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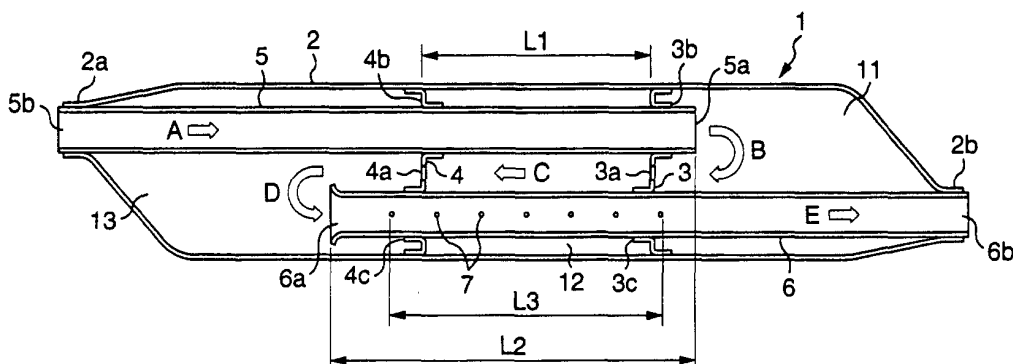
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(54) **INTERNAL COMBUSTION ENGINE SILENCER**

(57) A muffler for internal combustion engines, in order to achieve a high attenuating effect without reducing the attenuating effect in the high revolution range of the engine, comprising one or more expanding chambers 11 through 13 formed in a muffler 1, an inlet pipe 5 which opens into a expanding chamber 11 and introduces exhaust gas into the muffler 1, and an outlet pipe 6 which opens into other expanding chamber 13 and introduces exhaust gas out of the muffler 1. In the muffler, the exhaust gas discharged through an aperture 5a of this inlet pipe 5 is inverted once or more times in the muffler 1

and is introduced into an aperture 6a of the outlet pipe 6. In a contraflow area L2 in which the flowing direction C of exhaust gas flowing in the expanding chambers 11 through 13 and the flowing direction E of exhaust gas flowing in the outlet pipe 6 are not the same, interference holes 7 composing of a plurality of small holes communicating with the expanding chambers 11 through 13 are bored in the outlet pipe 6. The aperture area of the small holes 7 is kept at not less than 1% but not more than 5% of the surface area of the outlet pipe in the contraflow area L2.

FIG. 1



## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to an international combustion engine silencer, or a muffler for internal combustion engines.

### BACKGROUND ART

**[0002]** Among mufflers to be disposed on the exhaust line of an internal combustion engine are conventionally known ones having a U-turn structure in which exhaust gas is inverted once or more in the muffler. As a muffler having such a U-turn structure, the muffler illustrated in FIG. 11, for instance, is disclosed in the Japanese Utility Model Unexamined Publication JP-U-61-194718.

**[0003]** The muffler, as shown in FIG. 11, is provided within its housing 101, successively from the upstream side (left side in the drawing) onward, a first expanding chamber 102, a second expanding chamber 103, a third expanding chamber 104 and a resonator chamber 105 partitioned from one another. In the third expanding chamber 104 opens an inlet pipe 106 for introducing exhaust gas into the muffler, and the first expanding chamber 102 is provided with, opening into it, an outlet pipe 109 for discharging exhaust gas out of the muffler. Between the first expanding chamber 102 and the third expanding chamber 104 is disposed, opening into them, a conduit 107 to make possible communication between the two chambers 102 and 104. Further in the second expanding chamber 103, a small hole 111 is provided in the inlet pipe 106, a small hole 112 in the outlet pipe 109 and a small hole 113 in the conduit 107, to enable part of exhaust gas to be discharged out of or let into the second expanding chamber 103, to cause elements of sound wave energy in exhaust gas to interfere with one another and thereby to reduce exhaust noise.

**[0004]** In the above-described conventional muffler, there is an antinomic relationship that, in order to cause elements of sound wave energy in exhaust gas to interfere with one another in the second expanding chamber 103 section and the resultant interfering action to achieve a significant attenuating effect, the open area ratios of the small holes 111, 112 and 113 should be increased while raising the open area ratios of the small holes would reduce the attenuating effect in the high revolution range of the engine.

### Disclosure of the Invention

**[0005]** The present invention, therefore, is intended to provide a muffler capable of achieving a high attenuating effect without reducing the attenuating effect in the high revolution range of the engine.

**[0006]** In order to solve the problems noted above, the invention provides a muffler for internal combustion engines equipped with at least one expanding chamber

formed within the muffler, an inlet pipe opening into the expanding chamber to introduce exhaust gas into the muffler, and an outlet pipe opening into the expanding chamber to introduce exhaust gas out of the muffler, in which exhaust gas discharged from an opening in the inlet pipe is inverted once or more and introduced into an opening in the outlet pipe, wherein in a contraflow area of the muffler where the flowing direction of exhaust gas flowing in the expanding chamber and the flowing direction of exhaust gas flowing in the outlet pipe are not the same, interference holes composed of a plurality of small holes communicating with the expanding chamber are provided in the outlet pipe and the total aperture area of the interference holes is not less than 1% but not more than 5% of the surface area of the outlet pipe in the contraflow area.

**[0007]** With this configuration, exhaust noise flowing in the expanding chamber in one direction flows into the outlet pipe through the interference holes bored in the outlet pipe, interferes with exhaust noise flowing in the outlet pipe in the direction reverse to the flowing direction in the expanding chamber, and is attenuated by that interfering action.

**[0008]** According to the invention, at least one expanding chamber may be a plurality of expanding chambers, the inlet pipe is disposed to open into one of them and to introduce exhaust gas into the muffler, and the outlet pipe is disposed to open into other one and to introduce exhaust gas out of the muffler.

**[0009]** According to the invention, the range in which the interference holes are provided may as well be not less than 75% of the length of the outlet pipe in the contraflow area.

**[0010]** As this configuration causes various route differences to give rise to the interference, noise in a broad revolution range of the engine is attenuated.

**[0011]** Thus, as the route (distance) from the opening of the inlet pipe as the starting point to the interfering point differs with whether it runs via the opening of the outlet pipe or it runs via an interference hole, the time of arrival differs as much as this difference in route.

