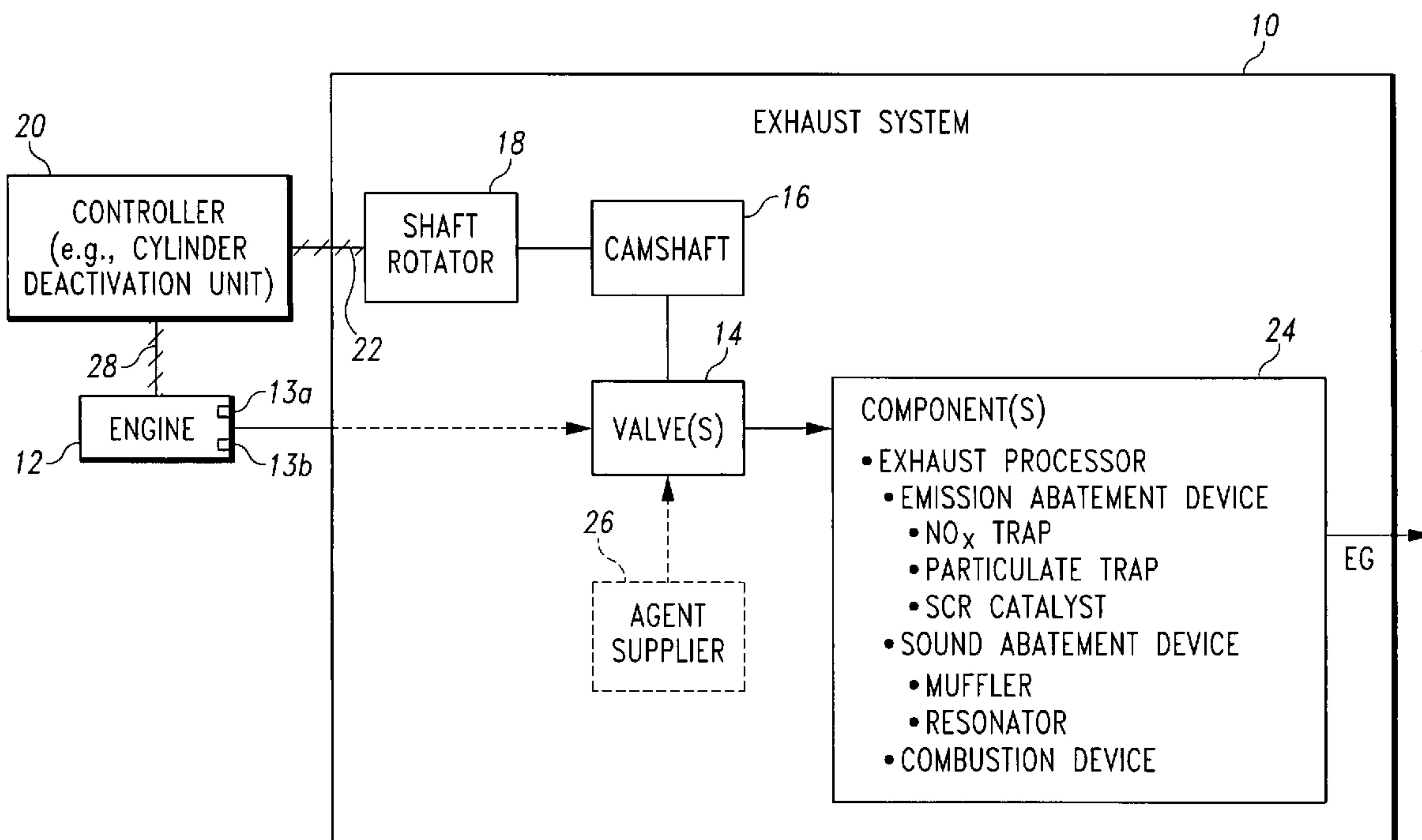


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(19) **United States**(12) **Patent Application Publication**
Coker et al.(10) **Pub. No.: US 2007/0163243 A1**(43) **Pub. Date: Jul. 19, 2007**(54) **EXHAUST SYSTEM WITH CAM-OPERATED
VALVE ASSEMBLY AND ASSOCIATED
METHOD****Publication Classification**(51) **Int. Cl.****F01L 9/04** (2006.01)**F01L 1/34** (2006.01)**F01N 3/00** (2006.01)(52) **U.S. Cl.** **60/286**; 60/295; 123/90.11;
123/90.16(75) Inventors: **Adam Coker**, Indianapolis, IN (US);
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INDIANAPOLIS, IN 46204 (US)(73) Assignee: **Arvin Technologies, Inc.**(21) Appl. No.: **11/332,919**(22) Filed: **Jan. 17, 2006**(57) **ABSTRACT**

An exhaust system for use with an engine comprises at least one valve and a camshaft. The at least one valve is configured to control flow in the exhaust system but is discrete from each intake valve of the engine and each exhaust valve of the engine. The camshaft is configured to operate the at least one valve. An associated method is disclosed.



