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(72) Inventeurs/Inventors:
YAMAMOTO, KAZUO, JP;
KAITA, KIHOKO, JP;
YASUDA, KAZUHIRO, JP;
KIDACHI, KIYOSHI, JP

(73) Propriétaire/Owner:
HONDA MOTOR CO., LTD., JP

(74) Agent: DENNISON ASSOCIATES

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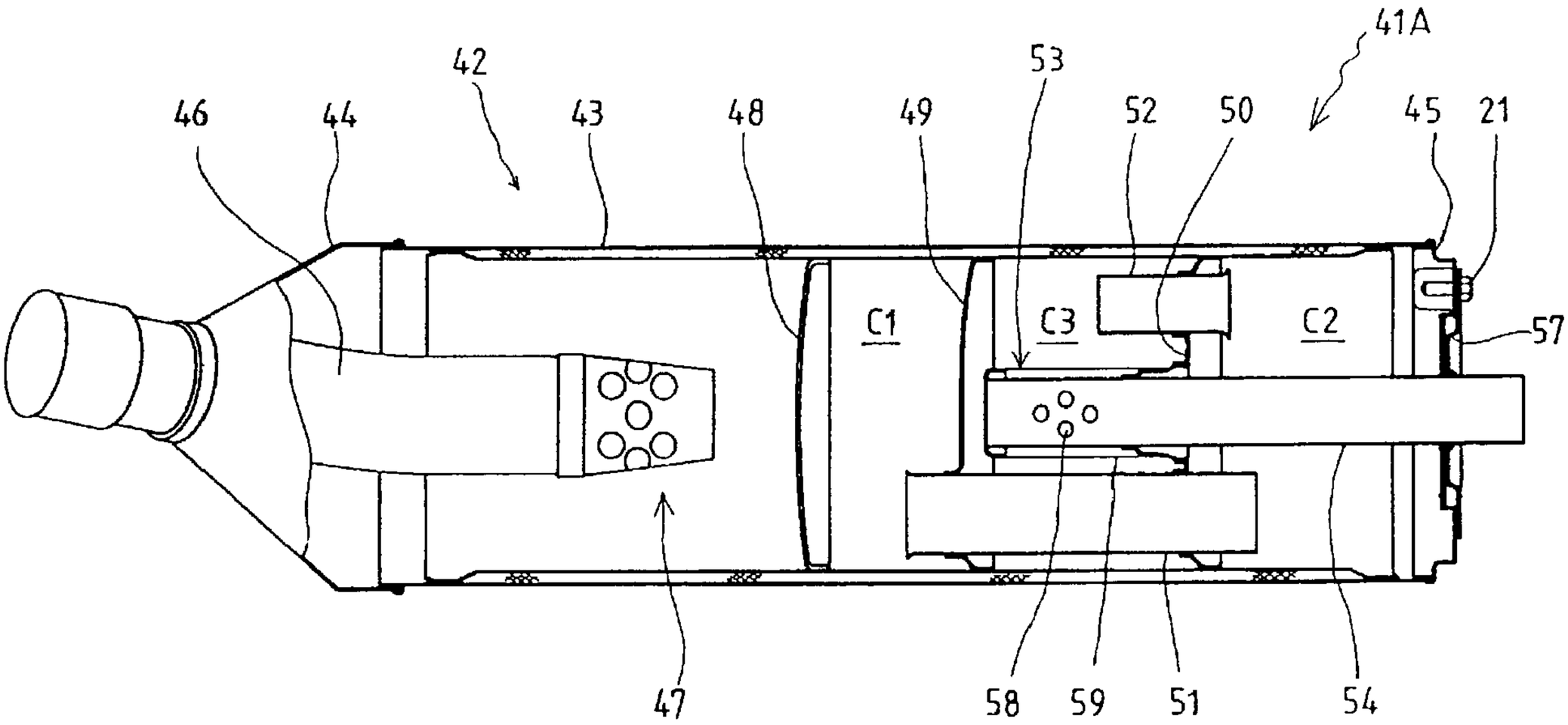



(57) Abrégé/Abstract:
An exhaust silencer for an internal combustion engine where a plurality of expansion chambers are defined by a plurality of bulkheads within a main body and a spark arrester equipped with a tail pipe is provided in a detachable manner at a rear part of the main body provides compatibility at all times with use on public roads or in racing and for which performance is improved in response to these objects. A structure is adopted where, at the time of installing a spark arrester, an exhaust flow is made to pass through at least one bulkhead three times due to the tail pipe and a plurality of communicating pipes, and when a spark arrester is detached, the exhaust flow flows through communicating pipes so as to bypass one of the plurality of expansion chambers and be discharged to outside.

## ABSTRACT OF THE DISCLOSURE

An exhaust silencer for an internal combustion engine where a plurality of expansion chambers are defined by a plurality of bulkheads within a main body and a spark arrester equipped with a tail pipe is provided in a detachable manner at a rear part of the main body provides compatibility at all times with use on public roads or in racing and for which performance is improved in response to these objects. A structure is adopted where, at the time of installing a spark arrester, an exhaust flow is made to pass through at least one bulkhead three times due to the tail pipe and a plurality of communicating pipes, and when a spark arrester is detached, the exhaust flow flows through communicating pipes so as to bypass one of the plurality of expansion chambers and be discharged to outside.

# EXHAUST SILENCER FOR INTERNAL COMBUSTION ENGINE

## FIELD OF THE INVENTION

The present invention relates to exhaust silencers connected to an exhaust pipe of an internal combustion engine of a motorcycle or four-wheeled buggy.

## BACKGROUND OF THE INVENTION

Exhaust silencers connected to exhaust pipes of internal combustion engines that define a plurality of expansion chambers using a plurality of bulkheads and that are provided with a spark arrester equipped with a tail pipe at a rear part of the same exhaust silencer, with the spark arrester being detachable, are well-known. A spark arrester is a device for catching sparks and soot included in exhaust gas of an internal combustion engine and preventing sparks and soot from being released to the atmosphere. When the spark arrester is detachable, gas pressure of the plurality of expansion chambers is set to be highest at the expansion chamber closest to the front near the exhaust pipe, sequentially becoming lower towards the rear within the exhaust silencer. The object of providing a detachable spark arrester is to enable maintenance of the silencer and the spark arrester and to enable changing of the spark arrester in order to provide exhaust devices for differing performance requirements at a low price (refer, for example, Japanese Patent Laid-open Publication No. Hei. 10-266828 (effects of the invention, FIG. 2, FIG. 5).

## SUMMARY OF THE INVENTION

The present invention therefore adopts an exhaust silencer provided with a detachable spark arrester equipped with a tail pipe at a rear part of a main body of an exhaust silencer equipped with a plurality of expansion chambers defined by a plurality of bulkheads. Here, compatibility is

provided at all times for both use on public roads and use in racing without changing the main body, and both quietness of the exhaust silencer or output performance of the internal combustion engine can be made high according to the respective objects.

In order to resolve the aforementioned problems, in a first aspect of the present invention, there is provided an exhaust silencer for an internal combustion engine with a plurality of expansion chambers defined by a plurality of bulkheads within a main body of an exhaust silencer connected to an exhaust pipe of an internal combustion engine and with a spark arrester equipped with a tail pipe provided in a detachable manner at a rear part of the main body, wherein a structure is adopted such that when the spark arrester is installed, exhaust flow is made to pass through at least one bulkhead three times by the tail pipe installed so as to connect the expansion chambers and plurality of communicating pipes fixed so as to connect the expansion chambers, and when the spark arrester is removed, exhaust flow passes through the communicating pipes and flows so as to bypass one of the plurality of expansion chambers so as to be released to the outside.

As a result of the present invention having the above configuration, when the spark arrester is installed, a so-called "three-pass" structure is adopted where exhaust gas passes through a bulkhead three times. Silencing of the exhaust silencer is therefore improved when traveling on public roads, and when the spark arrester is removed, this can be used as a racing exhaust silencer for which high-output is demanded. It is therefore possible to divide use of this exhaust silencer between traveling on public roads and racing use without changing the main portion of the exhaust silencer.

In another aspect of the invention, there is provided an exhaust silencer for an internal combustion engine with a plurality of expansion chambers defined by a plurality of bulkheads within a main body of an exhaust silencer connected to an exhaust pipe of an internal combustion engine and with a spark arrester equipped with a tail pipe provided in a detachable manner at a rear part of the main body, wherein a structure is adopted such that when the spark arrester is installed, exhaust flow is

made to pass through at least one bulkhead three times by the tail pipe installed so as to connect the expansion chambers and plurality of communicating pipes fixed so as to connect the expansion chambers, and when the spark arrester is removed, exhaust flow passes straight through a through-hole opening at the bulkheads when the spark arrester is removed so as to be released to the open air.

In this aspect of the invention also, when the spark arrester is installed, a so-called "three-pass" structure is adopted where exhaust gas passes through a bulkhead three times. Silencing of the exhaust silencer is therefore improved when traveling on public roads, and when the spark arrester is removed, this can be used as a racing exhaust silencer for which high-output is demanded without changing portions of the body of the exhaust silencer.

In an aspect of the present invention as described above, a seal is provided between the bulkheads and the spark arrester when the spark arrester is installed, and the seal is provided via a sliding part or elastic part permitting extension and retraction in the lengthwise direction of the tailpipe.

As the present invention is configured in this manner, gas and sound do not leak into neighboring expansion chambers and silencing is improved. Further, the tail pipe has a slide structure that permits extension and retraction. Thermal expansion is therefore relieved, there is little fatigue even with repeated expansion and retraction, and durability is improved. Further, it is therefore possible to provide a minimum pressure expansion chamber next to a maximum pressure expansion chamber, a three-pass structure can be realized, and silencing on public roads can be improved.

## BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

FIG. 1 is a longitudinal cross-sectional view of main body 2 of the exhaust silencer 1 of the first embodiment of the present invention.

FIG. 2 is a longitudinal cross-sectional view of public road travel specification state 1A of the exhaust silencer 1 of the first embodiment.

FIG. 3 is a view of the public road travel spark arrester 18 for use in the exhaust silencer 1 of the first embodiment, where FIG. 3(a) is a longitudinal cross-sectional view, and FIG. 3(b) is a view as viewed from the rear.

FIG. 4 is a longitudinal cross-sectional view of racing specification state 1B of the exhaust silencer 1 of the first embodiment.

FIG. 5 is a view of a racing spark arrester 31 used commonly in both the first embodiment and the second embodiment, where FIG. 5(a) is a longitudinal cross-sectional view and FIG. 5(b) is a view as viewed from the rear.

FIG. 6 is a theoretical view for illustrating a first example of a seal structure that can be applied between the first expansion chamber and the third expansion chamber in the public road travel specification state 1A of the exhaust silencer 1 of the first embodiment.

FIG. 7 is a theoretical view for illustrating a second example of a seal structure that can be applied between the first expansion chamber and the third expansion chamber in the public road travel specification state 1A of the exhaust silencer 1 of the first embodiment.

FIG. 8 is a theoretical view for illustrating a third example of a seal structure that can be applied between the first expansion chamber and the third expansion chamber in the public road travel specification state 1A of the exhaust silencer 1 of the first embodiment.

FIG. 9 is a longitudinal cross-sectional view of main body 42 of the exhaust silencer 41 of the first embodiment of the present invention.

FIG. 10 is a longitudinal cross-sectional view of public road travel specification state 41A of the exhaust silencer 41 of the second embodiment of the present invention.

FIG. 11 is a view of the public road travel spark arrester 45 for use in the exhaust silencer 41 of the second embodiment, where FIG. 11(a) is a longitudinal cross-sectional view, and FIG. 11(b) is a view from the rear.

FIG. 12 is a longitudinal cross-sectional view of racing specification state 41B of the exhaust silencer 41 of the second embodiment.

FIG. 13 is a side view of a motorcycle equipped with an exhaust silencer 1 of the present invention.