**[0012]** Therefore, as the phase of exhaust noise having entered into the outlet pipe via the opening of the outlet pipe differs from the phase of exhaust noise having entered into the outlet pipe via the interference holes (phase difference), they interfere with each other and the noise is attenuated.

**[0013]** Since the efficiency of attenuating is high at a phase difference of 180 degrees, in order to effectively attenuate noises of many different frequencies (noises in a broad revolution range of the engine), interference should be caused to occur at a variety of route differences.

**[0014]** According to the invention, since a variety of route differences are set by providing interference holes in a range of 75% or more of the length of the outlet pipe in the contraflow area (long range), noise in a broad revolution range of the engine is attenuated.

**[0015]** Further, according to the invention, bypass holes composed of a plurality of small holes communicating with the expanding chamber may be bored downstream from the part of the outlet pipe in the contraflow area, and the total aperture area of the interference holes and the bypass holes together may be kept not greater than the sectional area of the passage in the outlet pipe.

**[0016]** This configuration proves effective in attenuating noise in the low revolution area by virtue of its bypass holes.

**[0017]** Further, according to the invention, interference holes composed of a plurality of small holes communicating with the expanding chamber may be bored in the contraflow section of the inlet pipe.

**[0018]** With this configuration, an even greater attenuating effect can be achieved without reducing the attenuating effect in the high revolution range of the engine by boring the interference holes in the inlet pipe.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]** FIG. 1 is a side sectional view showing a first embodiment according to the present invention; FIG. 2A and FIG. 2B are front views of separators in FIG. 1, respectively; FIG. 3 is a diagram showing a result of analysis simulating a primary component of exhaust noise by varying a total aperture area of interference holes relative to a surface area of the outlet pipe in its contraflow area L2 in the embodiment of FIG. 1; FIG. 4 is a diagram showing a result of analysis simulating a relationship of an average attenuate level to an opening area ratio of the interference holes in the embodiment of FIG. 1; FIG. 5 is a side sectional view showing a second embodiment of the invention; FIG. 6 is a front view of a separator in FIG. 5; FIG. 7 is a side sectional view showing a third embodiment of the invention; FIG. 8 is a side sectional view showing a fourth embodiment of the invention; FIG. 9 is a sectional view taken along a line IX-IX in FIG. 8; FIG. 10 is a side sectional view showing a fifth embodiment of the invention; and FIG. 11 is a side sectional view showing a conventional muffler.

#### BEST MODES FOR CARRYING OUT THE INVENTION

**[0020]** Embodiments according to the present invention will be described with reference to FIG. 1 through FIG. 10.

**[0021]** FIG. 1 and FIG. 4 show a first embodiment of the invention.

**[0022]** In FIG. 1, a housing 2 in a muffler 1 is constituted of a metallic cylinder of which both ends are reduced in diameter to form constrictions 2a and 2b.

**[0023]** In the housing 2, a separator 3 in which a plurality of through holes 3a and two burring holes 3b and 3c are bored as shown in FIG. 2A and a separator 4 in which a plurality of through holes 4a and two burring holes 4b and 4c are bored as shown in FIG. 2B are fixed

with a prescribed spacing L1 between them, and they partition the housing 2 in the lengthwise direction into a first expanding chamber 11, a second expanding chamber 12 and a third expanding chamber 13.

**[0024]** In the housing 2, forcing into its constriction 2a and the burring holes 3b and 4b of the separators 3 and 4, an inlet pipe 5 for introducing exhaust gas into the muffler 1 is disposed, and its downstream side aperture 5a opens into the first expanding chamber 11. Incidentally, an upstream side aperture 5b is connected to an upstream side exhaust pipe.

**[0025]** Further, in the housing 2, forcing into its constriction 2b and the burring holes 3c and 4c of the separators 3 and 4, an outlet pipe 6 to discharge exhaust gas out of the muffler 1 is disposed, and its upstream side aperture 6a opens into the third expanding chamber 13. Incidentally, a downstream side aperture 6b is connected to a downstream side exhaust pipe.

**[0026]** In this muffler, with the range from the downstream side aperture 5a of the inlet pipe 5 to the upstream side aperture 6a of the outlet pipe 6 being assumed to be a contraflow area L2, the interference holes 7 constituted of a plurality of small holes communicating with the first through third expanding chambers 11 through 13 are bored, positioned in this contraflow area L2, in the outlet pipe 6.

**[0027]** The contraflow area L2, as will be further described afterwards, means a range in the muffler, similarly to the inlet pipe 5, the range in which the flowing direction of exhaust gas in the outlet pipe 6 is not identical with the flowing direction of exhaust gas in the expanding chambers.

**[0028]** Next will be described the actions of the first embodiment.

**[0029]** A greater part of exhaust gas having circulated through the upstream side exhaust pipe not shown in FIG. 1, after circulating within the inlet pipe 5 in the direction of an arrow A and flowing into the first expanding chamber 11 from the aperture 5a, inverts its flowing direction as indicated by an arrow B into the flowing direction indicated by arrow C, enters into the second expanding chamber 12 via the through holes 3a bored in the separator 3, and flows within the second expanding chamber 12 in the direction of the arrow C, i.e. upstream from the outlet pipe 6. It further flows into the third expanding chamber 13 via the through holes 4a bored in the separator 4, then inverts its flowing direction as indicated by an arrow D, circulates within the outlet pipe 6 from the aperture 6a of the outlet pipe 6 in the direction of an arrow E, reverse to its direction in the second expanding chamber 12, and then is discharged out of the muffler 1.

**[0030]** Exhaust noise, like the exhaust gas described above, circulates within the muffler and is attenuated by the expanding chambers 11 through 13 by their expansive actions.

**[0031]** Further, part of exhaust gas enters into the outlet pipe 6 from the expanding chambers 11 through 13

via the interference holes 7 constituted of small holes bored in the outlet pipe 6. Exhaust noises having then entered via the interference holes 7 together with the exhaust gas, mutually interfere with exhaust noise circulating in the outlet pipe 6 and are attenuated by this interfering action.

**[0032]** To add, by boring the interference holes 7 in as large a part of the contraflow area L2 as practicable, interference will be caused to occur with many different route differences, and accordingly this will exert an attenuating effect on noise in a broad revolution range of the engine. Therefore, it is preferable for an area L3 in which the interference holes 7 of FIG. 1 are bored to correspond to 75% or more of the length of the contraflow area L2.