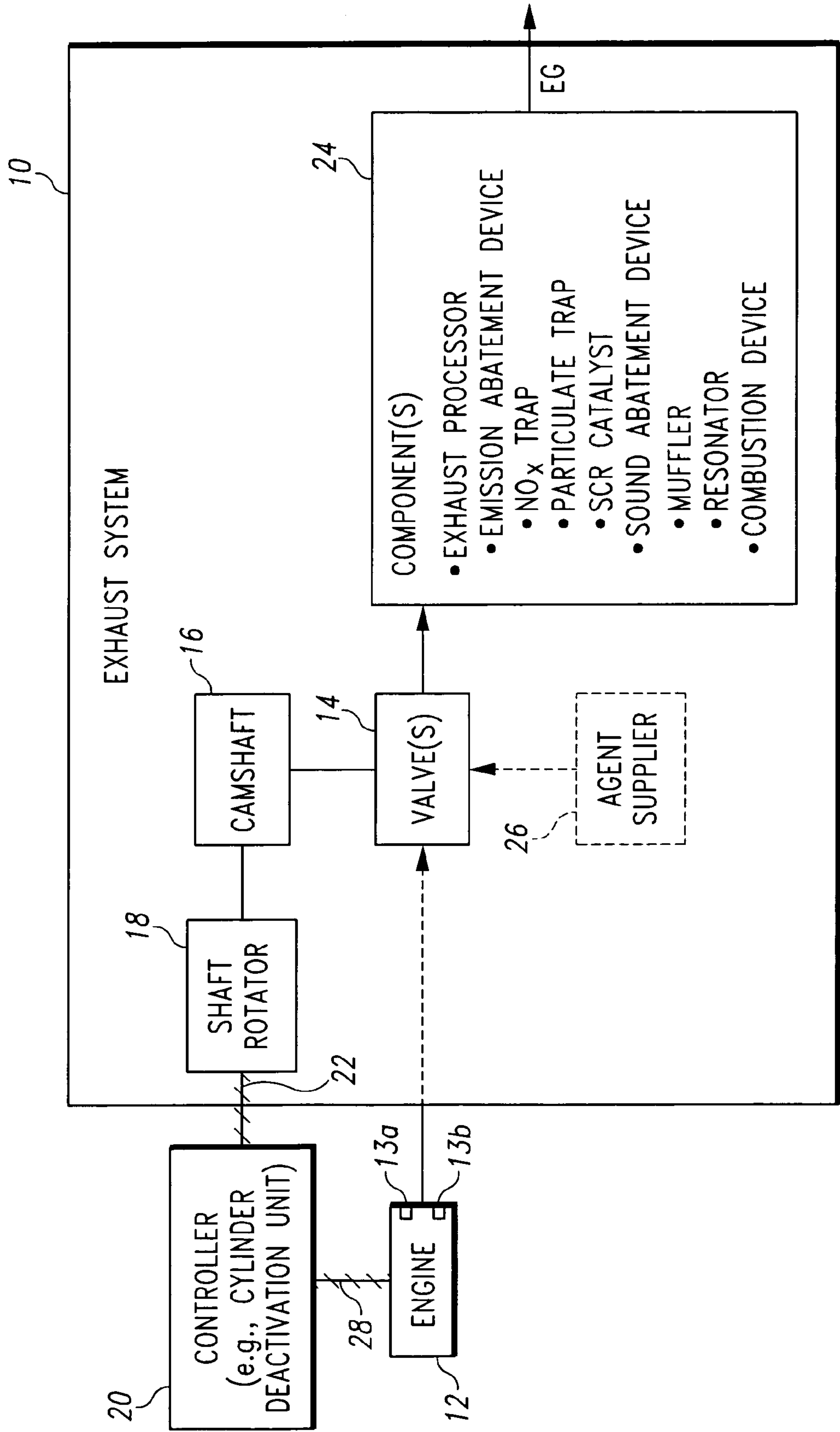


Fig. 1

