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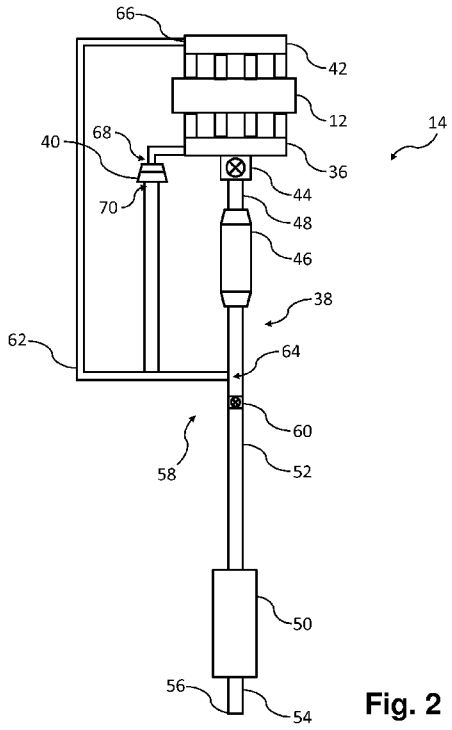

Fig. 2

(57) Abstract: An exhaust system (14) for a vehicle (10) having an engine (12) comprises: an exhaust pipe arrangement (38) defining a flow path for exhaust gas from a source of exhaust in the engine (12); and a sound transmission device (40) having at least one membrane (82) configured to vibrate so as to mechanically transmit sound waves incident upon it. The sound transmission device (40) defines a sound transmission path configured to receive sound waves output from the source of exhaust, the sound transmission path being distinct from the flow path.

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Vehicle Exhaust System with Sound Transmission Device

TECHNICAL FIELD

The present disclosure relates to a vehicle exhaust system and particularly, but not exclusively, to a vehicle exhaust system with a sound transmission device. Aspects of the invention relate to a vehicle.

BACKGROUND

The quality of the sound produced by a modern road vehicle during operation is an important aspect of the vehicle's overall impression upon users and observers.

While sound quality is a subjective metric, certain characteristics of the sound produced by the vehicle's internal combustion engine can be enhanced to increase perceived sound quality. For example, the sound produced by the combustion cycle of a naturally aspirated engine is desirable. Unfortunately, in some high performance cars, some characteristics of the sounds produced by the combustion cycle are often lost in complex exhaust systems, and particularly in those incorporating turbochargers.

Therefore, vehicle manufacturers often attempt to enhance the sound perceived by the user by connecting an intake of the engine to an interior of the vehicle via a valve. Alternatively, simulated engine sounds are played through the vehicle's speakers to enhance the user's experience. While the user is subjected to a higher sound quality while operating the vehicle, these techniques do not improve the quality of sound produced outside the vehicle.

Similarly, some attempts to reproduce engine noises by installing speakers in the exhaust system have been successful. However, this is a complicated solution and its implementation is difficult to achieve without considerable expense and continued maintenance.

It is an aim of the present invention to address disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided an exhaust system for a vehicle having an engine; the exhaust system comprising an exhaust pipe arrangement defining a flow path for exhaust gas from a source of exhaust in the engine, wherein the exhaust pipe arrangement comprises a turbine for a turbocharger which forms part of the flow path, and a sound transmission device defining a sound transmission path configured to receive sound waves output from the source of exhaust, having at least one membrane configured to vibrate so as to mechanically transmit sound waves incident upon it, wherein the sound transmission device comprises an inlet and an outlet, wherein the inlet is configured for communication with the source of exhaust, wherein the sound transmission path is distinct from the flow path.

It is an advantage of the invention that the sound quality of the engine is enhanced, not only internally within the vehicle cabin but externally of the vehicle also. The invention enables the sound of a naturally aspirated engine to be replicated with ease, which is a factor in the buying decision of the user, especially in the purchase of high performance vehicles. Moreover, this benefit is achieved using relatively inexpensive components, and without the need for the expense and maintenance of a separate speaker system to provide the desired sound quality.

The at least one membrane may be manufactured from a material that is able to operate at high temperature. The membrane is likely to come into contact with exhaust gases which may typically have temperatures in excess of 900°C, and so manufacturing the material to be able to operate at high temperatures around this level is particularly advantageous.

The sound transmission device typically comprises an inlet and an outlet, with the inlet configured for communication with the source of exhaust.

Optionally, the outlet may be configured for communication with the exhaust pipe arrangement. Advantageously, returning the transmitted sound waves to the exhaust pipe arrangement provides an improved sound quality that better resembles the sound

created by a naturally aspirated engine. In addition, by channelling the sound through the rest of the exhaust pipe arrangement, the sound may be further tuned by a silencer incorporated into the exhaust pipe arrangement.

The at least one membrane may extend across the device so as to define a first volume between the inlet and the membrane and a second volume between the membrane and the outlet. The first volume may be isolated from the second volume.

Isolating the first and second volumes in this way advantageously improves the flexibility of the placement of the device as there can be no net flow of exhaust gas between the inlet and the outlet, despite sound waves being transmitted across the device. The sound waves can therefore be returned to the exhaust pipe arrangement downstream of the catalytic converter or not returned to the exhaust pipe arrangement at all.

The second volume may be greater than the first volume. Having a greater second volume beneficially improves the potential transmission that can be achieved by the device.

The exhaust pipe arrangement may comprise a turbine for a turbocharger which forms part of the flow path, and the inlet of the sound transmission device may be connected to the exhaust pipe arrangement upstream of the turbine. By connecting the inlet of the device upstream of the turbine, the turbine can be bypassed by the sound waves passing through the device, resulting in better transmission of the engine noise through the system.

The outlet of the sound transmission device may be connected to the exhaust pipe arrangement downstream of the turbine. Connecting the outlet to the exhaust pipe arrangement downstream of the turbine beneficially allows the transfer of the higher quality sound through the system without encountering the turbine which causes an undesirable sound quality.