FIG. 14 is a side view of a four-wheeled buggy equipped with an exhaust silencer 1 of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 13 is a side view of a motorcycle 60 equipped with an exhaust silencer 1 of a first embodiment of the present invention. A power unit 65 integrating an internal combustion engine 63 and a transmission 64 is suspended at the center of a vehicle frame 62 spanning to the head pipe 61 of the motorcycle. The vehicle frame 62 is configured by connecting a plurality of members. The front fork 66 is rotatably supported at the head pipe 61, a handlebar 67 is mounted at an upper end of the head pipe 61, and a front wheel 68 is axially supported at a lower end. A front end of a rear fork 69 is pivoted at a rear part of the vehicle frame 62 so as to be capable of swinging up and down. A rear shock absorber 70 is installed between the rear fork 69 and the vehicle frame 62. A rear wheel 71 is axially supported at a rear end of the rear fork 69. The rear wheel 71 is driven by a chain 74 wrapped around a drive sprocket 72 installed at the end of an output shaft of the power unit 65 and a driven sprocket 73 fitted to a shaft of the rear wheel 71. The output shaft is parallel with the crankshaft etc. in a direction from left to right of the vehicle body. An exhaust pipe 75 spanning to an exhaust port provided at the front side of the internal combustion engine 63 goes around the right side of the vehicle body so as to reach the rear part of the vehicle body, and is connected to the front end of the exhaust silencer 1. The front end of the exhaust silencer 1 is connected to the vehicle frame 62 and is suspended from a seat rail 76 extending to the rear. A fuel tank 77 is installed at an

upper part of the vehicle frame 62 and a seat 78 is provided at an upper part of the seat rail 76. Numeral 79 is a side cover. An exhaust silencer of a second embodiment described later is installed at a position that is the same as the exhaust silencer 1.

FIG. 14 is a side view of a four-wheeled buggy (off-road saddled vehicle) 80 equipped with an exhaust silencer 1 of a first embodiment of the present invention. This buggy 80 is provided with a pair of left and right front wheels 82 and a pair of left and right rear wheels 83 to the front and rear of the vehicle frame 81, and a power unit 86 integrating an internal combustion engine 84 and a transmission 85 is supported in the center of the vehicle frame 81. The power unit 86 has a structure where the crankshaft 87 runs in the longitudinal direction of the vehicle. Rotation of the crankshaft 87 is transmitted to an output shaft 88 via each shaft of the transmission 85. Each of these shafts is parallel with the crank shaft 87 and is arranged in a direction running from the front to the rear of the vehicle body. The front wheel 82 is driven by a front drive shaft 89 coupled to a front end of the output shaft 88 and the rear wheel 83 is driven by a rear wheel drive shaft 90 coupled to a rear end of the output shaft 88. An exhaust pipe 91 spanning to an exhaust port provided at the front side of the internal combustion engine 84 goes around the side of the internal combustion engine 84 so as to reach the rear part of the vehicle body, and is connected to the front end of the exhaust silencer 1. The exhaust silencer 1 is suspended at a vehicle frame 81 between the vehicle frame 81 and the rear wheel 83. A handlebar 92, a fuel tank 93, and a seat 94 are installed in order from the front at an upper part of the vehicle. An exhaust silencer of a second embodiment described later is installed at a position that is the same as the exhaust silencer 1.

A configuration for the exhaust silencer 1 of the first embodiment of the present invention is now described. The exhaust silencer 1 of the first embodiment comprises a set of three members, an exhaust silencer body 2, and two types of spark arrester that can be attached to and detached from the main body 2, i.e. a public road travel spark arrester 18 and a racing spark arrester 31. The two types of spark arrester can be changed according to the purpose of the vehicle use. A state where the public road travel spark arrester 18 is installed at the exhaust silencer body 2 is referred to as a

public road travel specification state 1A of the first embodiment. A state where the racing spark arrester 31 is installed at the exhaust silencer body 2 is referred to as a racing specification state 1B of the first embodiment.

FIG. 1 is a vertical cross-section of a main body 2 of the exhaust silencer 1. In FIG. 1, the outward appearance of the main body 2 of the exhaust silencer 1 comprises a cylindrical central body part 3, a conical front cover 4, and a rear part end plate 5 having a large opening at a central part. The central body part 3 comprises an outer body plate 6, an inner body plate 7, and noise absorbing material 8 such as glass wool etc. filling in between the outer body plate 6 and the inner body plate 7. An introduction pipe 9 connected to the exhaust pipe of the internal combustion engine passes through the top part of the front cover 4 and an exhaust gas nozzle 10 at a front end opens out within the main body 2. The exhaust gas nozzle 10 is comprised of an end opening 11 of the introduction pipe 9 and a multiplicity of small holes 12 made in the side surface of the top part of the introduction pipe 9, with a gush of gas therefore being spread out about the surroundings.

In order from the front, a punching metal partition plate 13, a first bulkhead 14, and a second bulkhead 15 are provided at the inside of the inner body plate 7. A portion to the front of the first bulkhead 14 is a first expansion chamber C1, a portion to the rear from the second bulkhead 15 is a second expansion chamber C2, and a portion sandwiched between the first bulkhead 14 and the second bulkhead 15 is a third expansion chamber C3. The numbers of the expansion chambers follow the order in which the exhaust gas passes through in public road travel specification 1A (described later). The punching metal partition plate 13 is a sheet metal partition plate punched with a multiplicity of small holes allowing gas to pass freely. The partition plate 13 makes the speed of the exhaust gas uniform and prevents gas from building up within the first expansion chamber C1.

On the inside of the main body 2, a first communicating pipe 16 passing through the first bulkhead 14 and the second bulkhead 15 is fixed to these bulkheads. A second communicating pipe 17 passing through the second bulkhead 15 is fixed to the second bulkhead 15. It is also possible to provide

two first communicating pipes 16 with the same positional relationship with respect to a central line of the body.

FIG. 2 is a longitudinal cross-sectional view of public road travel specification state 1A of the exhaust silencer 1 of the first embodiment of the present invention. In this specification state 1A, the public road travel spark arrester 18 is installed so as to pass through the first bulkhead 14, second bulkhead 15, and the rear part end plate 5. The public road travel spark arrester 18 is installed by fixing a flange 20 welded to the rear part end part of the tail pipe 19 of the central part to the rear part end plate 5 using a bolt 21. A cylindrical gasket 22 is installed between the front end part of the tail pipe 19 and the first bulkhead 14 to prevent gas from flowing through.

FIG. 3 is a view of the public road travel spark arrester 18 for use in the public road travel specification state 1A for the exhaust silencer 1, where FIG. 3(a) is a longitudinal cross-sectional view, and FIG. 3(b) is a view from the rear. In order from the front end, a tail pipe front cover 23, a first support ring 24, a second support ring 25, and the flange 20 are welded to the tail pipe 19 of the spark arrester 18. The cylindrical gasket 22 is installed at the outer periphery of the tail pipe 19 between the tail pipe front cover 23 and the first support ring 24. A multiplicity of gas-introducing small holes 26 are provided at a portion of the side surface of the tail pipe 19 sandwiched between the first support ring 24 and the second support ring 25. Further, stainless steel wire mesh 27 for preventing sparks and soot from flowing out is spot-welded to an outer periphery part of the first support ring 24 and the second support ring 25. A fitting bolt through-hole 20a is provided at the flange 20.

In the public road travel specification state 1A of the exhaust silencer 1 shown in FIG. 2, exhaust gas exhausted from the internal combustion engine (not shown) gushing into the main body 2 of the exhaust silencer 1 via the introduction pipe 9 is exhausted to the open air by passing through the first expansion chamber C1, first communicating pipe 16, second expansion chamber C2, second communicating pipe 17, third expansion chamber C3, stainless steel wire mesh 27, gas-introducing small holes 26 and tail pipe 19. The exhaust gas alternately passes through large volume

expansion chambers and long communicating pipes so that gas pressure is reduced by the extent of repeated expansion and compression, noise is muffled, and the exhaust gas is then purified by the stainless steel wire mesh 27 before being exhausted from the rear end of the tail pipe 19.

In the public road travel specification state 1A of this exhaust silencer 1, the gas flow has a so-called "three-pass" structure where the gas flow passes through the second bulkhead 15 three times via the first communicating pipe 16, second communicating pipe 17, and the tail pipe 19. This structure improves sound-abating effects by elongating the gas flow path.

FIG. 4 is a longitudinal cross-sectional view of racing specification state 1B of the exhaust silencer 1 of the first embodiment. It is possible to improve output of the internal combustion engine during use of the exhaust silencer 1 in racing simply by detaching the public road travel spark arrester 18. However, when there is no spark arrester, sparks and soot are simply discharged into the open air and this is not preferable from an environmental point of view. In the racing specification conditions 1B for the exhaust silencer 1 of this embodiment, the public road travel spark arrester 18 is detached, and a short racing spark arrester 31 is installed in its place. The dimensions of the racing spark arrester 31 are short in the axial direction. Therefore, in the racing specification state 1B, a central through-hole 14a for the first bulkhead 14 and a central through-hole 15a for the second bulkhead 15 are opened up.

FIG. 5 is a view of a racing spark arrester 31, where FIG. 5(a) is a longitudinal cross-sectional view and FIG. 5(b) is a view as viewed from the rear. The racing spark arrester 31 is comprised of a tail pipe 32 that is short in the axial direction but has a large diameter, an annular member 33, stainless steel mesh 34 stretched at the front surface and side surface of the annular member 33, and a flange 35 welded to the tail pipe 32. The other end of the stainless steel mesh 34 stretched at the side surface of the annular member 33 is spot-welded to the tail pipe 32. As shown in FIG. 4, the racing spark arrester 31 is installed by fixing the flange 35 of the racing spark arrester 31 to the rear part end plate 5 using a bolt 21 inserted through a fitting bolt insertion hole 35a.

The racing specification state 1B of the exhaust silencer 1 of the first embodiment shown in FIG. 4, exhaust gas exhausted from the internal combustion engine (not shown) gushing into the main body 2 of the exhaust silencer 1 via the introduction pipe 9 is exhausted to the open air by passing through the first expansion chamber C1, central through-hole 14a, third expansion chamber C3, central through-hole 15a, second expansion chamber C2, stainless steel mesh 34 and tail pipe 32. The central through-hole 14a and the central through-hole 15a through which the exhaust gas passes have large diameters and permit the gas to advance in a straight line and therefore present little resistance to the gas flowing out. Further, the tail pipe 32 is also short with a large diameter and therefore also presents little resistance to the gas flowing out. For these reasons, output of the internal combustion engine is improved by the racing specification state 1B of the exhaust silencer 1 equipped with the racing spark arrester 31 and a state appropriate for racing is attained.

When the exhaust silencer 1 of the first embodiment is assembled for the public road travel specification state 1A (FIG. 2), of the first to third expansion chambers, the first expansion chamber C1 at maximum pressure and the third expansion chamber C3 at minimum pressure are next to each other. Sound abating effects decrease sharply when gas leaks between the chambers. It is therefore necessary to provide a gas leakage prevention seal between the first bulkhead 14 and the public road travel spark arrester 18. The tail pipe 19 of the public road travel spark arrester 18 extends when the internal combustion engine is running and retracts when the internal combustion engine is halted. The seal therefore has to maintain its functioning even in the case of the extension and retraction.

FIG. 6 to FIG. 8 are theoretical views for illustrating various types of seal structures that can be applied between the first expansion chamber C1 and the third expansion chamber C3 in the public road travel specification state 1A of the exhaust silencer 1 of the first embodiment. Portions corresponding to portions shown in FIG. 2 are given the same numerals. The drawings are slightly simplified. The punching metal partition plate 13 is not the object of discussion and is therefore omitted from these drawings.