**[0033]** The result of analysis simulating the primary component of exhaust noise during acceleration by varying the total aperture area S2 (open area ratio) of the interference holes 7 relative to the surface area S1 of the outlet pipe 6 in the contraflow area L2 is shown in FIG. 3.

**[0034]** From this result, it is seen that a greater attenuating effect can be achieved by increasing the open area ratio. At the same time, however, it is also seen that if the open area ratio is excessively increased, the attenuating effect in the high revolution range of the engine deteriorates.

**[0035]** Further, the result of analysis simulating the relationship of the average attenuate level (the average of the attenuate levels at different frequencies of revolution) to the open area ratio with respect to an aperture ratio of 0% by varying the open area ratio more finely is shown in FIG. 4.

**[0036]** From the result shown in FIG. 4, it is found preferable for the open area ratio to be not less than 1% but not more than 5%. It is even more preferable for the ratio to be not less than 1.5% but not more than 3.5%.

**[0037]** FIG. 5 and FIG. 6 show a second embodiment of the invention.

**[0038]** Referring to FIG. 5, the housing of a muffler 21 is composed of a shell 22 cylindrically formed of a steel plate and outer plates 23 and 24 caulk-coupled to both ends of the shell 22. Within the housing, a separator 31 in which a plurality of through holes 31a and a burring hole 31b are bored as shown in FIG. 6 is fixed, and the housing is partitioned by the separator 31 into a first expanding chamber 29 and a second expanding chamber 30.

**[0039]** An inlet pipe 25, positioned on the first expanding chamber 29 side, is inserted into a burring hole 22a of the shell 22, with its end being blocked by a cap 27 disposed in the opposite position to the burring hole 22a.

**[0040]** Further, in the side face of the inlet pipe 25 are bored discharge ports (apertures) 28 so that exhaust gas in the inlet pipe 25 can flow into the first expanding chamber 29 via the discharge ports 28.

**[0041]** An outlet pipe 26 is inserted into a burring hole 24a of an outer plate 24 and the burring hole 31b of the

separator 31, so that an aperture 26a on the upstream side open into the second expanding chamber 30.

**[0042]** Referring to FIG. 5, with the range from the discharge ports 28 of the inlet pipe 25 to the upstream side aperture 26a in the outlet pipe 26 being assumed to be a contraflow area L4, interference holes 32 constituting of a plurality of small holes communicating with the first and second expanding chambers 29 and 30 are bored, positioned in this contraflow area L4, in the outlet pipe 26.

**[0043]** Next will be described the actions of the second embodiment.

**[0044]** Referring to FIG. 5, exhaust gas having circulated in the inlet pipe 25 as indicated by an arrow F flows into the first expanding chamber 29 via the discharge ports 28 of the inlet pipe 25; then a greater part of the exhaust gas flows into the first expanding chamber 29 as indicated by an arrow G, flows into the second expanding chamber 30 via the through holes 31a of the separator 31, and flows within the second expanding chamber 30 as indicated by an arrow H; then after inverting its flowing direction as indicated by an arrow I, flows into the outlet pipe 26 via the upstream side aperture 26a of the outlet pipe 26, and circulates within the outlet pipe 26 in the direction of an arrow J, which is reverse to the flowing directions G and H within the first and second expanding chambers 29 and 30.

**[0045]** Then, part of exhaust gas circulating in the first expanding chamber 29 and the second expanding chamber 30 flows into the outlet pipe 26 via the interference holes 32 constituting of small holes bored in the outlet pipe 26. Exhaust noise having entered into the outlet pipe 26 via the interference holes 32 together with this exhaust gas mutually interferes with exhaust noise flowing within the outlet pipe 26 in the direction inverse to the flowing directions in the two expanding chambers 29 and 30, thereby attenuating the exhaust noise.

**[0046]** This second embodiment can achieve a similar effect to the first embodiment by keeping the open area ratio of the interference holes 32 not less than 1% but not more than 5% or, more preferably, not less than 1.5% but not more than 3.5%.

**[0047]** Further, it is preferable for an area L5 in which the interference holes 32 are bored to correspond to 75% or more of the length of the contraflow area L4 shown in FIG. 5.

**[0048]** FIG. 7 shows a third embodiment of the invention.

**[0049]** Referring to FIG. 7, the housing 42 of a muffler 41 is constituted of a metallic cylinder of which both ends are coaxially reduced in diameter to form a constriction 42a and a constriction 42b.

**[0050]** In the housing 42, the separator 3 in which through holes 3a are bored as shown in the first embodiment and the separator 4 in which the through holes 4a are bored are fixed with the prescribed spacing L1 between them, and they partition the housing 42 in the longitudinal direction into a first expanding chamber 51, a

second expanding chamber 52 and a third expanding chamber 53.

**[0051]** In the housing 42, as in the foregoing embodiment, an inlet pipe 45 for introducing exhaust gas into the muffler 41 is disposed, held by the constriction 42a and the separators 3 and 4, and an aperture 45a on its downstream side opens into the first expanding chamber 51. Incidentally, an aperture 45b on its upstream side is connected to an upstream exhaust pipe.

**[0052]** In the housing 42, as in the foregoing embodiment, an outlet pipe 46 for discharging exhaust gas out of the muffler 41 is disposed, held by the constriction 42b and the separators 3 and 4, and an aperture 46a at its upstream end opens into the third expanding chamber 53. Incidentally, an aperture 46b on its downstream side is connected to a downstream exhaust pipe.

**[0053]** Both the inlet pipe 45 and the outlet pipe 46 are disposed in a bent form to be shifted to each other in the muffler 41 as shown in FIG. 7.

**[0054]** Referring to FIG. 7, with the range from an aperture 45a at the downstream end of the inlet pipe 45 to an aperture 46a at the upstream end of the outlet pipe 46 being assumed to be the contraflow area L2, interference holes 47 composed of a plurality of small holes communicating with the first through third expanding chambers 51 through 53 are bored, positioned in the contraflow area L2, in the outlet pipe 46.