For example, the exhaust pipe arrangement may comprise an emission control system, which may comprise a catalytic converter, and the outlet of the sound transmission

device may be connected to the exhaust pipe arrangement upstream of the emission control system or downstream of the emission control system.

In another embodiment, the exhaust pipe arrangement may comprise an exhaust gas recirculation pipe, and the outlet of the sound transmission device may be connected to the exhaust pipe arrangement upstream of the exhaust gas recirculation pipe. Alternatively, the outlet of the sound transmission device may connect to the exhaust gas recirculation pipe.

In any of the above embodiments, the point at which the outlet of the sound transmission device is connected to the exhaust pipe arrangement will depend upon the intended resultant sound. The path taken by the sound waves after re-entering the exhaust pipe arrangement will alter the characteristics of the sound.

The sound transmission path may extend to an environment external to the vehicle.

The inlet of the sound transmission device may be connected to the exhaust manifold.

The sound transmission device may comprise a casing that surrounds the at least one membrane and extends from the inlet of the device to the outlet of the device, wherein the cross-sectional area of the casing in the vicinity of the outlet is greater than the cross-sectional area of the casing in the vicinity of the inlet.

The sound transmission path may be angled acutely relative to the flow path. Angling the sound transmission path relative to the flow path can be done to beneficially create a smooth transition between the two paths, improving sound transmission within the system.

The sound transmission device may comprise a plurality of membranes. A plurality of membranes advantageously increases the potential to tune the device to output sound with desired characteristics

The sound transmission device may be configured to attenuate sound that flows along the flow path through destructive interference.

The sound transmission device may comprise a sound symposer.

The sound transmission device may cause an amplification of the transmitted sound.

According to another aspect of the invention, there is provided a vehicle comprising an exhaust system according to the aforementioned aspect of the invention. The vehicle may further comprise an exhaust manifold and an engine.

According to another aspect of the invention, there is provided a sound transmission device for use in the vehicle exhaust system or the vehicle according to aforementioned aspects of the invention, the sound transmission device comprising at least one membrane configured to vibrate so as to mechanically transmit sound waves incident upon it, and a casing surrounding the at least one membrane.

According to another aspect of the invention, there is provided a vehicle comprising an exhaust system in accordance with the aforementioned aspect of the invention.

According to another aspect of the present invention there is provided an exhaust system for a vehicle having an engine; the exhaust system comprising an exhaust pipe arrangement defining a flow path for exhaust gas from a source of exhaust in the engine, and a sound transmission device defining a sound transmission path configured to receive sound waves output from the source of exhaust, wherein the sound transmission path is distinct from the flow path. The sound transmission device may have at least one membrane configured to vibrate so as to mechanically transmit sound waves incident upon it.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to

amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic block diagram of a vehicle incorporating a vehicle exhaust system;

Figure 2 is a schematic representation of a vehicle exhaust system of one embodiment of the invention that may be incorporated into the vehicle Figure 1;

Figure 3 is a schematic representation of a vehicle exhaust system of an alternative embodiment of the invention that may be incorporated into the vehicle Figure 1;

Figure 4 is a schematic representation of a sound transmission device that may be incorporated into the vehicle exhaust system of Figure 2 or Figure 3; and

Figure 5 is a schematic representation of a connection between the vehicle exhaust system and the sound transmission device of Figure 2.

DETAILED DESCRIPTION

Figure 1 is a schematic block diagram of a vehicle 10 powered by an internal combustion engine 12, wherein the vehicle 10 includes a vehicle exhaust system 14 according to an embodiment of the invention.

The vehicle 10 includes a pair of front wheels 16, 18 which are mounted at each end of a front steering axle 20, wherein the front wheels 16, 18 are controlled by a steering wheel (not shown) in a conventional manner. The internal combustion engine 12 is coupled to a transmission 22 which transmits power generated by the engine 12 to a

drive shaft 24. In turn, the drive shaft 24 transmits power to a rear axle 26 via a differential 28. A rear wheel 30, 32 is mounted at each end of the rear axle 26 to propel the vehicle 10.

Waste gas created by the combustion of fuel by the engine 12 is carried away from the engine 12 by a vehicle exhaust system 14 before being expelled into the environment beyond a rear end 34 of the vehicle 10.

The vehicle exhaust system 14, as shown in Figure 2, incorporates an exhaust manifold 36, an exhaust pipe arrangement 38 and a sound transmission device 40. The exhaust manifold 36 is arranged to collect exhaust gas from the engine 12, which is the source of the exhaust in this case, and channel the gas into the exhaust pipe arrangement 38. The engine 12 is connected to an intake manifold 42 that supplies air to the engine 12 from a vehicle intake system (not shown). Neither of the engine 12 or the intake manifold 42 form part of the exhaust system 14 as claimed, and may be manufactured and supplied separately from the exhaust system 14.

The exhaust pipe arrangement 38 includes a turbine 44 that forms part of a turbocharger, the entirety of which is not shown in Figure 2. When forming part of the vehicle exhaust system 14, the exhaust pipe arrangement 38 is in communication with the exhaust manifold 36 such that exhaust gas collected by the manifold 36 is channelled through the turbine 44. The turbine 44 is driven by the exhaust gas channelled through it and drives a compressor (not shown) of the turbocharger in the conventional manner.

The exhaust pipe arrangement 38 further includes an emission control system 46, such as a catalytic converter, to reduce the concentration of potentially harmful gases present in the exhaust gas. Exhaust gas flows from the turbine 44 to the emission control system 46 via an initial pipe portion 48. It is envisaged, however, that the emission control system 46 and turbine 44 may be connected directly in alternative embodiments, with no requirement for the initial pipe portion 48.