FIG. 6 is an example where the cylindrical gasket 22 of the format shown in FIG. 2 is installed between the first bulkhead 14 and the tail pipe 19 of the public road travel spark arrester 18. This seals in the diameter direction. A stainless steel wool gasket, a glass wool gasket, a steel gasket, or a cladding material of these can be used as the gasket 22. Mutual sliding takes place with a member making contact at the outer periphery or the inner periphery of the gasket 22 in order to permit extension and retraction of the tail pipe 19, the rear end of which is fixed.

FIG. 7 is an example where a ring-shaped resilient gasket 36 is installed between the first bulkhead 14 and a first support ring 24 (FIG. 3) of the public road travel spark arrester 18. This seals in an axial direction. This gasket 36 is made of a fibrous aluminum material. This may be SUS material or SK material, etc. These are extendable and retractable gasket materials. Further, the inner periphery of the ring-shaped resilient gasket 36 and the tail pipe 19 are capable of sliding over each other. It is therefore possible to permit extension and retraction of the tail pipe 19, the rear end of which is fixed.

FIG. 8 is an example where a ring-shaped metal member 37 fitted to a tail pipe 19 of the public road travel spark arrester 18 is thrust in an axial direction from the rear end side of the tail pipe 19 towards the first bulkhead 14. The tail pipe 19 is urged forwards by a coil spring 39 fitted between a bolt screwed into the rear part end plate 5 and the flange 20 welded to the rear end of the tail pipe 19. This causes the tail pipe 19 to push the ring-shaped metal member 37 in the direction of the first bulkhead 14. In order to ensure reliable contact with the first bulkhead 14 of the ring-shaped metal member 37, it is necessary to provide a gap between the rear part end plate 5 and the flange 20 even under initial conditions. In order to prevent gas leaking from between the rear part end plate 5 and the flange 20, a gasket 40 having resilience is fitted to this part. When the tail pipe 19 expands due to heating, the tail pipe 19 extends to the rear while pushing in the coil spring so as to permit extension and retraction of the tail pipe 19. With regards to increasing the gap between the rear part end plate 5 and the flange 20, gas leakage is prevented by using a resilient gasket 40. In the above example, a separate ring-shaped

metal member 37 is provided to the front of the first support ring 24, but it is also possible for the first support ring 24 itself to make contact with the first bulkhead 14.

Next, a description is given of a configuration for an exhaust silencer 41 of a second embodiment of the present invention. The exhaust silencer 41 of the second embodiment comprises a set of three members, an exhaust silencer body 42, and two types of spark arrester that can be attached to and detached from the main body 42, i.e. a public road travel spark arrester 53 and a racing spark arrester 31. The two types of spark arrester can be changed according to the purpose of the vehicle use. A state where the public road travel spark arrester 53 is installed at the exhaust silencer body 42 is referred to as a public road travel specification state 41A of the exhaust silencer 41 of the second embodiment. A state where the road travel spark arrester 31 is installed at the exhaust silencer body 42 is referred to as a public road travel specification state 41B of the exhaust silencer 41 of the second embodiment. The racing spark arrester 31 is the same as that (of FIG. 5) used in the first embodiment. This exhaust silencer 41 is also connected to an exhaust pipe of an internal combustion engine of a motorcycle or four-wheeled buggy as shown in FIG. 13 and FIG. 14.

FIG. 9 is a vertical cross-section of a main body 42 of the exhaust silencer 41. In FIG. 9, the outward appearance of the main body 42 of the exhaust silencer 41 comprises a cylindrical central body part 43, a conical front cover 44, and a rear part end plate 45 having a large opening at a central part. An introduction pipe 46 connected to the exhaust pipe of the internal combustion engine passes through the top part of the front cover 44 and an exhaust gas nozzle 47 at a front end opens out within the main body 42. This configuration is the same as for the first embodiment.

In order from the front, a punching metal partition plate 48, a first bulkhead 49, and a second bulkhead 50 are provided at the inside of an inner body plate. A portion to the front of the first bulkhead 49 is a first expansion chamber C1, a portion to the rear from the second bulkhead 50 is a second expansion chamber C2, and a portion sandwiched between the first bulkhead 49 and the second bulkhead 50 is a third expansion chamber C3 . The numbers of the expansion chambers follow the order with which

the exhaust gas passes through in public road travel specification 41A (described later). A punching metal partition plate 48 is a sheet metal partition plate punched with a multiplicity of small holes. The speed of the exhausted gas is therefore made uniform and gas is prevented from building up in the first expansion chamber C1. A first communicating pipe 51 passing through the first bulkhead 49 and the second bulkhead 50 is fixed to these bulkheads. A second communicating pipe 52 passing through the second bulkhead 50 is fixed to the second bulkhead 50.

The point where the exhaust silencer body 42 differs from the exhaust silencer body 2 of the first embodiment is that there is no central through-hole at the first bulkhead 42. This relates to the absence of a central through-hole, but the first communicating pipe 51 is made slightly thicker to take into consideration performance when converting to a race specification state 42B described later. It is also possible to provide two first communicating pipes 51 of slightly smaller diameters with the same positional relationship with respect to a central line of the body.

FIG. 10 is a longitudinal cross-sectional view of public road travel specification state 41A of the exhaust silencer 41 of the second embodiment of the present invention. In this specification state 41A, the public road travel spark arrester 53 is installed so as to pass through the second bulkhead 50, and the rear part end plate 45. The public road travel spark arrester 53 is installed by fixing a flange 57 welded to the rear part end part of the tail pipe 54 of the central part to the rear part end plate 45 using a bolt 21. The overall length of the public road travel spark arrester 53 is made short to provide compatibility with the fact that the first bulkhead 49 has no central through-hole.

FIG. 11 is a view of the public road travel spark arrester 53 for use in the public road travel specification state 41A for the exhaust silencer 41, where FIG. 11(a) is a longitudinal cross-sectional view, and FIG. 11(b) is a view as viewed from the rear. In order from the front, a tail pipe front cover 55, a support ring 56, and a flange 57 are welded to the tail pipe 54 being a center tail pipe 54. A multiplicity of gas-introducing small holes 58 are made in the side surface of the front end part of the tail pipe 46. A stainless steel mesh 59 is made to span the side surface of the tail pipe front cover 55 and

the support ring 56 and is spot-welded. The public road travel spark arrester 53 is fitted to the rear part end plate 45 using a bolt 21 inserted through a fitting bolt through-hole 57a of a flange 57 that is welded to the tail pipe 54.

In the public road travel specification state 41A of the exhaust silencer 41 shown in FIG. 10, exhaust gas exhausted from the internal combustion engine (not shown) gushing into the main body 42 of the exhaust silencer 41 via the introduction pipe 46 is exhausted by passing through the first expansion chamber C1, first communicating pipe 51, second expansion chamber C2, second communicating pipe 52, third expansion chamber C3, stainless steel wire mesh 59, gas-introducing small holes 58 and tail pipe 54. The gas flow for this exhaust silencer 41 is also a so-called three-pass structure where the gas flow passes through the second bulkhead 50 three times. The exhaust gas alternately passes through large volume expansion chambers and long communicating pipes so that gas pressure is reduced by the extent of repeated expansion and retraction, noise is muffled, and the exhaust gas is then purified by the stainless steel wire mesh 59 before being exhausted to the open air from the rear end of the tail pipe 54.

There is no central through-hole at the first bulkhead at the exhaust silencer 41 of this embodiment. The gas leakage seal structure (FIG. 6 to FIG. 8) provided in order to prevent gas from leaking between the first expansion chamber C1 and the third expansion chamber C3 in the public road travel specification state 1A for the exhaust silencer 1 of the first embodiment can therefore be omitted and the structure is simplified accordingly.

FIG. 12 is a longitudinal cross-sectional view of racing specification state 41B of the exhaust silencer 41 of the second embodiment. It is possible to improve output of the internal combustion engine during use of the exhaust silencer 41 in racing simply by detaching the public road travel spark arrester 53. However, when there is no spark arrester, sparks and soot are simply discharged into the open air and this is not preferable from an environmental point of view. Because of this, the public road travel spark arrester 53 is removed, and the racing spark arrester 31 short in

overall length shown in FIG. 5 is installed. The racing spark arrester 31 is the same as that used in the first embodiment.

In the racing specification state 41B (FIG. 12) of the exhaust silencer 41 of the second embodiment, exhaust gas exhausted from the internal combustion engine (not shown) gushing into the main body 42 of the exhaust silencer 41 via the introduction pipe 46 is exhausted to the open air by passing through the first expansion chamber C1, first communicating pipe 51, second expansion chamber C2, stainless steel mesh 34 and tail pipe 32. In the race specification state 41B of this embodiment, exhaust gas passes through the first communicating pipe 51 so as to be exhausted to the open air without passing through the third expansion chamber C3. Namely, compared to the public road travel specification state 41A (FIG. 10), the path by which gas flows out is made shorter. There is therefore little resistance to the gas flowing out, the output of the internal combustion engine is improved, and a state appropriate for racing is attained.

With the race specification state 41B of the exhaust silencer 41 of the second embodiment, the exhaust gas cannot go in a straight line and makes a detour so as to flow via the first communicating pipe 51. The increase in output of the internal combustion engine is therefore insufficient. Because of this, the first communicating pipe 51 of this embodiment is of a diameter that is made large compared to the first communicating pipe 16 of the exhaust silencer 1 of the first embodiment in order to reduce resistance to the gas flowing out. Instead of this, it would also be possible to provide two first communicating pipes 51 of smaller diameters.

As described in detail above, in each of the above embodiments, a spark arrester equipped with a tail pipe is detachably provided at a rear part of an exhaust silencer body equipped with a plurality of expansion chambers defined by a plurality of bulkheads. It is therefore possible to provide compatibility instantaneously with both use on public roads and use in racing without changing the main body simply by removing a public road spark arrester or changing this spark arrester for a racing spark arrester.

A three-pass structure is adopted when traveling on public roads and the silencing of the exhaust silencer is therefore improved. When the spark arrester is then removed or is replaced with a racing spark arrester, the output of the internal combustion engine is improved. It is therefore possible to divide use of this exhaust silencer between traveling on public roads and racing use without removing the main body of the exhaust silencer.

Further, in the public road travel specification state 1A of the exhaust silencer 1 of the first embodiment, leakage of gas or sound into a neighboring expansion chamber does not occur due to the seal structure shown in FIG. 6 to FIG. 8 and silencing is therefore improved. Further, the tail pipe has a slide structure that permits extension and retraction. Thermal expansion is therefore suppressed, there is little fatigue even with repeated expansion and retraction, and durability is improved. Further, it is therefore possible to provide a minimum pressure third expansion chamber next to a maximum pressure first expansion chamber within the main body 2 of the exhaust silencer 1, a three-pass structure can be realized, and silencing on public roads can be improved. With the exhaust silencer 41 of the second embodiment, a central through-hole for passing the tail pipe through the first bulkhead is not provided. Silencing occurring in public road travel specification state 41A is therefore dramatically improved, the seal structure between the first expansion chamber and the third expansion chamber is not necessary, and the structure is simplified.

Although various preferred embodiments of the present invention have been described herein in detail, it will be appreciated by those skilled in the art, that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An exhaust muffler for use with an internal combustion engine, said exhaust muffler comprising: a hollow main body having a plurality of bulkheads therein, said bulkheads dividing the interior of said main body into a plurality of expansion chambers; said main body being connectable to an exhaust pipe of an internal combustion engine; a plurality of communicating pipes fixed in said main body so as to connect the expansion chambers; and a spark arrester which is removably attachable to said main body and which comprises a tail pipe, wherein said muffler is configured such that when the spark arrester is installed, exhaust flow is made to pass through at least one bulkhead three times by the spark arrester installed so as to connect the expansion chambers and by the plurality of communicating pipes fixed so as to connect the expansion chambers, and when the spark arrester is removed, exhaust flow may pass straight through a through-hole opening in each of the bulkheads and outwardly from said main body so as to be released outside of said exhaust muffler.