**[0055]** Further in the outlet pipe 46 are bored, positioned downstream of the contraflow area L2, bypass holes 48 composed of a plurality of small holes communicating with the first expanding chamber 51. Incidentally, it is preferable for the bypass holes 48 to be as far downstream of the outlet pipe 46 as practicable.

**[0056]** Also, it is preferable for the total aperture area of the interference holes 47 and the bypass holes 48 together to be kept not greater than the passage area of the outlet pipe 46.

**[0057]** Further in the inlet pipe 45, in its contraflow area L2, are bored interference holes 49 composed of a plurality of small holes communicating with the second expanding chamber 52.

**[0058]** Since this embodiment is similar to the first embodiment in the rest of the structure, the same constituent parts in it are denoted by respectively the same reference signs as the foregoing, and their description is dispensed with.

**[0059]** Next will be described the actions of the third embodiment.

**[0060]** This third embodiment, besides achieving similar actions and effects to the first embodiment described above, also proves effective in attenuating noise in the low revolution range by virtue of the bypass holes 48 bored in the outlet pipe 46.

**[0061]** Further, the presence of the interference holes 49 in the inlet pipe 45 makes it possible to achieve an even greater attenuating effect without reducing the attenuating effect in the high revolution range of the engine.

**[0062]** FIG. 8 and FIG. 9 show a fourth embodiment of the invention.

**[0063]** This fourth embodiment is a version of the third embodiment described above modified in the inlet pipe 45 and the outlet pipe 46, in which the sections of an inlet pipe 65 and an outlet pipe 66 are formed in a substantially D shape within the muffler 41 as shown in FIG. 9, and these pipes are joined together to form a substantially circular sectional shape.

**[0064]** Further, a wire mesh 74 is held between the downstream end of the outlet pipe 66 and the constriction 42b of the housing 42 to enable any difference in thermal expansion between the housing 42 and the outlet pipe 66 to be absorbed.

**[0065]** Furthermore, it is preferable for the total aperture area of the interference holes 47 and the bypass holes 48 together to be kept not greater than the passage area in the substantially D shaped sectional area of the outlet pipe 46.

**[0066]** Since this embodiment is similar to the third embodiment in the rest of the structure, the same constituent parts in it are denoted by respectively the same reference signs as the foregoing, and their description is dispensed with.

**[0067]** This fourth embodiment can achieve similar actions and effects to the third embodiment described above.

**[0068]** Also, though the fourth embodiment described above is an example in which the inlet pipe 65 and the outlet pipe 66 are formed in a D sectional shape and joined together, it is also conceivable to use a separate pipe whose inside is divided in the radial direction with a partitioning board to form in parallel passages each having a substantially D-shaped section and to whose open ends the inlet pipe and the outlet pipe are joined, respectively.

**[0069]** Although each of the first embodiment through the fourth embodiment described above is provided with a plurality of expanding chambers, only one expanding chamber may as well be disposed in the muffler as in a fifth embodiment shown in FIG. 10.

**[0070]** The fifth embodiment is a modified version of the third embodiment less the separators 3 and 4, in which a single expanding chamber 91 is formed in the housing 42 of a muffler 81.

**[0071]** Incidentally, the inlet pipe 45 and the outlet pipe 46 are supported by stays 93 and 94, respectively.

**[0072]** Since this embodiment is similar to the third embodiment in the rest of the structure, the same constituent parts in it are denoted by respectively the same reference signs as the foregoing, and their description is dispensed with.

**[0073]** Further, the housing of the muffler can as well be formed by some other known method than what was described with respect to the foregoing first through fifth embodiments, such as joining press-formed shells to each other, and its sectional shape can also be selected as desired.

**[0074]** It is further conceivable to dispose sound absorbing materials, thermal expansion difference absorbing mechanisms and exhaust gas purifying mechanisms midway on the inlet pipe and the outlet pipe.

#### INDUSTRIAL APPLICABILITY

**[0075]** Because of what has been stated so far, according to the present invention, it is possible to achieve a high attenuating effect without reducing the attenuating effect in the high revolution range of the engine.

**[0076]** Also according to the invention, an attenuating effect in an even broader revolution range of the engine can be achieved if interference holes are disposed in a range of 75% or more of the length in the contraflow area of the outlet pipe.

**[0077]** Further according to the invention, an attenuating effect in the low revolution range can be achieved by boring bypass holes communicating with the expanding chamber(s) in the downstream part matching the contraflow area of the outlet pipe and keeping the total aperture area of the interference holes and the bypass holes together not greater than the sectional area of the passage in the outlet pipe.

**[0078]** Also according to the invention, an even greater attenuating effect can be achieved without reducing the attenuating effect in the high revolution range of the engine by boring interference holes communicating with the expanding chamber(s) in the inlet pipe in its contraflow area.

them to introduce exhaust gas into the muffler, and said outlet pipe is disposed to open into other one to introduce exhaust gas out of the muffler.

5 **3.** The muffler for internal combustion engines as claimed in Claim 1 or Claim 2, wherein said interference holes are disposed in a range of not less than 75% of a length of said outlet pipe in said contraflow area.

10 **4.** The muffler for internal combustion engines as claimed in Claim 1, Claim 2 or Claim 3, wherein bypass holes composing of a plurality of small holes communicating with said expanding chamber are bored downstream from a part of said outlet pipe in said contraflow area, and a total aperture area of said interference holes and said bypass holes together is not greater than a sectional area of a passage in said outlet pipe.

15 **5.** The muffler for internal combustion engines as claimed in Claim 1, Claim 2, Claim 3 or Claim 4, wherein interference holes composing of a plurality of small holes communicating with said expanding chamber are bored in said contraflow section of said inlet pipe.

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#### Claims

1. A muffler for internal combustion engines comprising at least one expanding chamber formed within the muffler, an inlet pipe opening into said expanding chamber to introduce exhaust gas into the muffler, and an outlet pipe opening into said expanding chamber to introduce exhaust gas out of the muffler, in which exhaust gas discharged from an opening in said inlet pipe is inverted once or more and then introduced into an opening in said outlet pipe, wherein, in a contraflow area in which a flowing direction of exhaust gas flowing in said expanding chamber and a flowing direction of exhaust gas flowing in said outlet pipe are different, interference holes composed of a plurality of small holes communicating with said expanding chamber are bored in said outlet pipe, and the total aperture area of said interference holes is not less than 1% but not more than 5% of a surface area of said outlet pipe in said contraflow area.