Downstream of the emission control system 46, the exhaust pipe arrangement 38 further includes a muffler 50 to reduce the noise output from the exhaust system 14. The muffler 50 is in connection with the emission control system 46 by an intermediate pipe portion

52. A final pipe portion 54 extends from the muffler 50 and beyond the rear 34 of the vehicle 10, a first end 56 of the exhaust pipe arrangement 38, from which exhaust gas is able to exit the exhaust system 14, is defined by the final pipe portion 54. The initial, intermediate and final pipe portions 48, 52, 54 are considered to be components of the exhaust pipe arrangement 38.

The turbine 44, emission control system 46, muffler 50 and connecting pipe portions 48, 52, 54 define a flow path for exhaust gas flow. The exhaust pipe arrangement 38 further incorporates an exhaust gas recirculation (EGR) system 58 for recirculating exhaust flow back to the engine 12. The EGR system 58 includes an EGR valve 60 and an EGR pipe 62, the EGR valve 60 being incorporated within the intermediate pipe portion 52 of the exhaust pipe arrangement 38 between the emission control system 46 and the muffler 50. The EGR pipe 62 is connected to and branches from the intermediate pipe portion 52 at a point 64 that is upstream of the EGR valve 60 i.e. between the emission control system 46 and the EGR valve 60.

When the vehicle exhaust system 14 is incorporated into a vehicle 10, the EGR pipe 62 connects to the intake manifold 42, thereby defining a second end 66 of the exhaust pipe arrangement 38 from which exhaust gas is able to exit the exhaust system 14.

Many other exhaust pipe arrangements are possible without departing from the scope of the invention as claimed.

The EGR valve 60 regulates the amount of exhaust gas flowing from the engine 12 to each end 56, 66 of the exhaust pipe arrangement 38, and therefore to the environment. When the EGR valve 60 is fully open, substantially all of the exhaust gas flows along the exhaust pipe arrangement 38 as it would if the EGR system 58 were not incorporated. In this case, the exhaust gas flows from the exhaust manifold 36 to the first end 56 of the arrangement through the components in the order: exhaust manifold 36; turbine 44; initial pipe portion 48; emission control system 46; intermediate pipe portion 52; muffler 50; final pipe portion 54.

At some point during operation, the EGR valve 60 may be partially closed by a control system (not shown), directing some exhaust gas to flow through the EGR pipe 62,

towards the second end 66 of the exhaust system 14 via the EGR pipe 62, where the exhaust gas returns to the intake manifold 42. In this case, the flow path is defined from the exhaust manifold 36 to the second end 66 of the arrangement 38 through the components in the order: turbine 44; initial pipe portion 48; emission control system 46; intermediate pipe portion 52; EGR pipe 62.

Therefore, at least one flow path for engine exhaust gas is defined at any time when a source of exhaust is present and in communication with the exhaust manifold 36. When the EGR valve 60 is open, a first flow path is defined that follows the path as described above from the exhaust manifold 36 to the final pipe portion 54 i.e. the first end 56. A partially closed EGR valve 60 defines two flow paths: a first flow path from the exhaust manifold 36 to the first end 56 as above; and a second flow path from the exhaust manifold 36 through the EGR pipe 62 to the second end 66.

The sound transmission device 40 of the exhaust system 14 will now be described. The sound transmission device 40 connects via an inlet 68 to the exhaust manifold 36. An outlet 70 of the sound transmission device 40 connects to the EGR pipe 62.

Figure 3 shows an alternative embodiment of the present invention, in which the vehicle exhaust system 114 differs only from the vehicle exhaust system 14 of Figure 2 in that the outlet 70 of the sound transmission device 40 does not connect to the EGR pipe 62, and instead connects to the initial pipe portion 48 of the exhaust pipe arrangement 38.

In both the arrangements of Figures 2 and 3, the sound transmission device 40 connects to the exhaust manifold 36 and the exhaust pipe arrangement 38 so that the inlet 68 and the outlet 70 of the device 40 are upstream and downstream of the turbine 44 respectively. In doing this, the sound transmission device 40 defines a sound transmission path through the device 40 that is distinct from the flow path for exhaust gas. The sound transmission device 40 therefore transmits the sound from the engine 12 without the transfer of exhaust gas. This maintains separate flow and sound transmission paths from the exhaust manifold 36. By doing this, the exhaust gas flows through the emission control system 46 as required and the sound transmission device 40 does not allow the exhaust gas flow to by-pass the emission control system 46.

The sound transmission path allows the sound output from the engine 12 to bypass the turbine 44 of the turbocharger, and to be reintroduced to the exhaust pipe arrangement 38 before being expelled to the environment. By doing this, characteristic sounds and features of the sound produced by the engine 12 are not lost by the action of the turbine 44 of the turbocharger, and a real sound is created that is output from the exhaust system 14 in the same manner that sound from a naturally aspirated engine would be expelled from the vehicle's exhaust system.

Despite distinct flow and sound transmission paths being determined by the exhaust pipe arrangement 38 and the sound transmission device 40 respectively, it is expected that some sound will flow from the engine 12 through the turbine 44 of the turbocharger in the conventional manner.

In addition to the transmission of the engine sounds, the device 40 may be tuned to alter the characteristics of the noise travelling directly through the exhaust pipe arrangement 38. For example, the design of the device 40 may be such that a high pitched 'whining' frequency that is characteristic of turbochargers is counteracted using destructive interference.

Tuning may comprise selecting the relationship between the surface area of the membrane and its material thickness to cause a resonance to mechanically transmit sound waves incident upon it, in use.

The selection of more than one membrane each having a different ratio of surface area to material thickness may result in the transmission of a range of different sounds from the engine. The membrane or combination of membranes may also be selected for the destruction of a range of different sounds from the engine

In alternative configurations to those shown in Figures 2 and 3, the inlet 68 of the sound transmission device 40 may connect to any other pipe portion of the exhaust pipe arrangement 38, provided that said pipe portion is incorporated into the exhaust pipe arrangement 38 upstream of the turbine 44 of the turbocharger.