2. The exhaust muffler for an internal combustion engine of claim 2, wherein a seal is provided between one of said bulkheads and the spark arrester, and wherein the seal comprises a sliding part or elastic part permitting extension and retraction of the tail pipe in the lengthwise direction thereof relative to said bulkhead.

Fig. 1

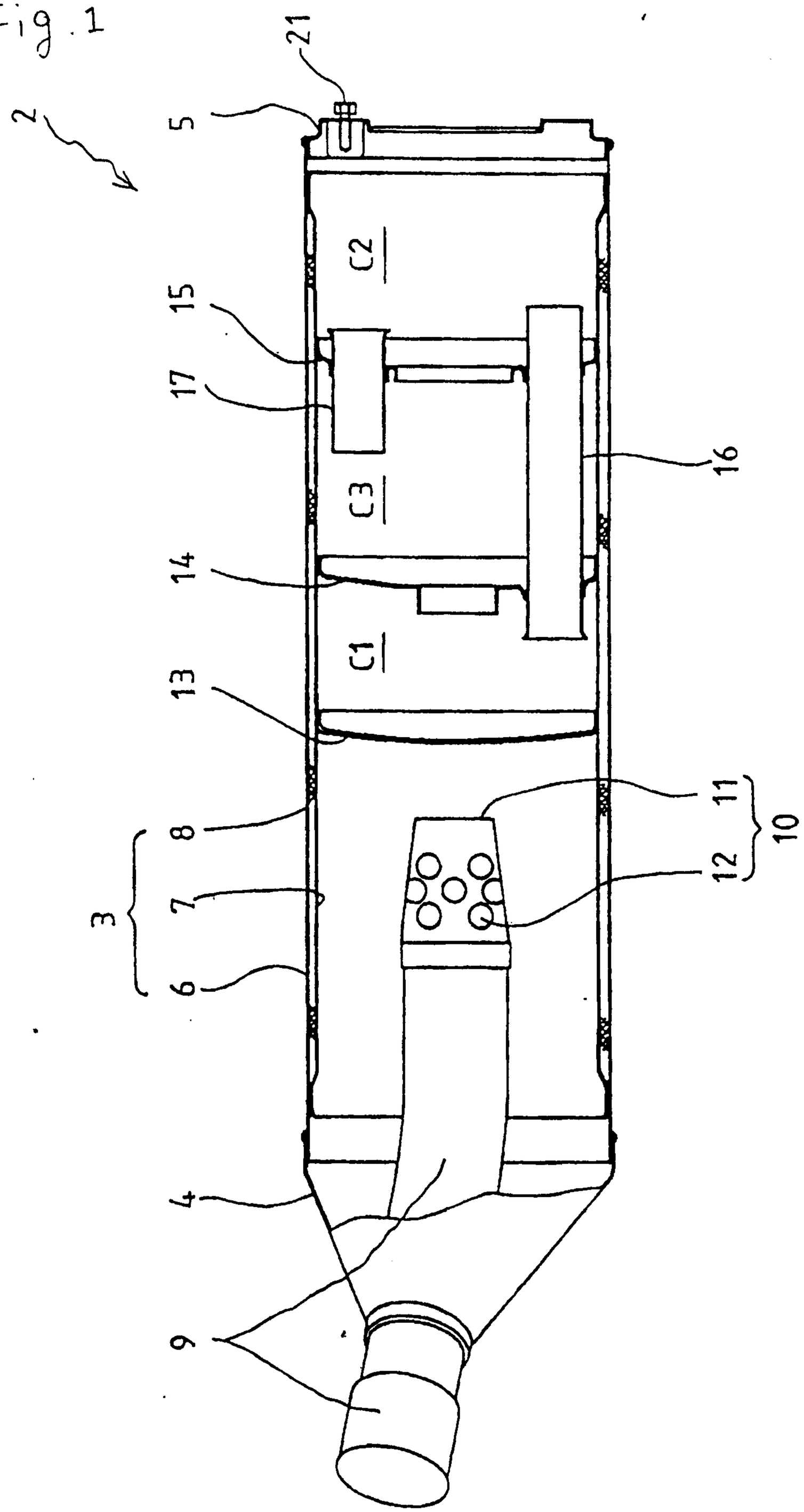


Fig. 2

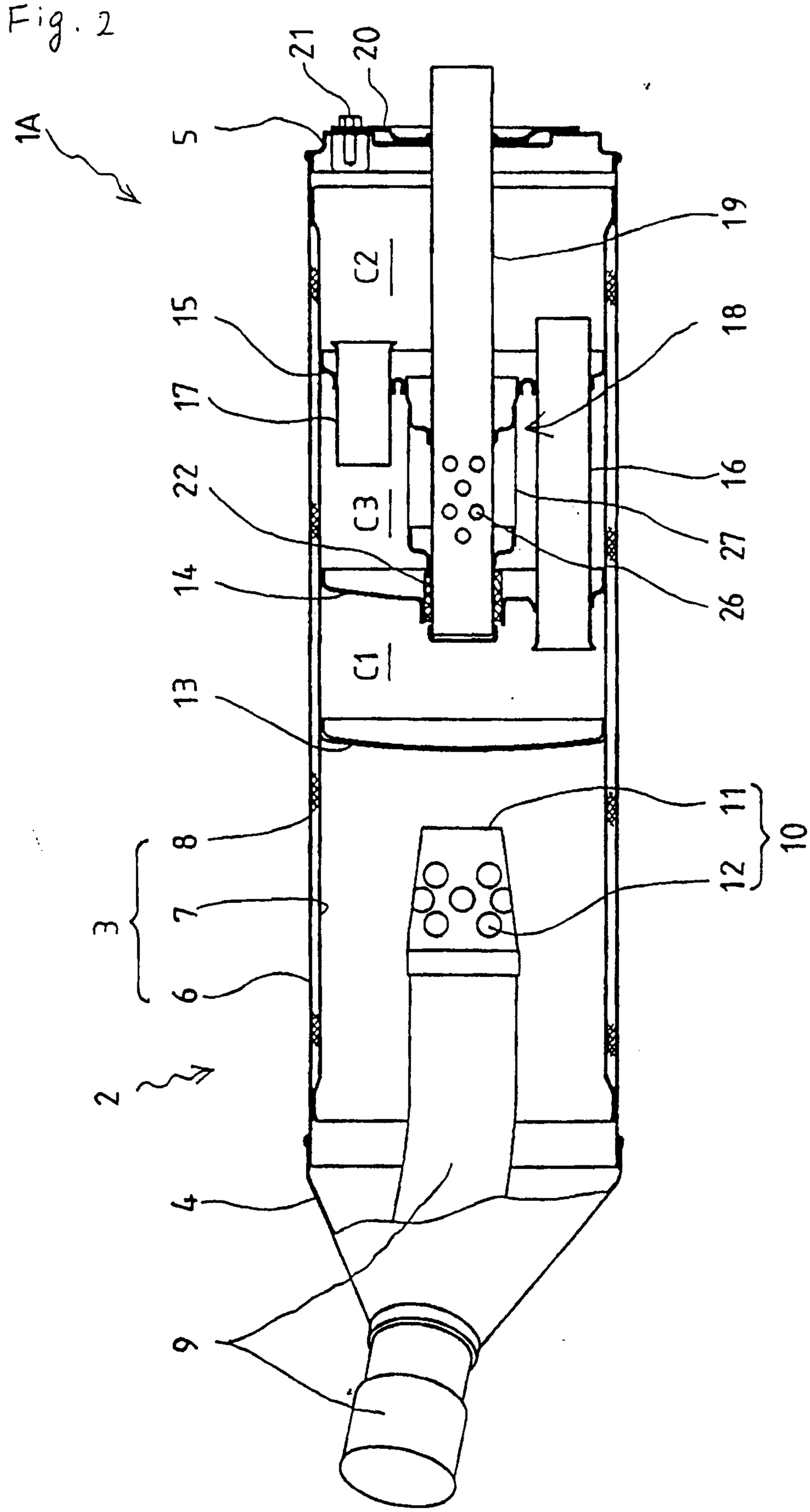
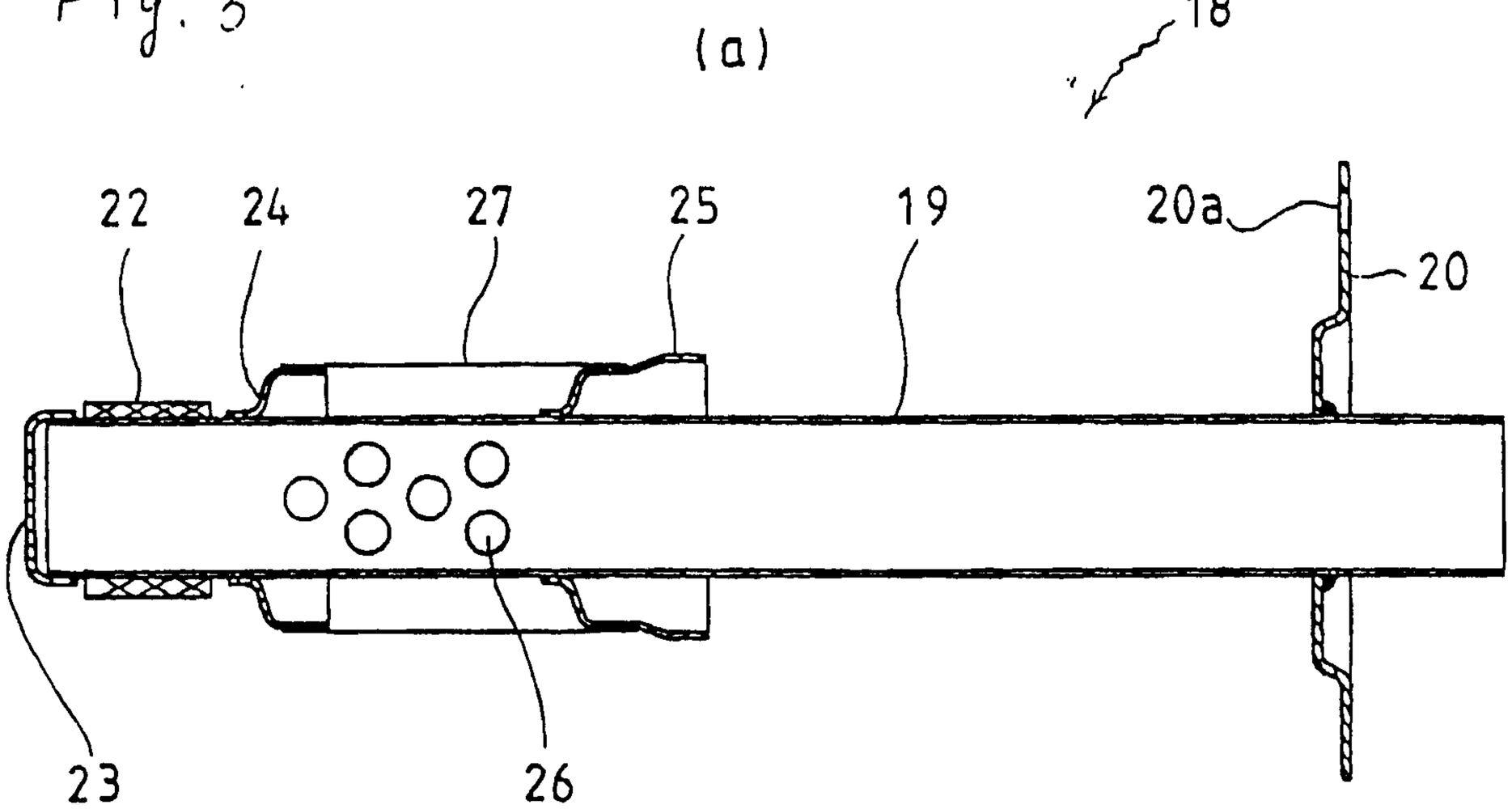