2. The muffler for internal combustion engines as claimed in Claim 1, wherein said at least one expanding chamber is a plurality of expanding chambers, said inlet pipe is disposed to open into one of

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FIG. 1

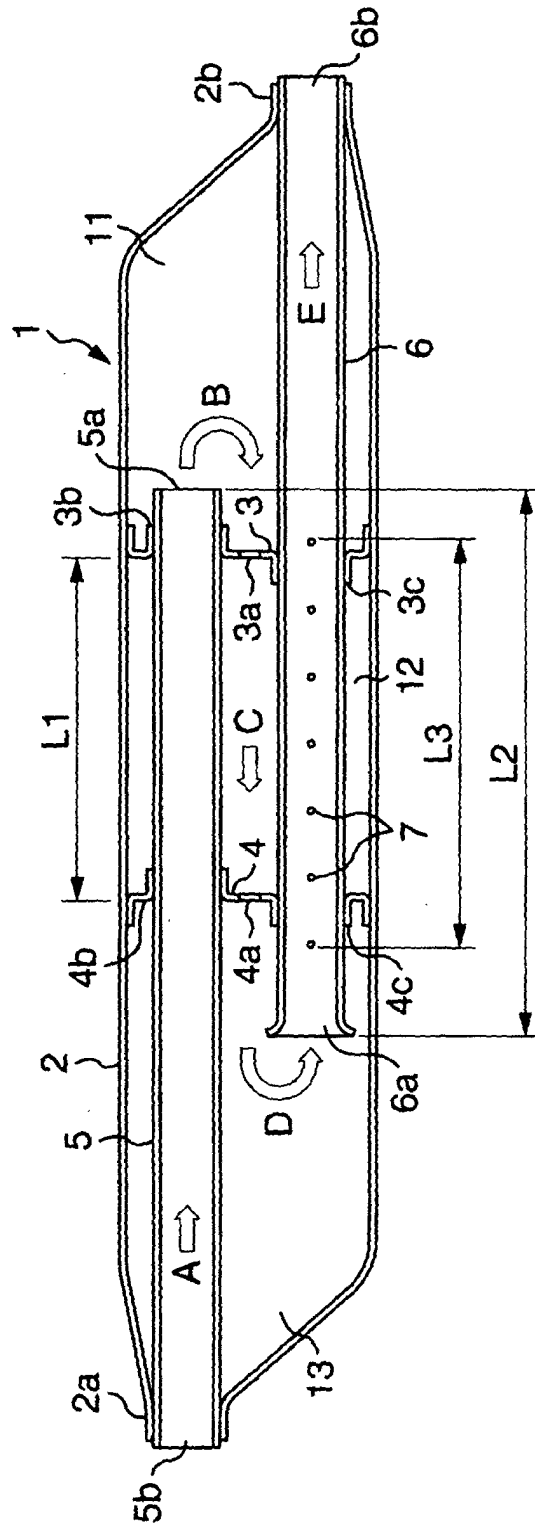


FIG. 2A

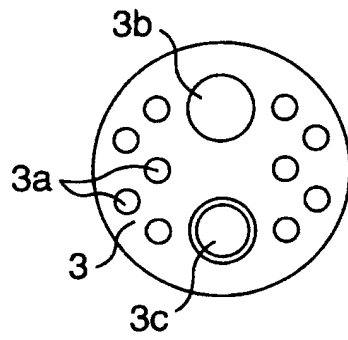


FIG. 2B

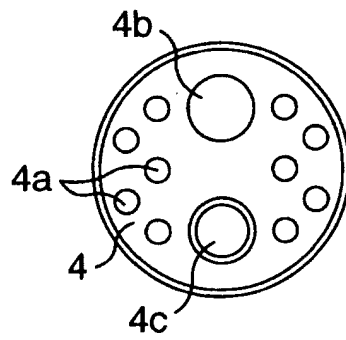




FIG. 3

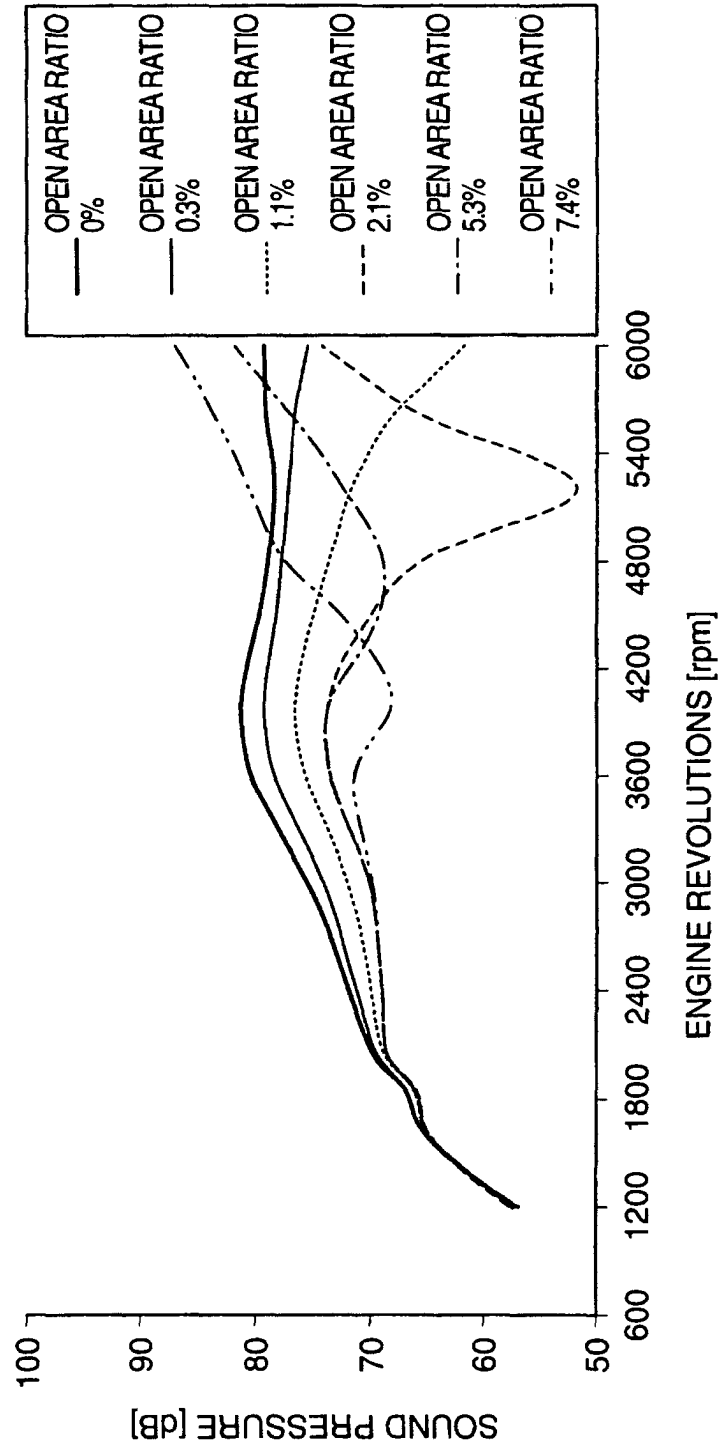


FIG. 4

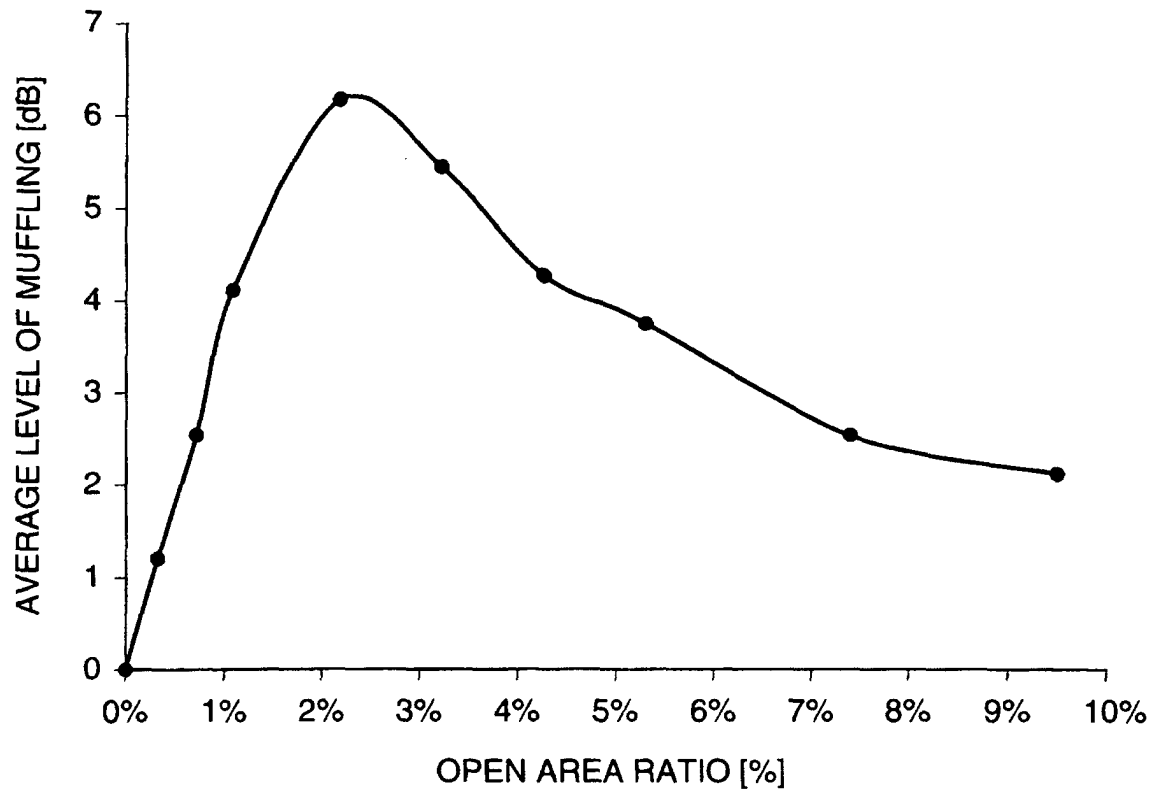


FIG. 5

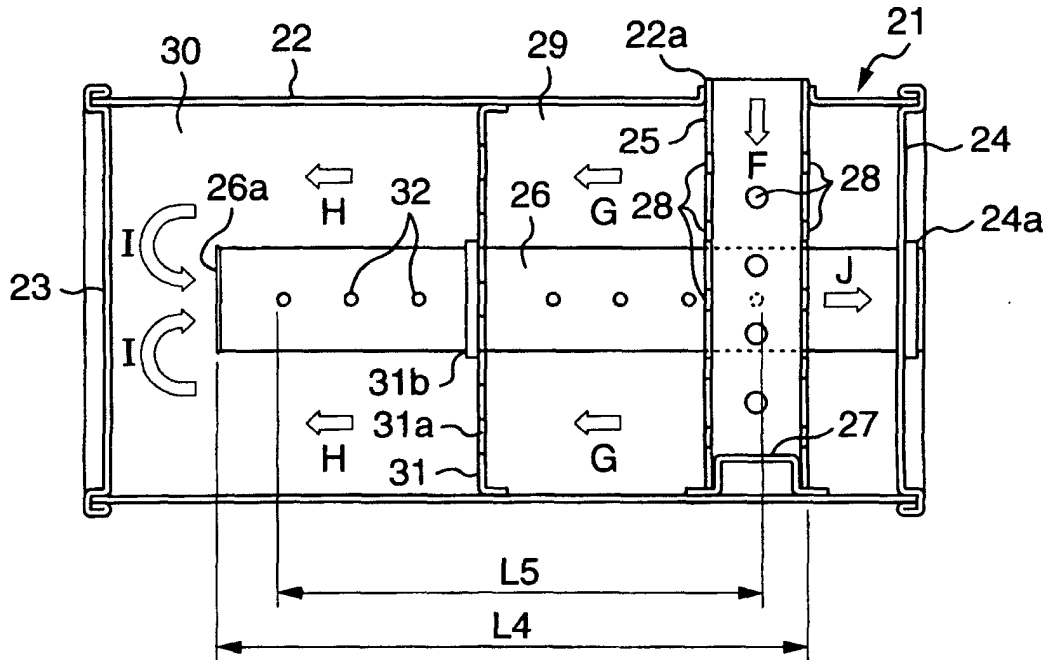


FIG. 6

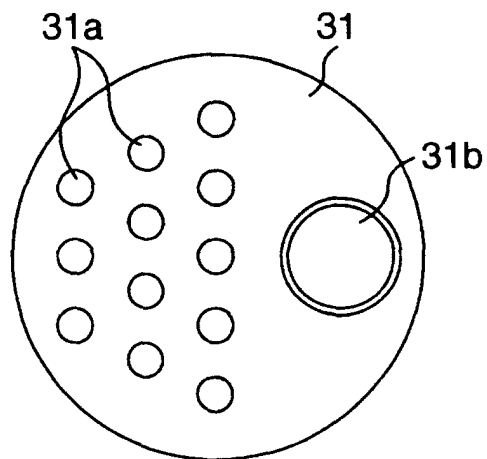


FIG. 7

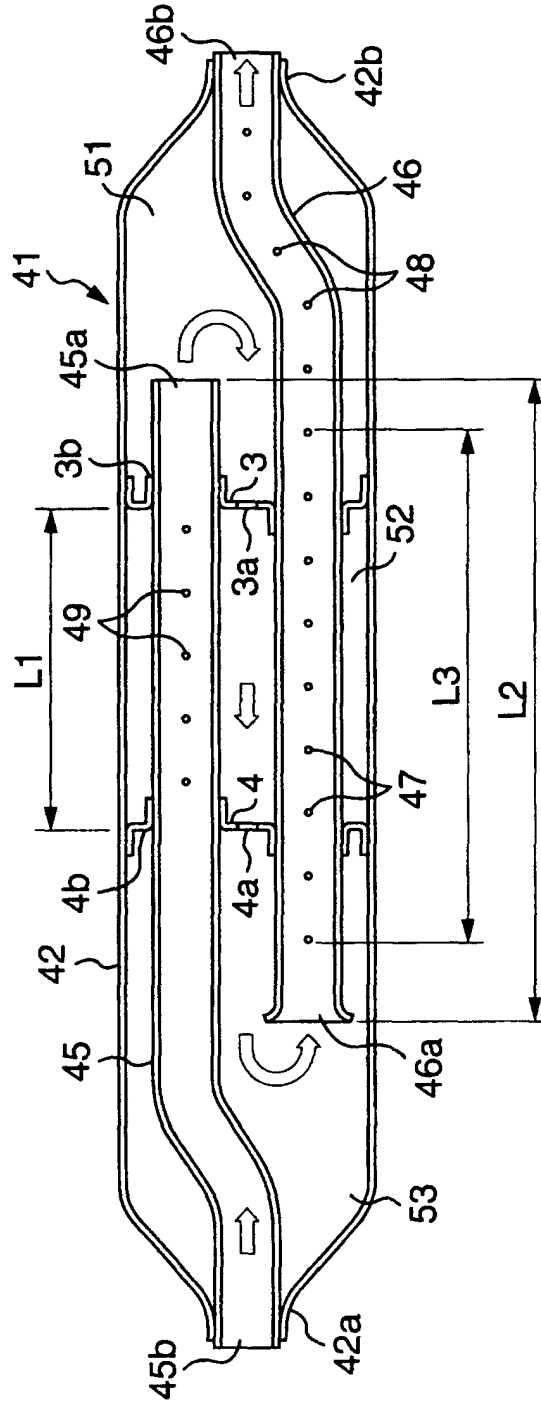


FIG. 8

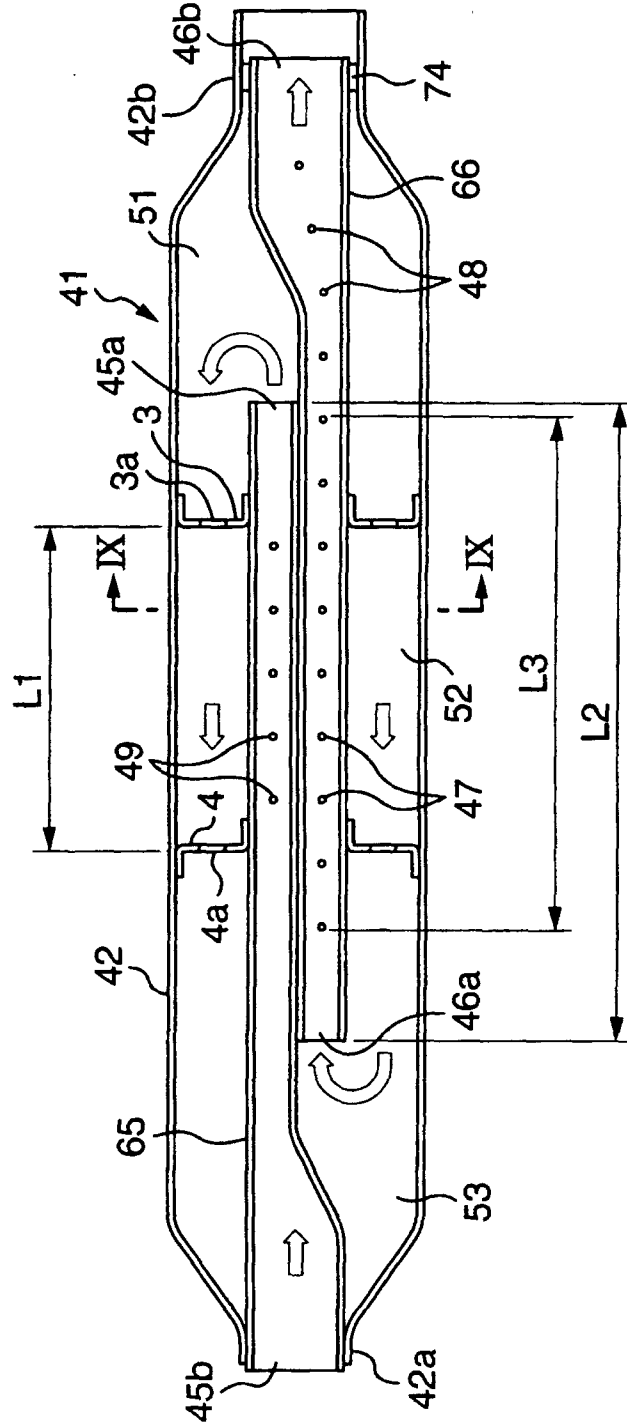


FIG. 9

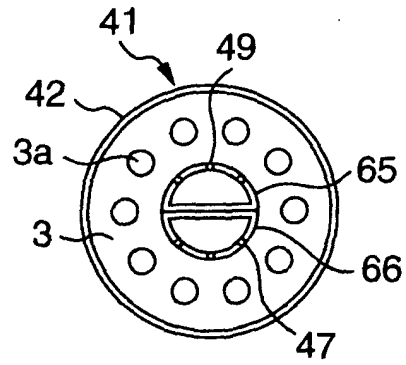


FIG. 11

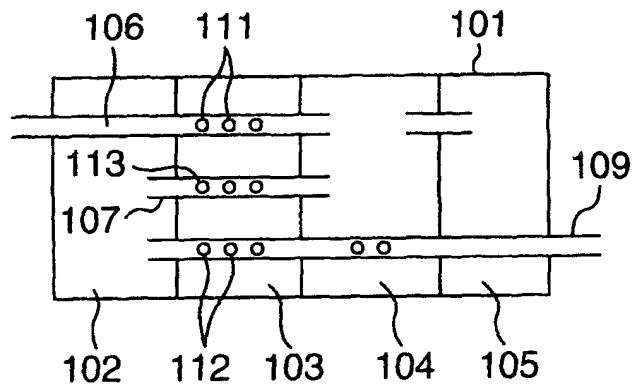