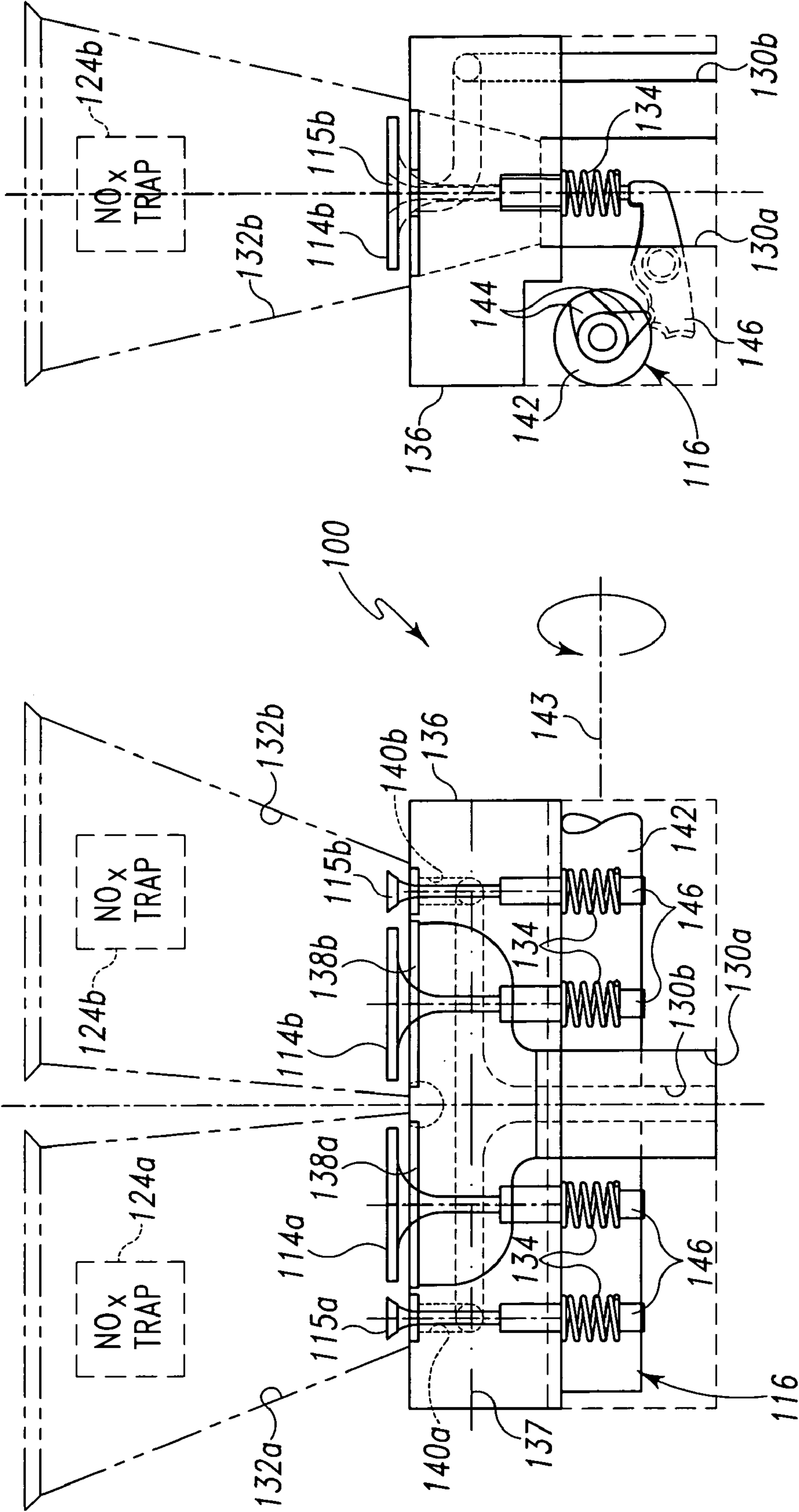


Fig. 2

Fig. 3