Fig. 3

(a)




(b)

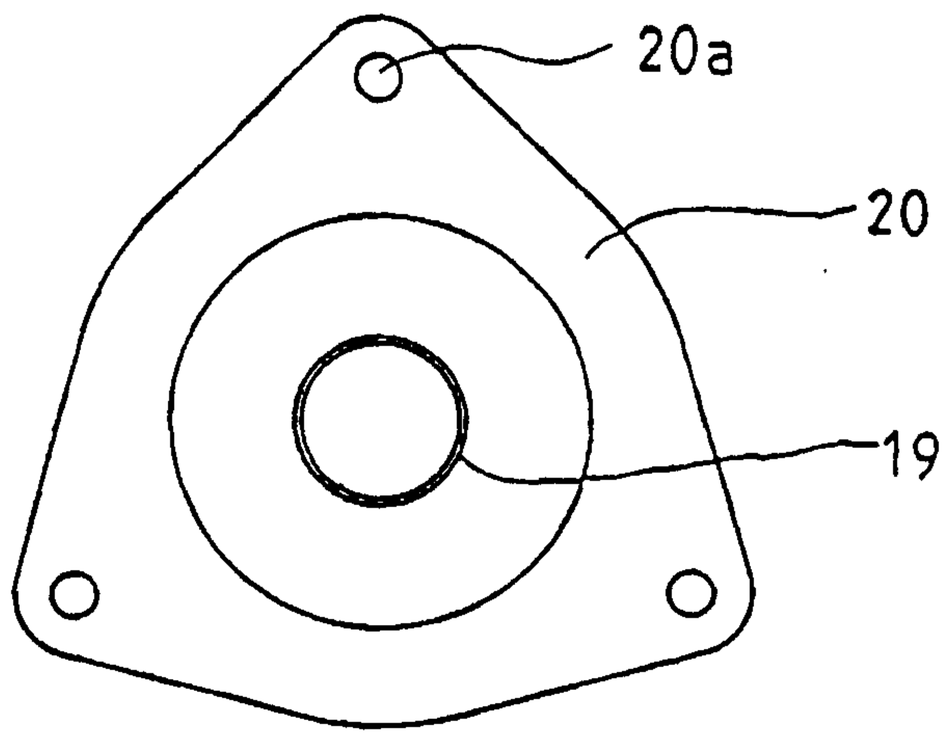


Fig.4

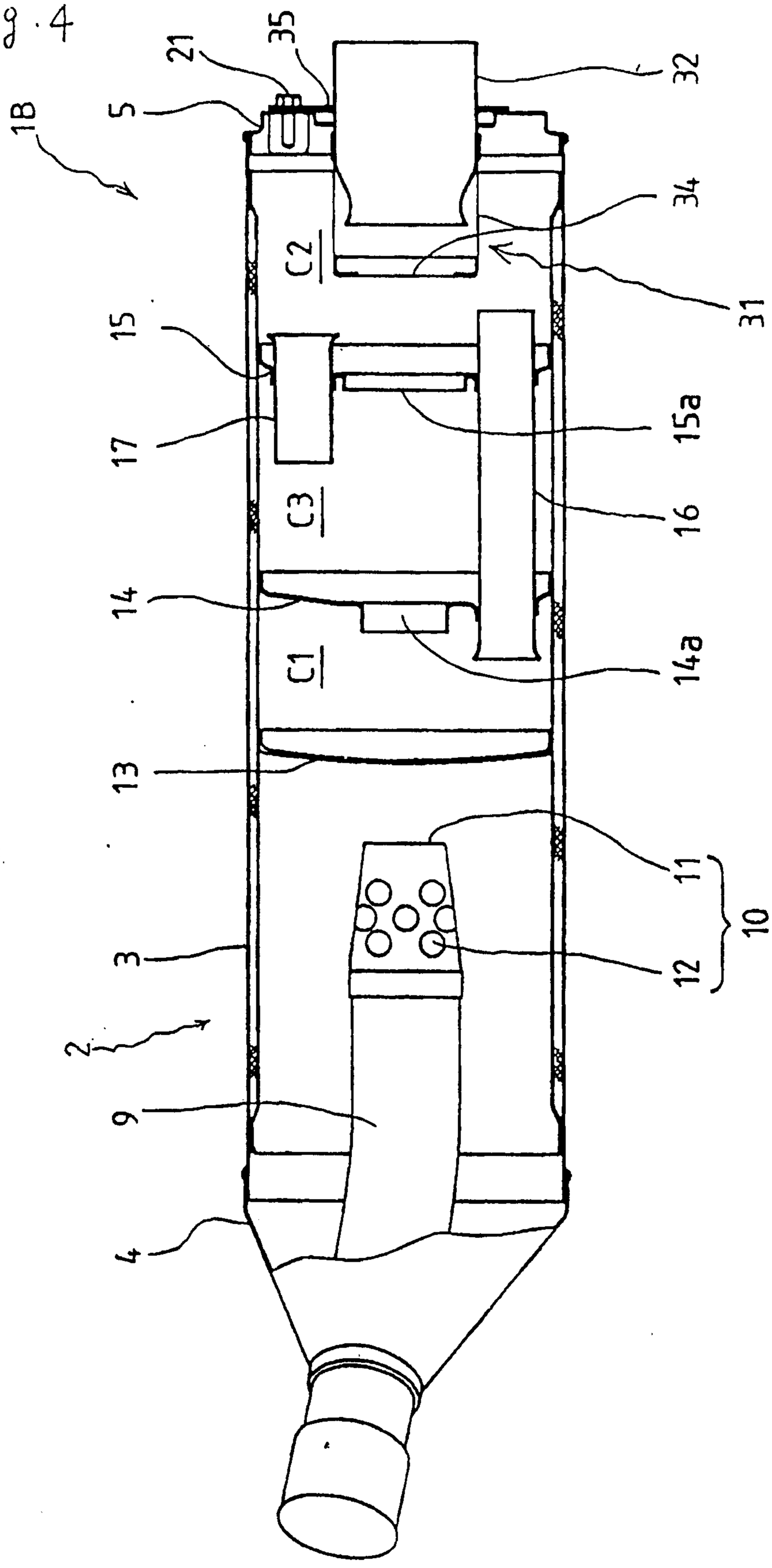


Fig. 5

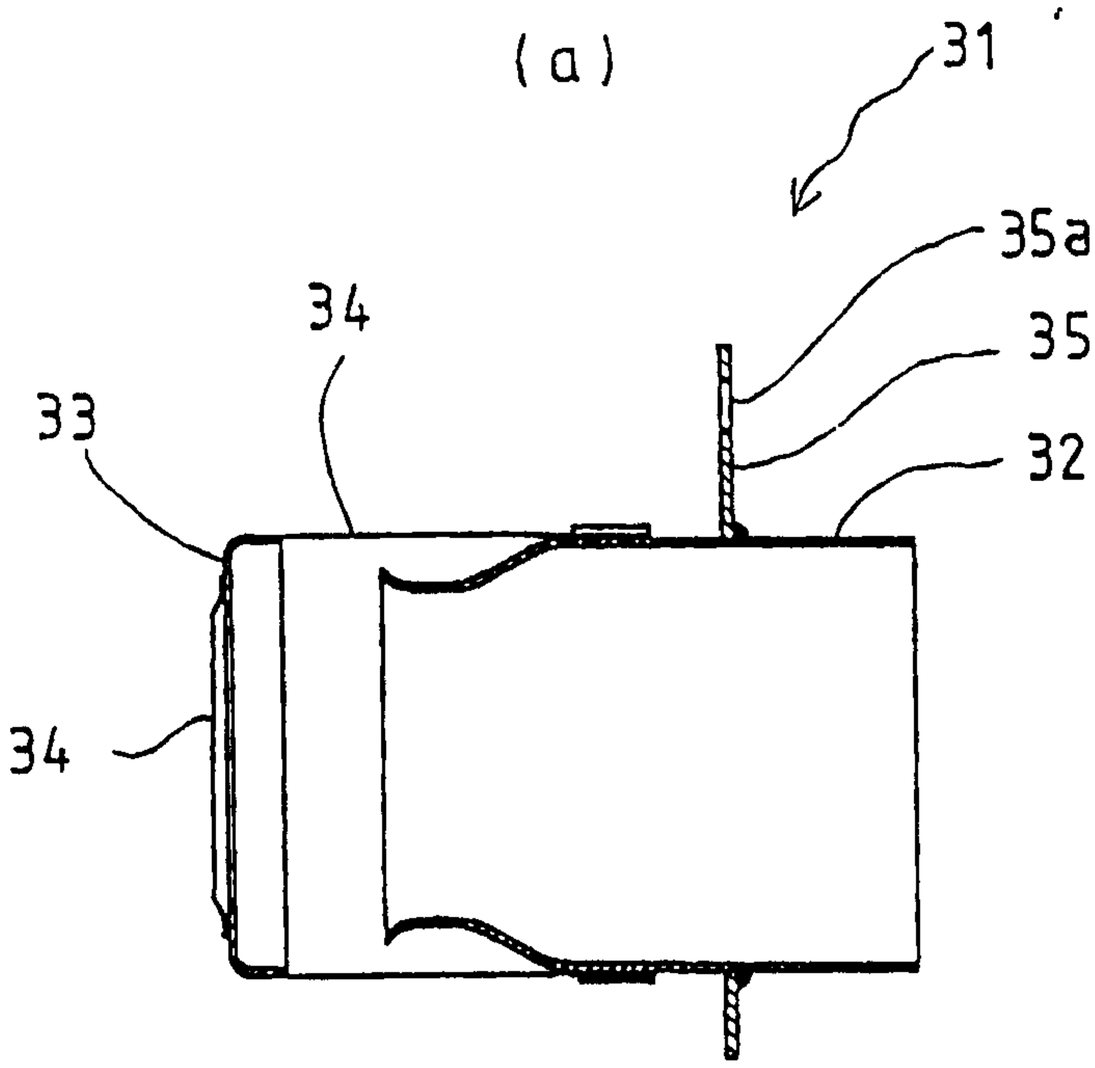
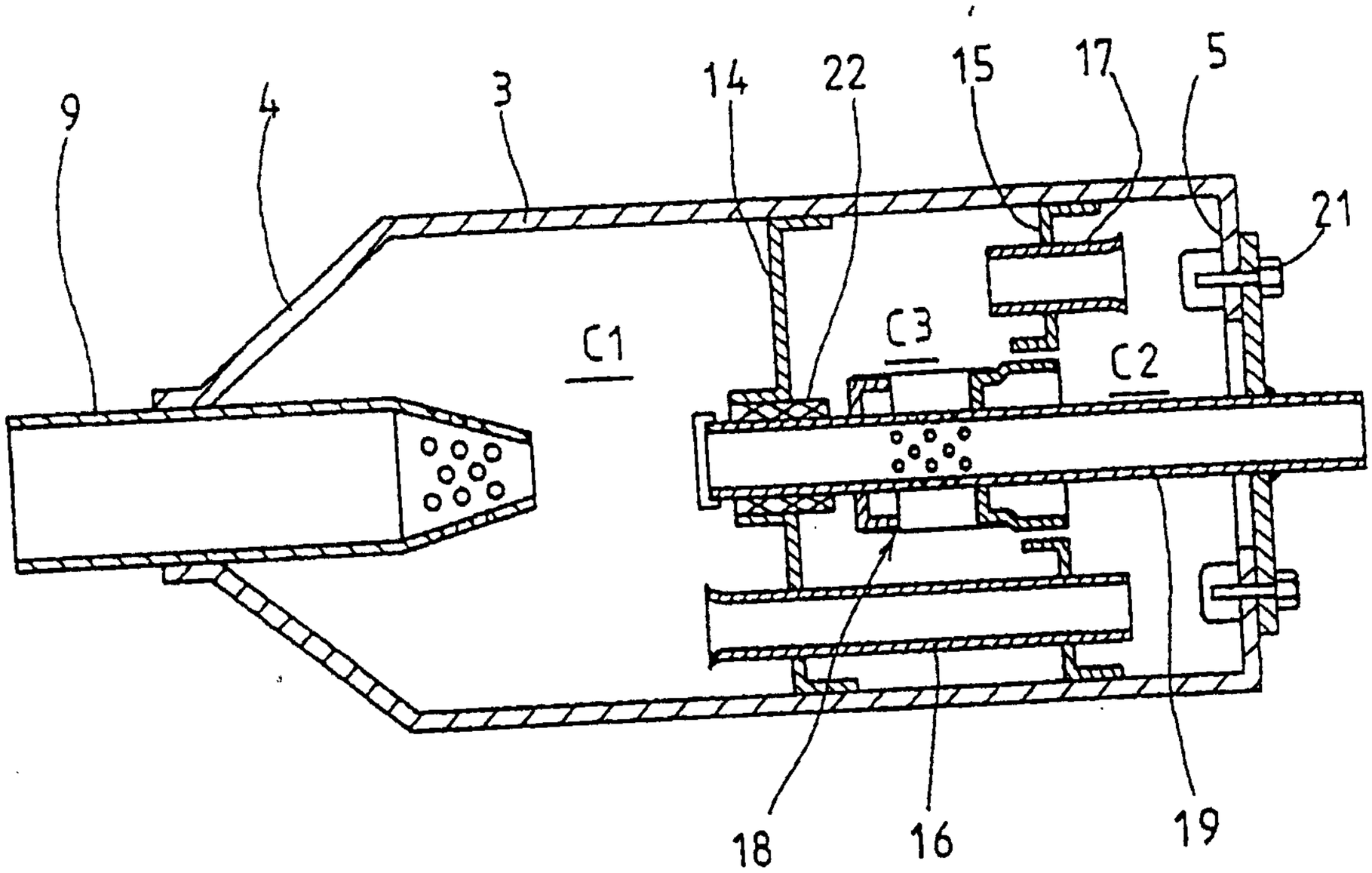