The sound transmission device 40 may return the transmitted sound waves to the exhaust pipe arrangement 38 at many differing points. For example, in some embodiments, the sound transmission device 40 and the exhaust pipe arrangement 38 reconnect at the intermediate pipe portion 52 rather than the initial pipe portion 48. In another embodiment, the sound transmission device 40 may reconnect directly to the muffler 50. The advantage of reintroducing the transmitted sound output to the exhaust pipe is that the sound output could be tuned further within a muffler in the conventional manner.

It is also possible that the sound transmission device 40 does not reconnect to the exhaust pipe arrangement 38, meaning that the sound transmission path does not reintroduce the transmitted sound output to the exhaust pipe arrangement 38. Instead, an outlet pipe connected to the device 40 may extend beyond the rear 34 of the vehicle 10 so that the outlet pipe reintroduces the sound waves to the environment. Alternatively, the outlet pipe connected to the device 40 directs the transmitted sound output to the environment in a chosen direction.

Referring to Figure 4, the device 40 is formed of a casing 80 which defines the inlet 68 and the outlet 70 of the device 40, and a membrane 82. A wall 84 of the casing 80 diverges between an inlet end 86 and an outlet end 88, such that the cross sectional area of the casing 80 increases, in a tapered manner, between the inlet end 86 and the outlet end 88. The divergence of the wall 84 of the casing 80 in the manner described improves the sound transmission properties of the device 40.

The membrane 82 is incorporated within the casing 80, and extends across the full width of the casing 80 to divide the volume within the casing 80 into a first volume 94 and a second volume 96. The first volume 94 is defined between the inlet end 86 of the casing 80 and a first surface 98 of the membrane 82, while the second volume 96 is defined between the outlet end 88 of the casing 80 and a second surface 100 of the membrane 82. As the membrane 82 extends across the entire cross section of the casing 80, the first and second volumes 94, 96 are isolated from one another so that no exhaust gas flow is able to flow across the membrane 80 from the first 94 to the second volume 96, or vice versa.

The casing 80 is manufactured from a material similar to that of the pipes 48, 52, 54 used to convey gas between the components of the exhaust system 14. The material from which the casing 80 is manufactured has a high stiffness and is reflective internally so that only the membrane 82 radiates the sound, and no sound energy is lost by radiation through or absorption by the casing 80.

The membrane 82 is manufactured to be thin, durable and semi-rigid. The membrane 82 is manufactured from a material chosen for having a high strength to weight ratio and an ability to withstand the high temperatures present in the exhaust gas, which may typically exceed 900°C. In some embodiments, the membrane 82 may be corrugated.

The sound transmission device 40, having a membrane 82 and casing 80 of this kind, may be considered to be a sound symposer.

The sound transmission device 40 transmits sound travelling along the sound transmission path by the action of the membrane 82, without allowing exhaust gas to flow through the device 40 between the inlet 68 and the outlet 70. When a source of exhaust is in communication with the exhaust system 14, exhaust gas is channelled from the exhaust manifold 36 to both the inlet 68 of the device 40 and the exhaust pipe arrangement 38. The exhaust gas channelled to the device 40 is received within the first volume 94. A pressure differential is caused within the device 40 between the first and second volumes 94, 96, and any change in the pressure in the first volume 94 due to sound waves formed by the combustion cycle of the engine 12 is therefore transmitted by vibration of the membrane 82. Each vibration of the membrane 82 due to a sound wave incident upon it generates an equivalent sound wave within the second volume 96, and from the second volume 96 the equivalent sound waves are directed back to the appropriate part of the exhaust pipe arrangement 38, as in Figures 2 and 3. Finally, the sound wave is output from the exhaust system 14 at the first end 56 of the exhaust pipe arrangement 38.

The nature of the connection between the sound transmission device 40 and the exhaust pipe arrangement 38 is configured to ensure the sound waves propagate through the exhaust system 14 correctly. Figure 5 illustrates the connection between the sound transmission device 40 and the exhaust pipe arrangement 38 in one embodiment. In the

configuration shown, the sound transmission device 40 is connected to the EGR pipe 62 via the connecting pipe 92 such that the sound transmission path S is inclined in an acute sense relative to the exhaust flow path E. By inclining the paths relative to one another in this manner, the sound waves are directed in the intended direction of travel through the exhaust pipe arrangement 38. Furthermore, inclining the paths in this way retains as much of the energy of the transmitted sound waves as possible, reducing the attenuation of the sound waves by unnecessary reflection as much as possible.

In alternative embodiments of the invention, a plurality of membranes is incorporated into the sound transmission device. In some of these embodiments, each membrane of the plurality of membranes is tuned to attenuate a particular frequency or frequency band. In other embodiments the membranes may have broadband attenuation.

It will be appreciated that while the above description relates to an exhaust system 14 specifically for use in a vehicle 10, the exhaust system 14 may be used in conjunction with any source of exhaust for the purpose of enhancing the quality of the sound of the source of exhaust.

Many modifications may be made to the above examples without departing from the scope of the present invention as defined in the accompanying claims.

CLAIMS

1. An exhaust system for a vehicle having an engine; the exhaust system comprising:

an exhaust pipe arrangement defining a flow path for exhaust gas from a source of exhaust in the engine, wherein the exhaust pipe arrangement comprises a turbine for a turbocharger which forms part of the flow path; and

a sound transmission device defining a sound transmission path configured to receive sound waves output from the source of exhaust, having at least one membrane configured to vibrate so as to mechanically transmit sound waves incident upon it, wherein the sound transmission device comprises an inlet and an outlet, wherein the inlet is configured for communication with the source of exhaust;

wherein the sound transmission path is distinct from the flow path.

2. The exhaust system of Claim 1, wherein the at least one membrane is manufactured from a material that is operable at a temperature in excess of the temperature of exhaust gas.