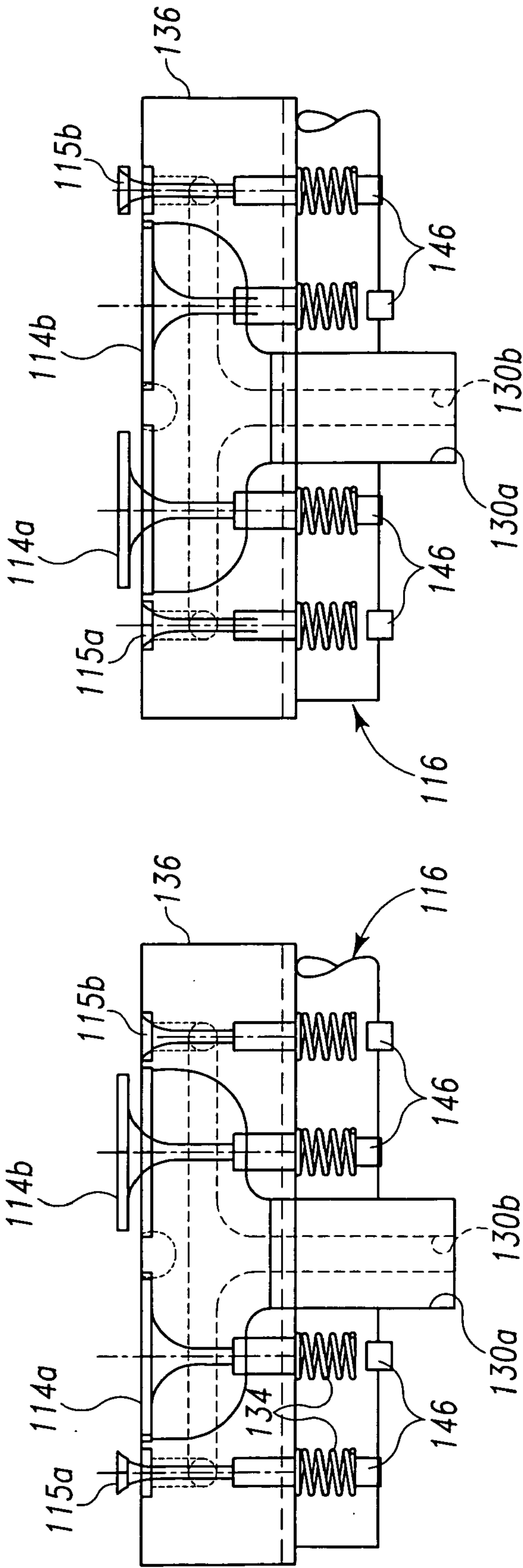


Fig. 4