Fig. 6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C1
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C2
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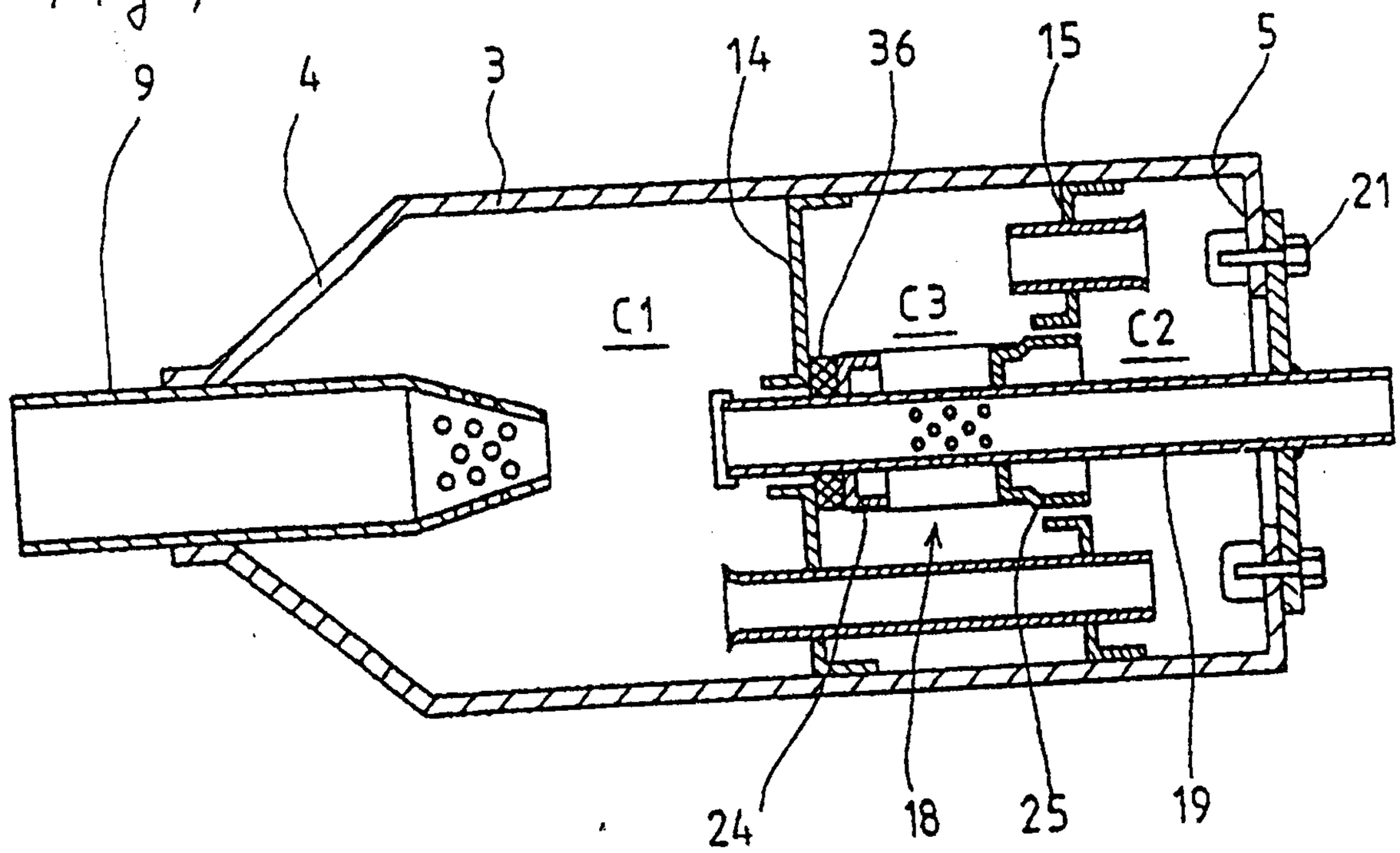
Fig. 7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C1
C3
C2
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Fig.8