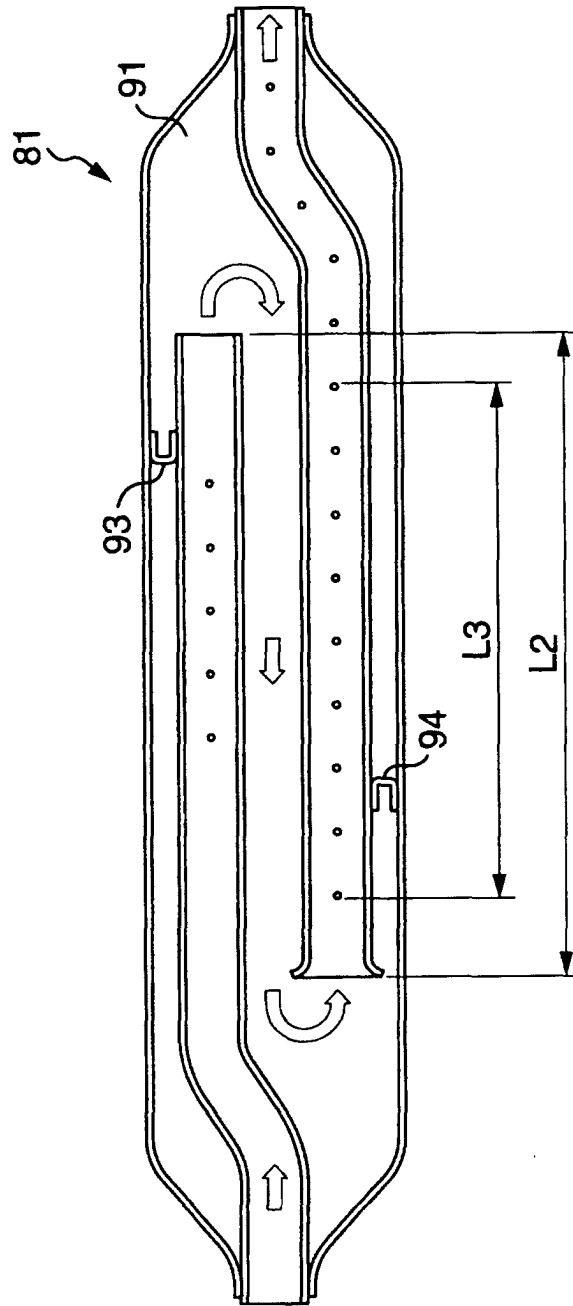


FIG. 10



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/01815

| A. CLASSIFICATION OF SUBJECT MATTER<br>Int.Cl. <sup>7</sup> F01N1/08  |  |                       |
|---|--|-----------------------|
| According to International Patent Classification (IPC) or to both national classification and IPC   |  |                       |
| B. FIELDS SEARCHED  |  |                       |
| Minimum documentation searched (classification system followed by classification symbols)<br>Int.Cl. <sup>7</sup> F01N1/08  |  |                       |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2003<br>Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003 |  |                       |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  |  |                       |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT  |  |                       |