3. The exhaust system of Claim 1 or Claim 2, wherein the outlet is configured for communication with the exhaust pipe arrangement.

4. The exhaust system according to any preceding claim, wherein the at least one membrane extends across the device so as to define a first volume between the inlet and the membrane and a second volume between the membrane and the outlet, wherein the first volume is isolated from the second volume so as to prevent the flow of exhaust gas through the apparatus.

5. The exhaust system of Claim 4, wherein the second volume is greater than the first volume.

6. The exhaust system of any preceding claim, wherein the inlet of the sound transmission device is connected to the exhaust pipe arrangement upstream of the turbine.

7. The exhaust system of Claim 6, wherein the outlet of the sound transmission device is connected to the exhaust pipe arrangement downstream of the turbine.

8. The exhaust system of any preceding claim, wherein the exhaust pipe arrangement comprises an emission control system, and wherein the outlet of the sound transmission device is connected to the exhaust pipe arrangement upstream of the emission control system.

9. The exhaust system of any preceding claim, wherein the exhaust pipe arrangement comprises an emission control system, and wherein the outlet of the sound transmission device is connected to the exhaust pipe arrangement downstream of the emission control system.

10. The exhaust system of claims 8 or 9, wherein the emission control system comprises a catalytic converter.

11. The exhaust system of any preceding claim, wherein the exhaust pipe arrangement comprises an exhaust gas recirculation pipe, and wherein the outlet of the sound transmission device is connected to the exhaust pipe arrangement upstream of the exhaust gas recirculation pipe.

12. The exhaust system of any preceding claim, wherein the exhaust pipe arrangement comprises an exhaust gas recirculation pipe and wherein the outlet of the sound transmission device is connected to the exhaust gas recirculation pipe.

13. The exhaust system of any one of claims 1 to 6, wherein the sound transmission path extends to an environment external to the vehicle.

14. The exhaust system of any preceding claim, wherein the inlet of the sound transmission device is connected to the exhaust manifold.

15. The exhaust system of any preceding claim, wherein the sound transmission device comprises a casing that surrounds the at least one membrane and extends from the inlet of the device to the outlet of the device, wherein the cross-sectional area of the casing in the vicinity of the outlet is greater than the cross-sectional area of the casing in the vicinity of the inlet.

16. The exhaust system of any preceding claim, wherein the sound transmission path is angled acutely relative to the flow path.

17. The exhaust system of any preceding claim, wherein the sound transmission device comprises a plurality of membranes.

18. The exhaust system of any preceding claim, wherein the sound transmission device is configured to attenuate sound that flows along the flow path through destructive interference.

19. The exhaust system of any preceding claim, wherein the sound transmission device comprises a sound symposer.

20. A vehicle comprising an exhaust system as claimed in any one of Claims 1 to 19.

21. The vehicle of Claim 20 further comprising an exhaust manifold and an engine.

22. A sound transmission device for use in the vehicle exhaust system of any of Claims 1 to 19, or the vehicle of Claims 20 to 21, the sound transmission device comprising:

at least one membrane configured to vibrate so as to mechanically transmit sound waves incident upon it; and

a casing surrounding the at least one membrane.

23. An exhaust system substantially as herein described with reference to the accompanying drawings.

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24. A vehicle substantially as herein described with reference to the accompanying drawings.