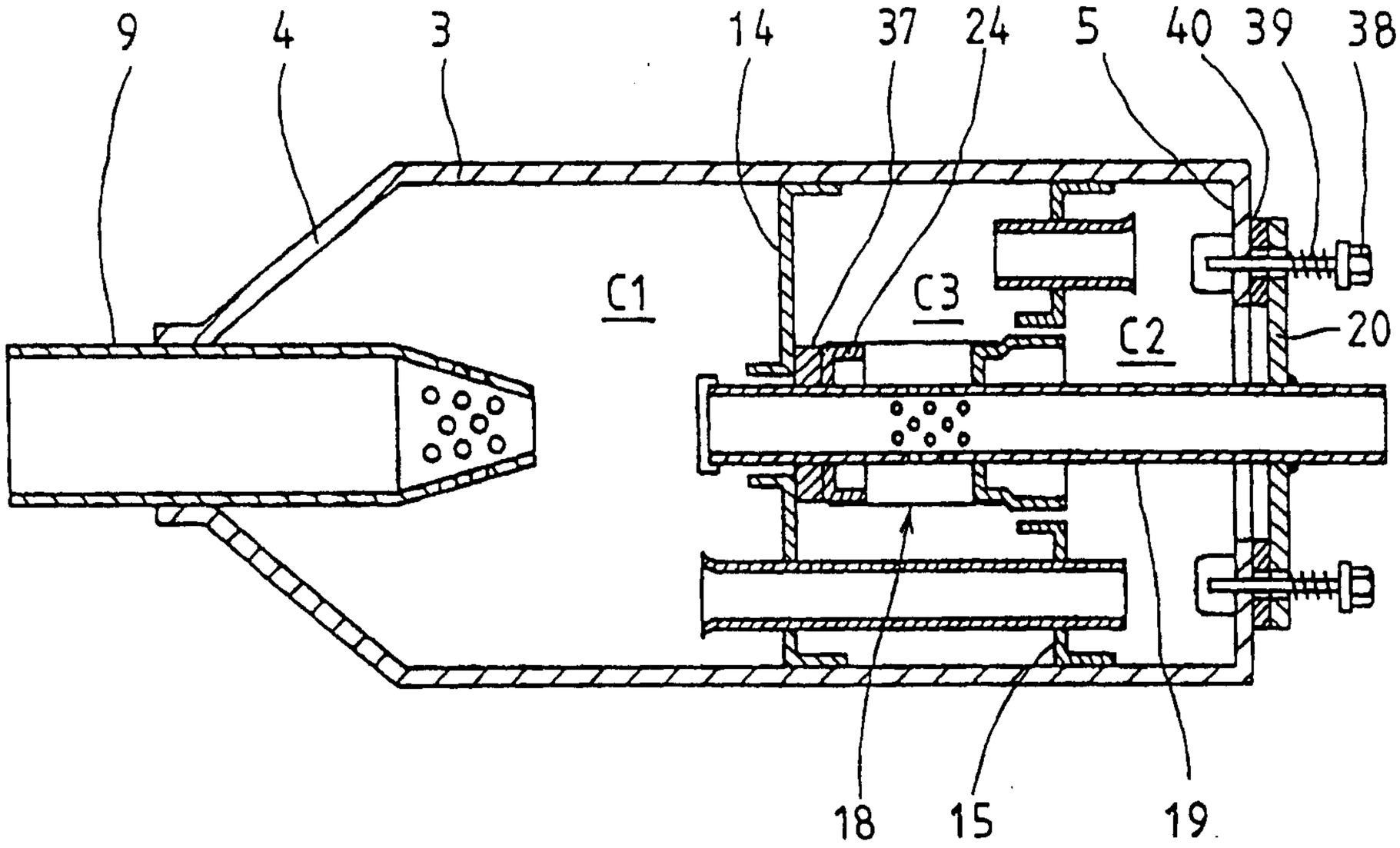


Fig.9

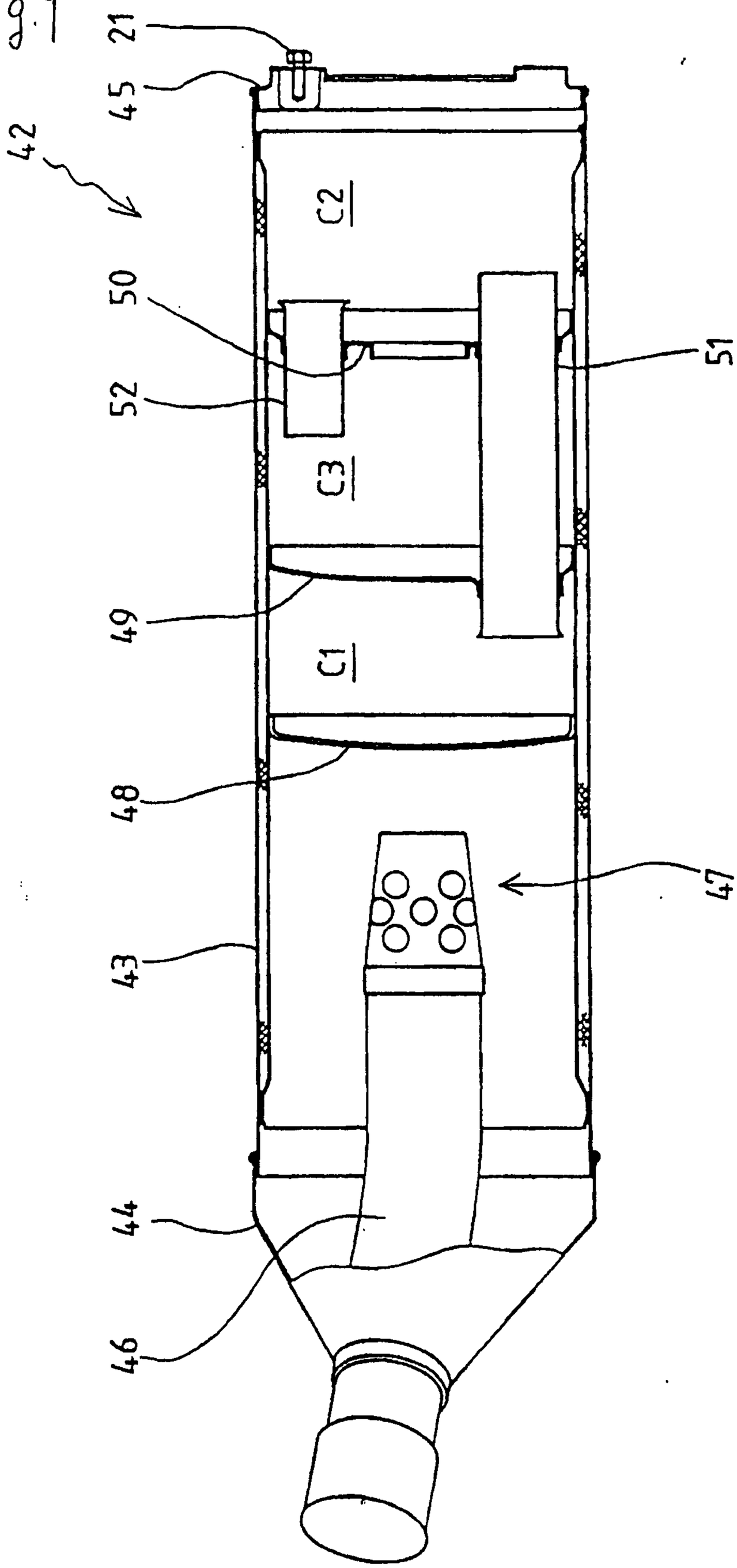


Fig. 10

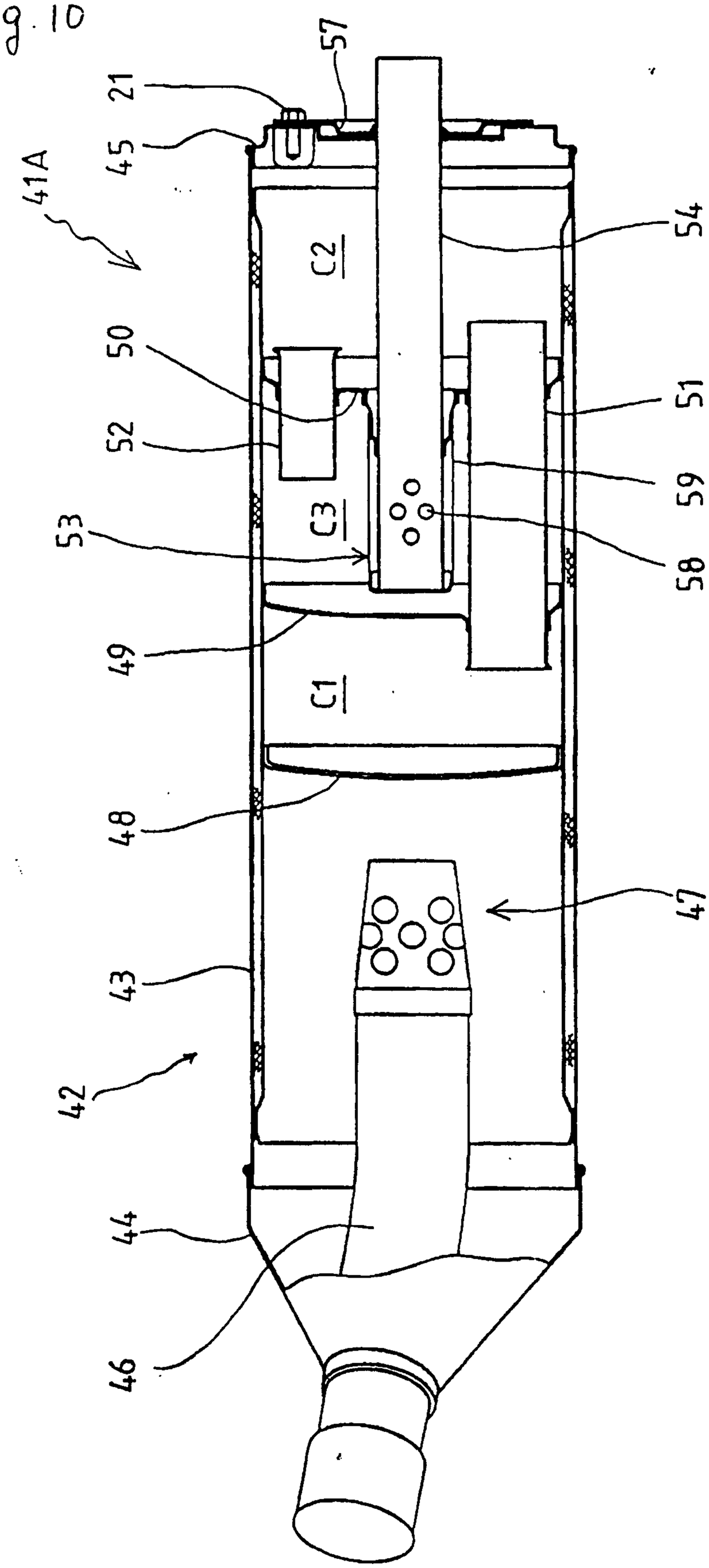


Fig 11

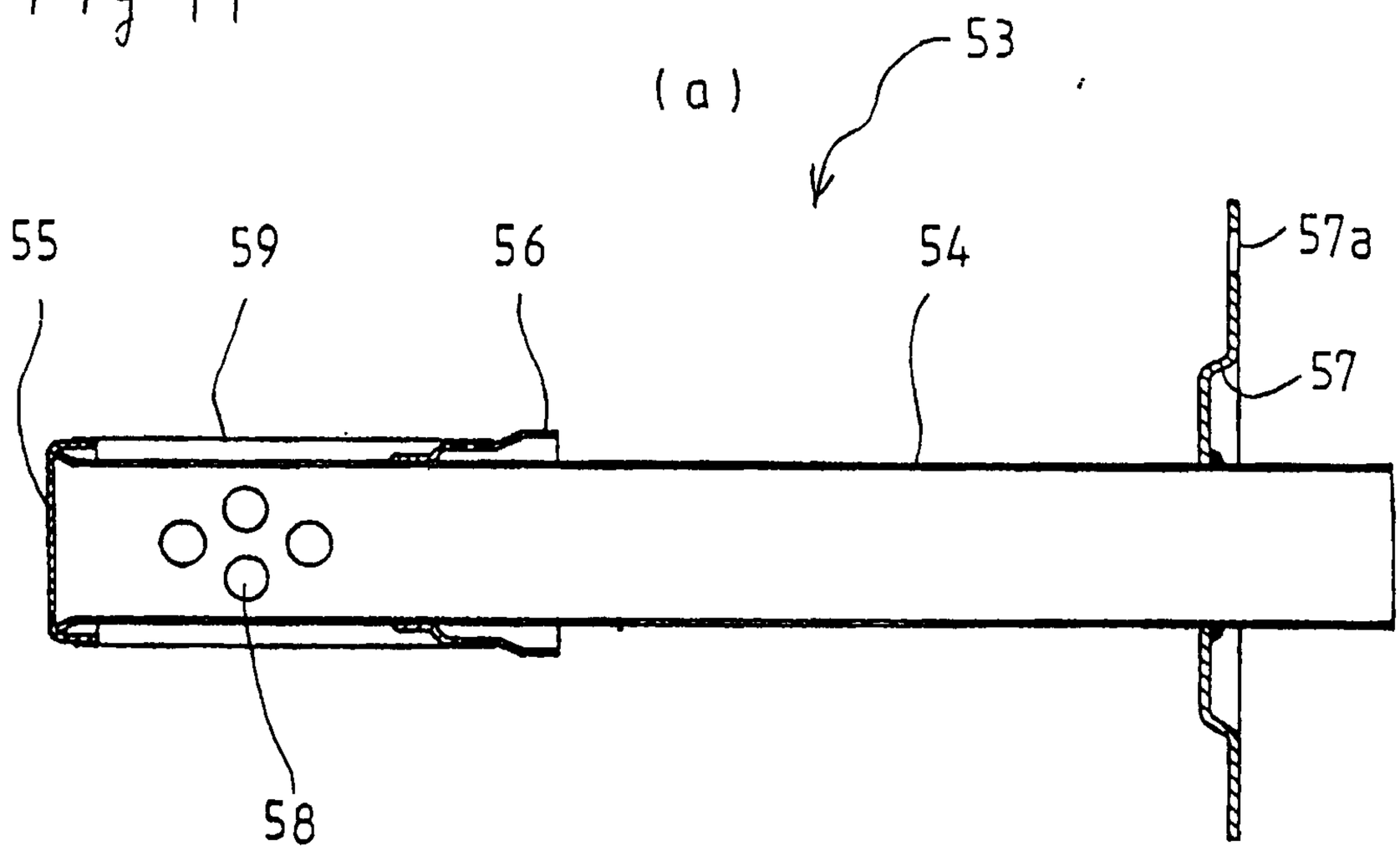


Fig. 12

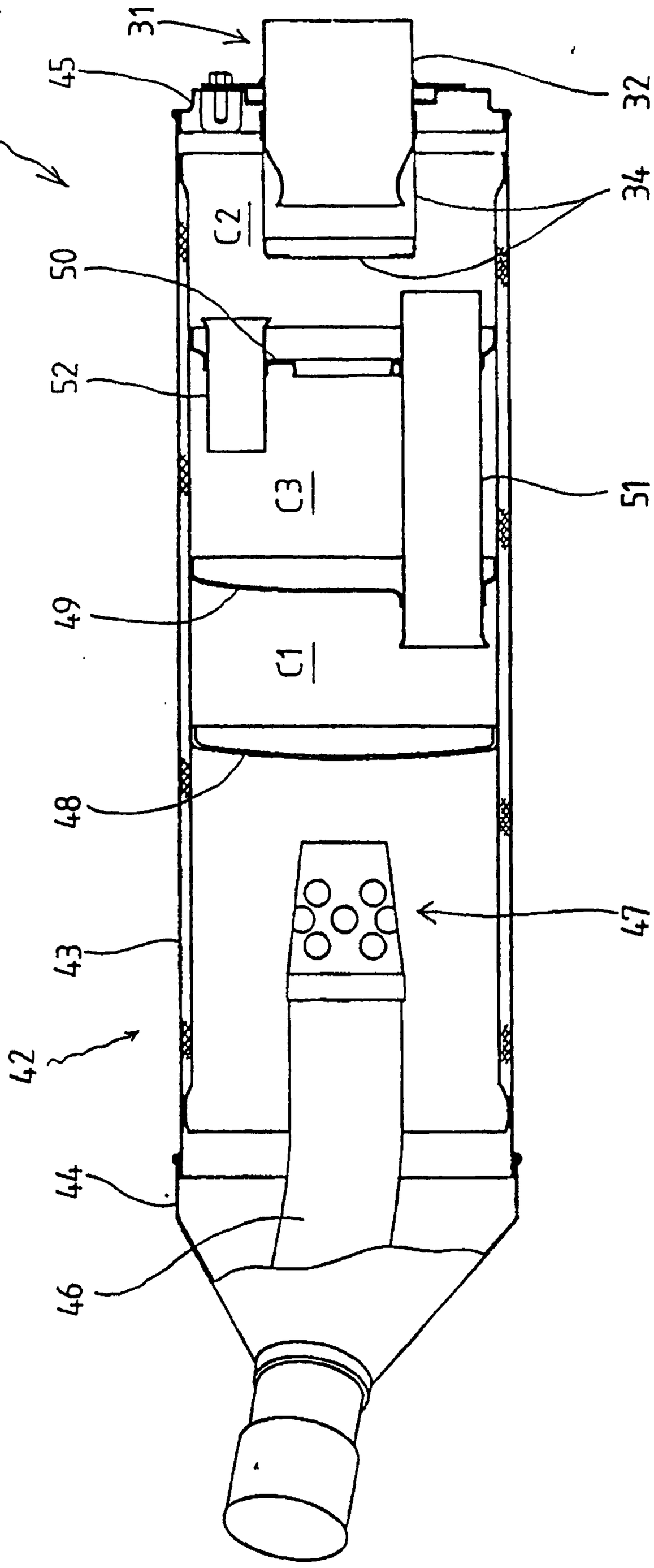


Fig. 13

