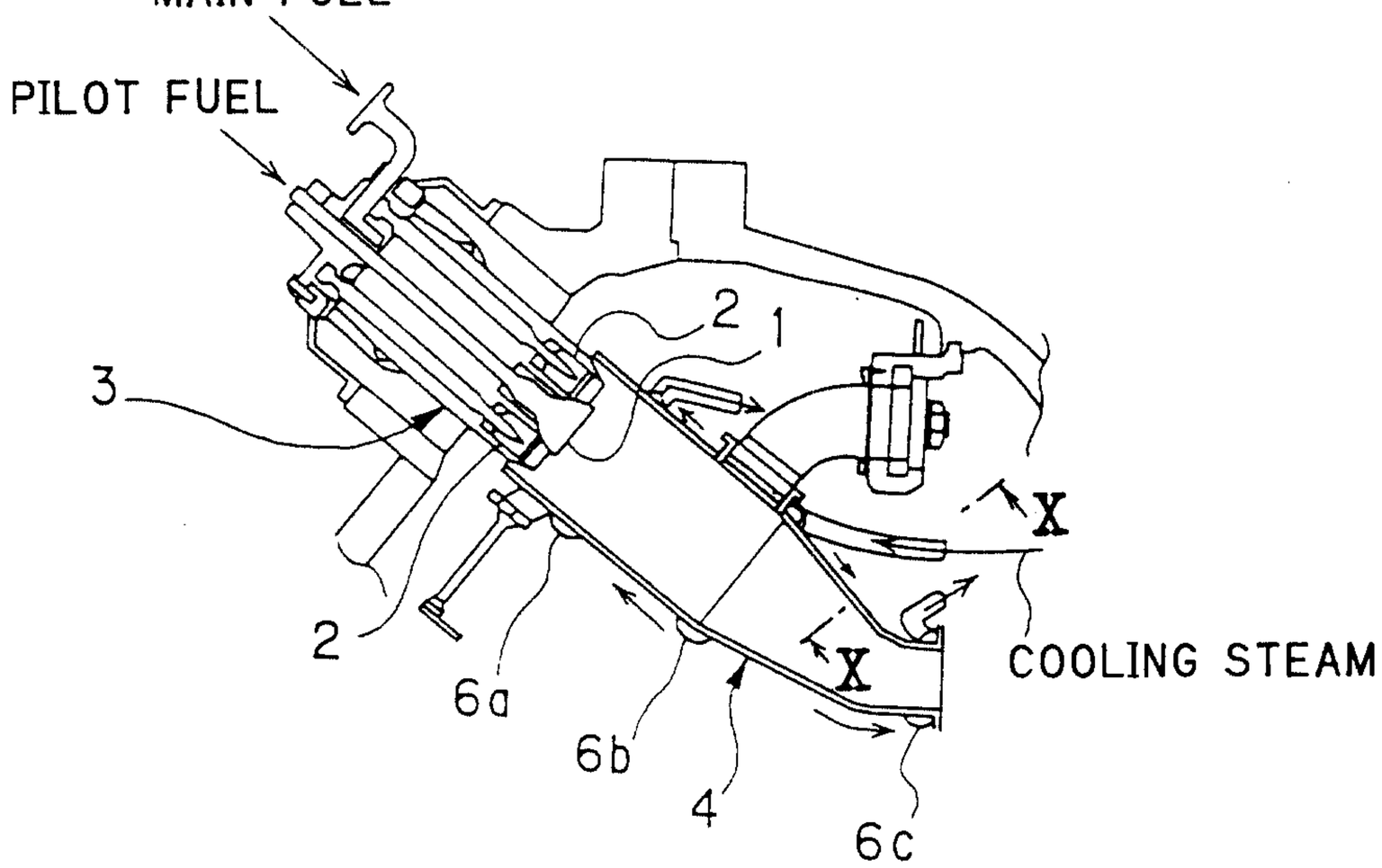
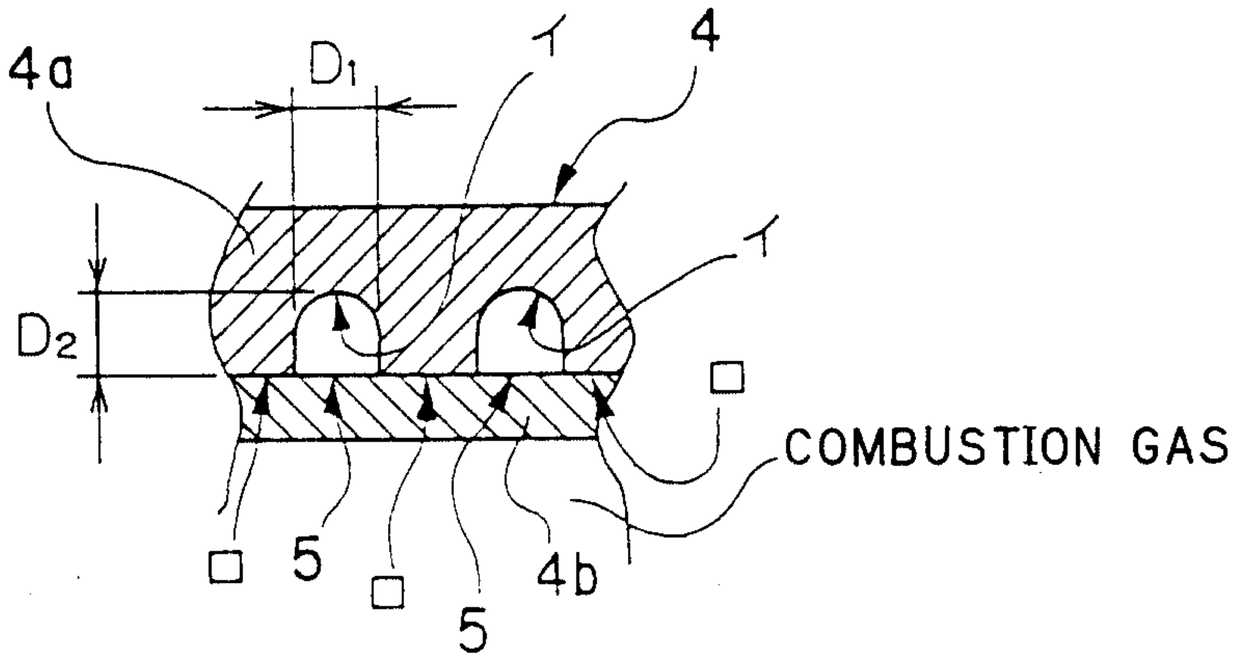
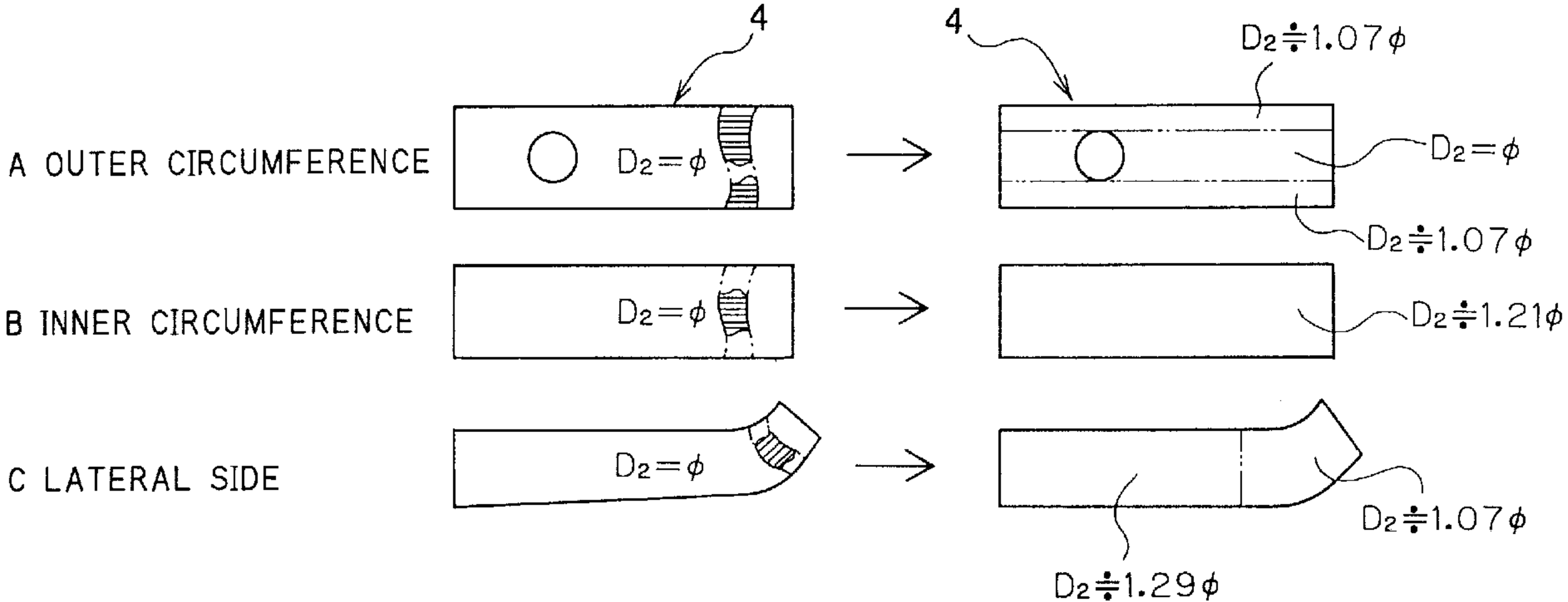


Fig.10

RELATED ART




A OUTER CIRCUMFERENCE
B INNER CIRCUMFERENCE
C LATERAL SIDE
4
4
D2=φ
D2=φ
D2=φ
D2≒1.07φ
D2≒1.07φ
D2≒1.21φ
D2≒1.07φ
D2≒1.29φ