| Category*   | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
| Y   | US 4735283 A1 (Tenneco Inc.),<br>05 April, 1988 (05.04.88),<br>Full text; all drawings<br>& JP 63-147911 A & DE 3740341 A<br>& FR 2607868 A & BR 8706549 A<br>& KR 9503730 B   | 1-5                   |
| Y   | Microfilm of the specification and drawings annexed<br>to the request of Japanese Utility Model Application<br>No. 53532/1985 (Laid-open No. 171816/1986)<br>(Mitsubishi Motors Corp.),<br>25 October, 1986 (25.10.86),<br>Full text; all drawings<br>(Family: none) | 1-3                   |
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International application No.

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| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |   |                       |
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| Category*   | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No. |
| Y   | JP 50-160631 A (Toyota Motor Corp.),<br>26 December, 1975 (26.12.75),<br>Full text; Figs. 4, 5<br>(Family: none)  | 4                     |
| A   | JP 11-315712 A (Nissan Motor Co., Ltd.),<br>16 November, 1999 (16.11.99),<br>Full text; Fig. 8<br>(Family: none)  | 4                     |
| A   | Microfilm of the specification and drawings annexed<br>to the request of Japanese Utility Model Application<br>No. 197066/1981 (Laid-open No. 102704/1983)<br>(Nippon Radiator Kabushiki Kaisha),<br>13 July, 1983 (13.07.83),<br>Full text; Fig. 3<br>(Family: none) | 4                     |

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