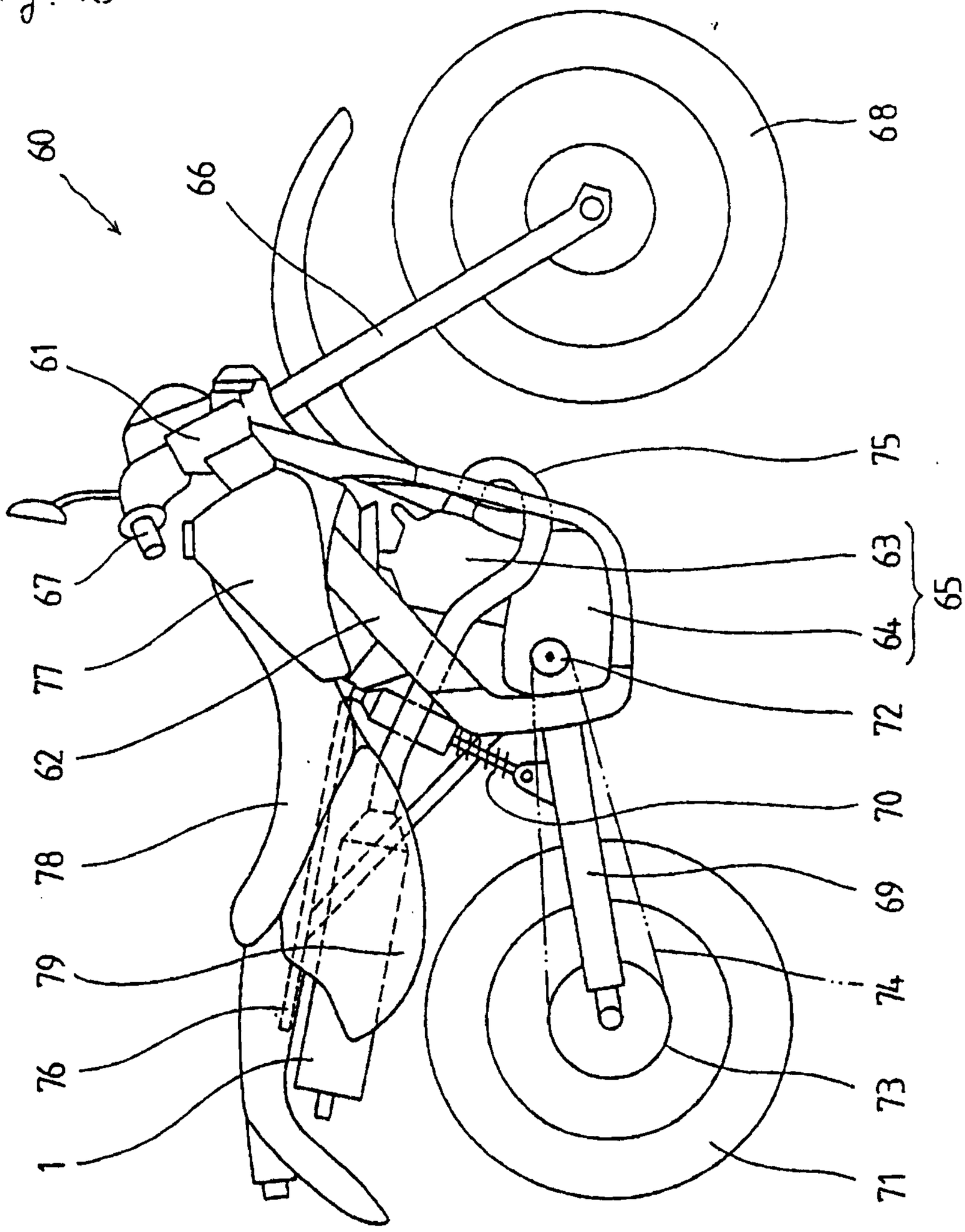
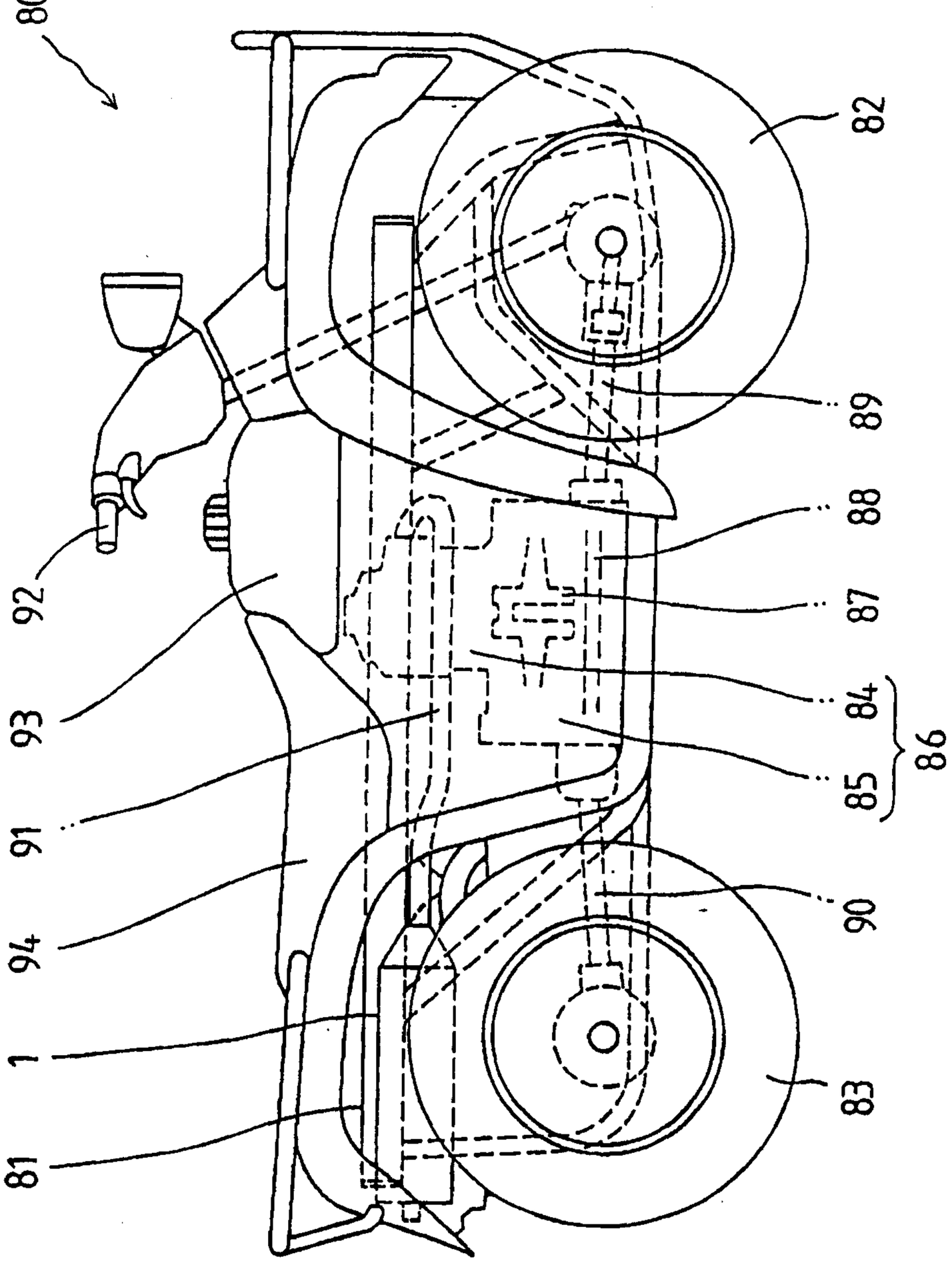
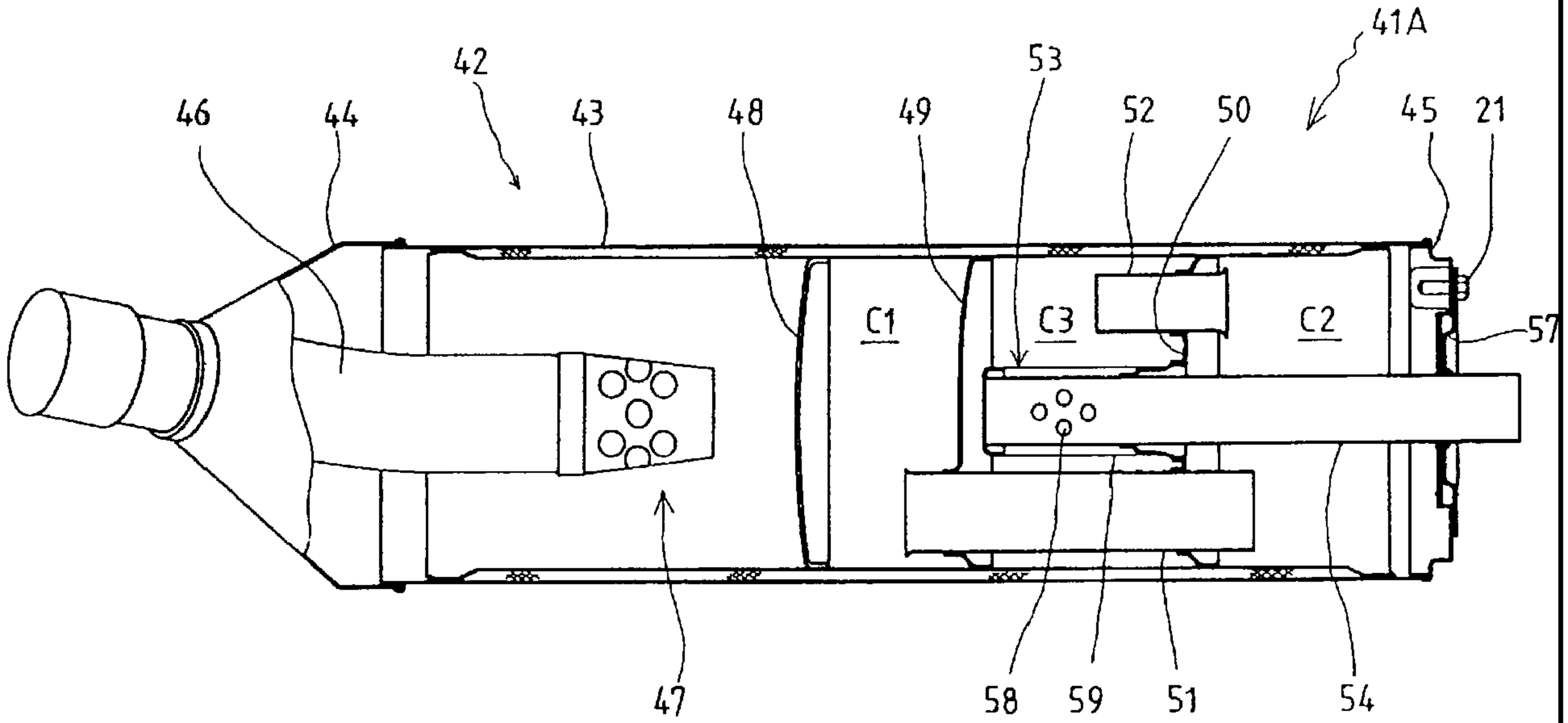


Fig. 14

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C1
C3
C2
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