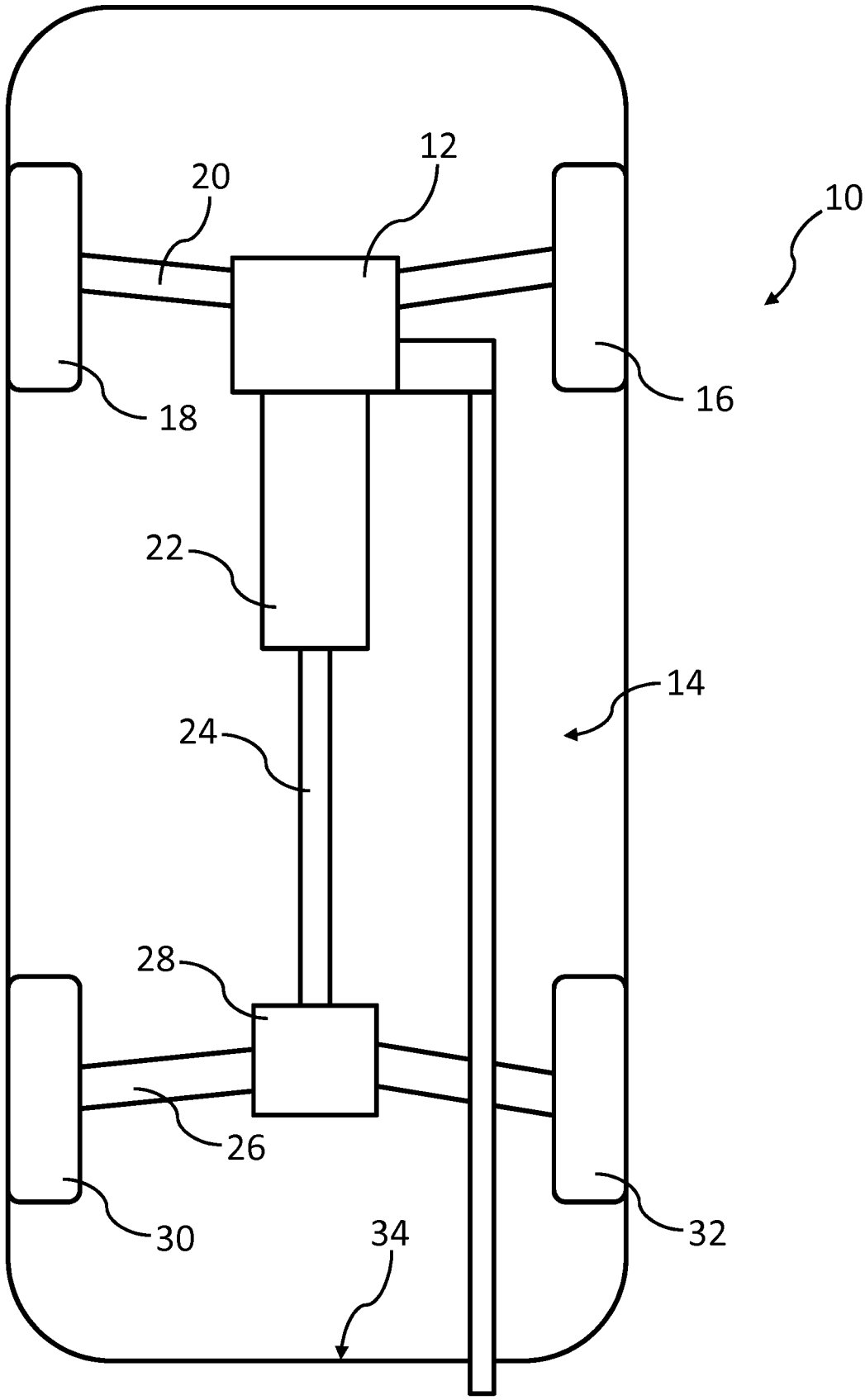

Fig. 1

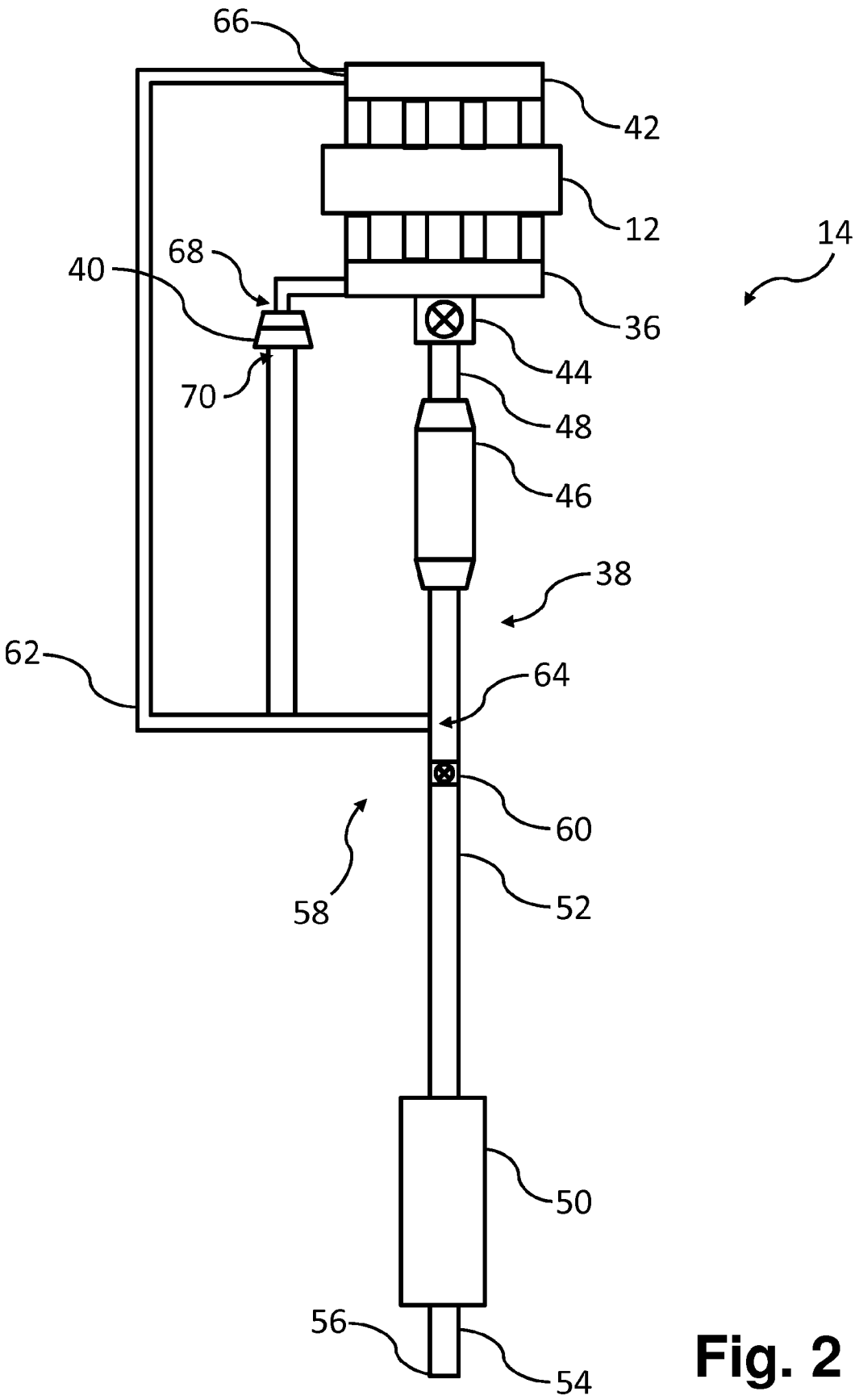

Fig. 2

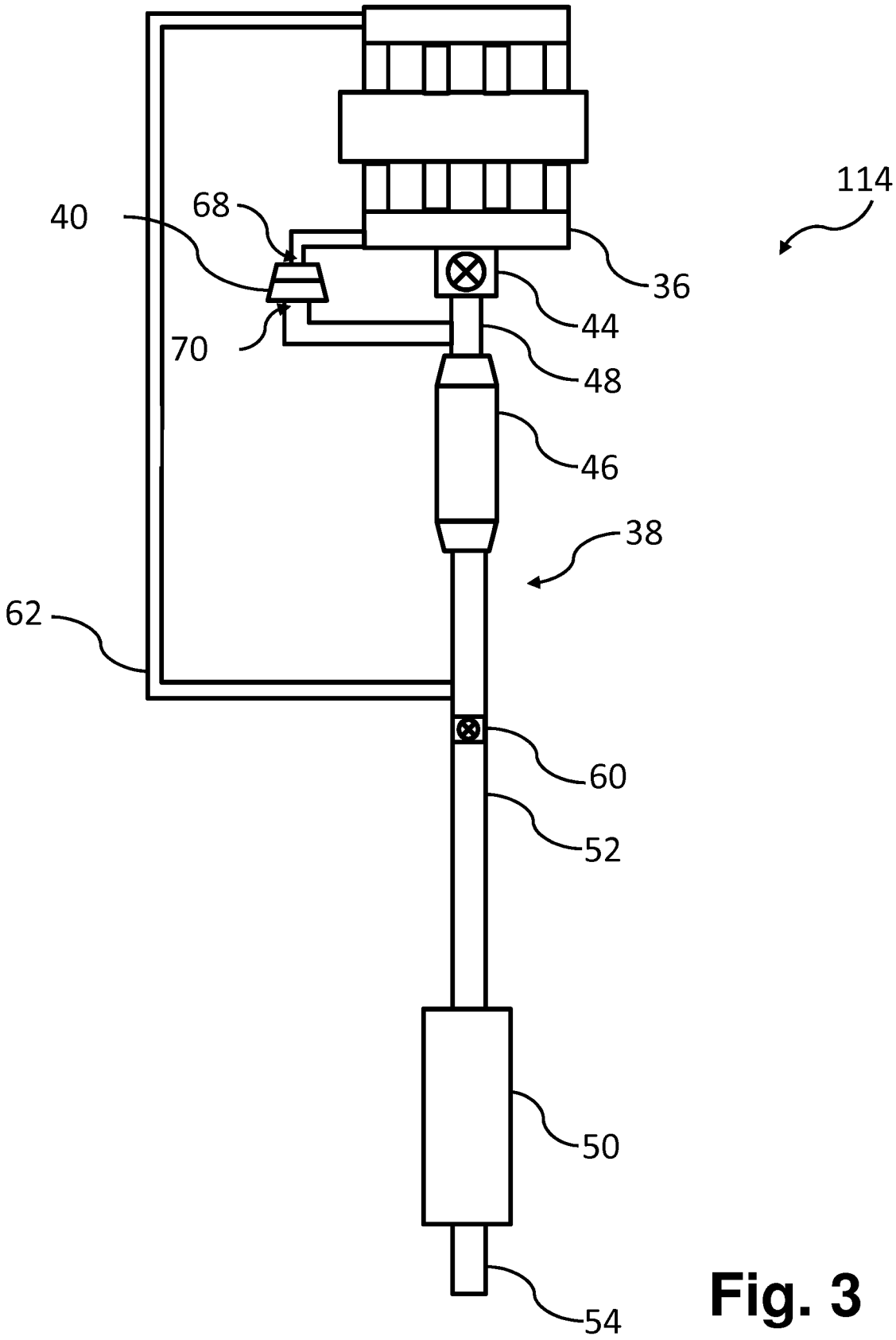

Fig. 3

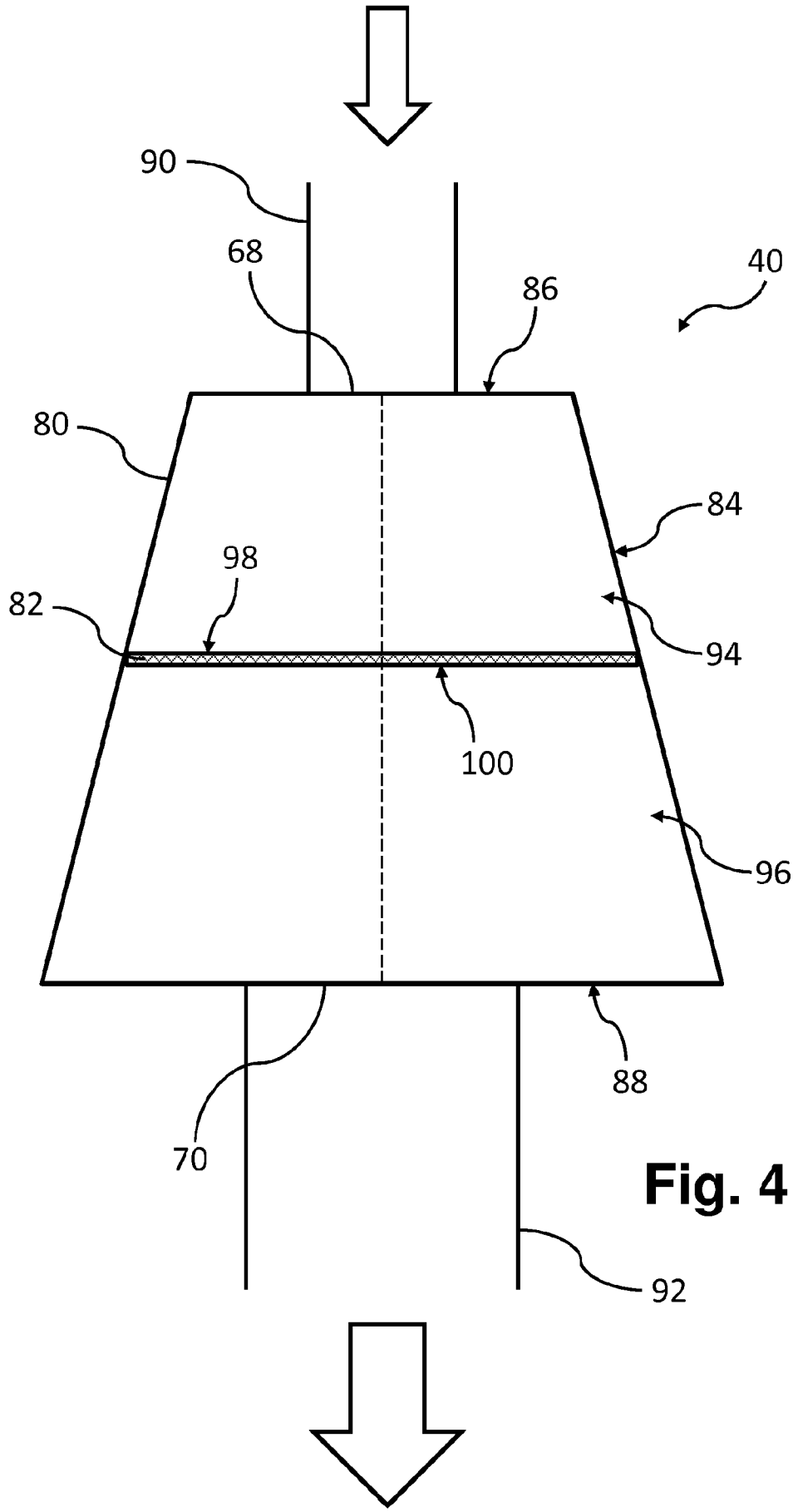

Fig. 4

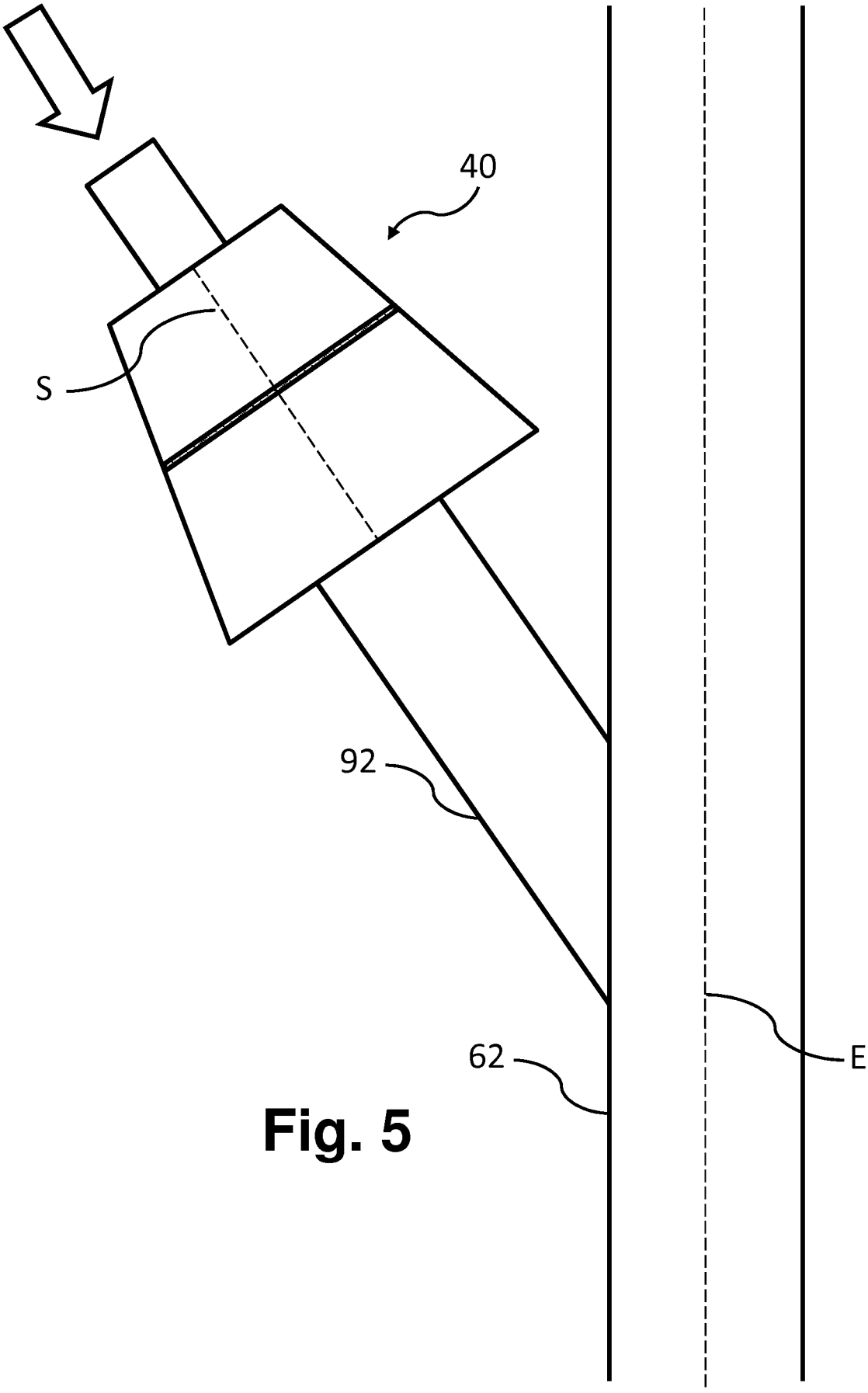

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/077947

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N1/06 G10K11/18
ADD.

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)
F01N G10K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 2008 150968 A (TOYOTA MOTOR CORP) 3 July 2008 (2008-07-03) abstract; figures 1,2	1,2,4, 14,18-22 5,6,10, 11,15,17

X Y A	DE 10 2010 053075 A1 (DAIMLER AG [DE]) 6 June 2012 (2012-06-06) paragraphs [0022] - [0027]; figure 1	1-4,6,7, 9,10,13, 18-22 16,17 5,8,11, 12,14,15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 January 2018	19/01/2018

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/077947

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	paragraphs [0020], [0021], [0025], [0026]; figure 1	1,2,4, 10,13, 19-21
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Y	column 5, line 31 - column 6, line 5; figure 1 column 8, lines 6-25; figure 4	17

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