Fig. 5

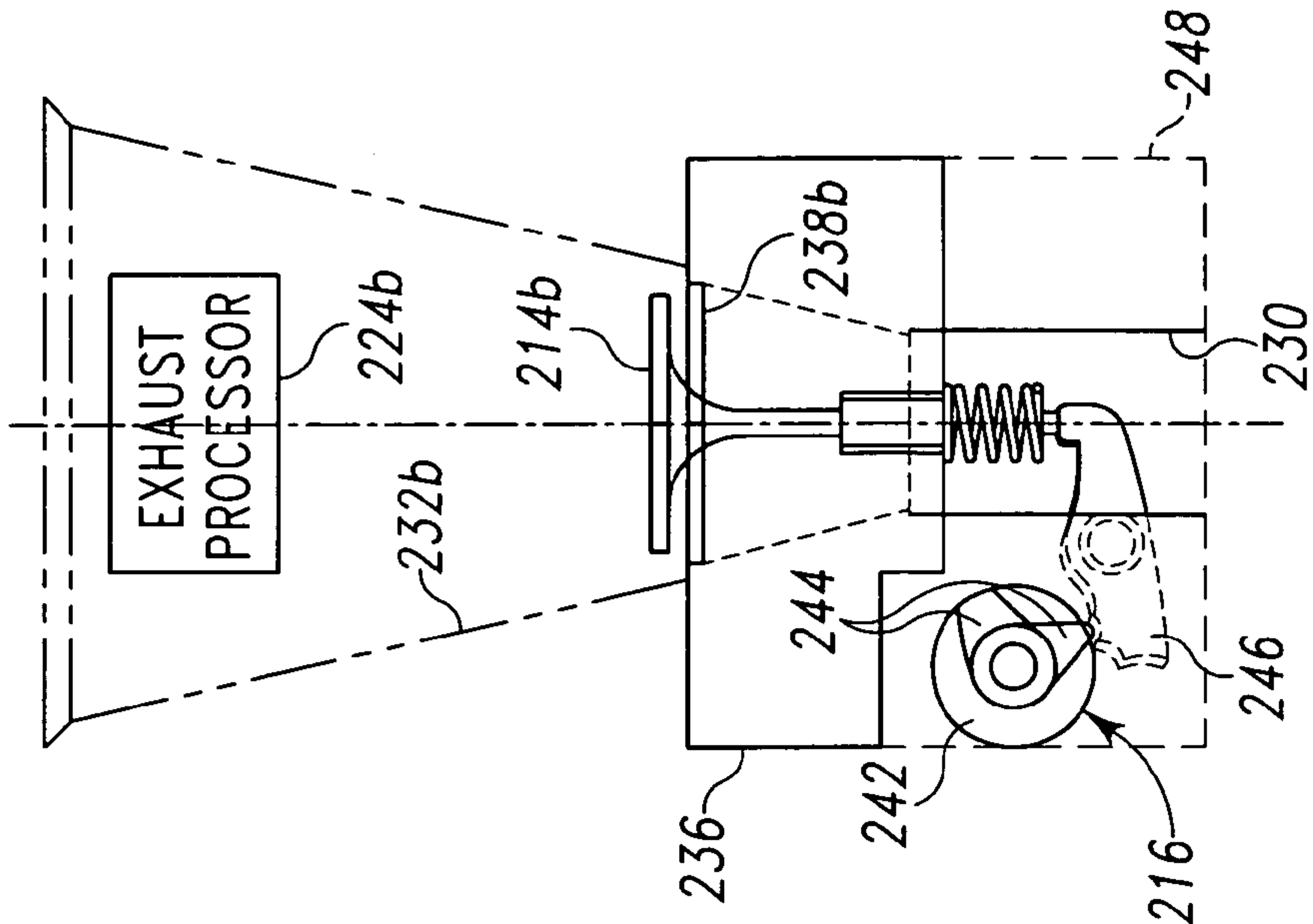


Fig. 6

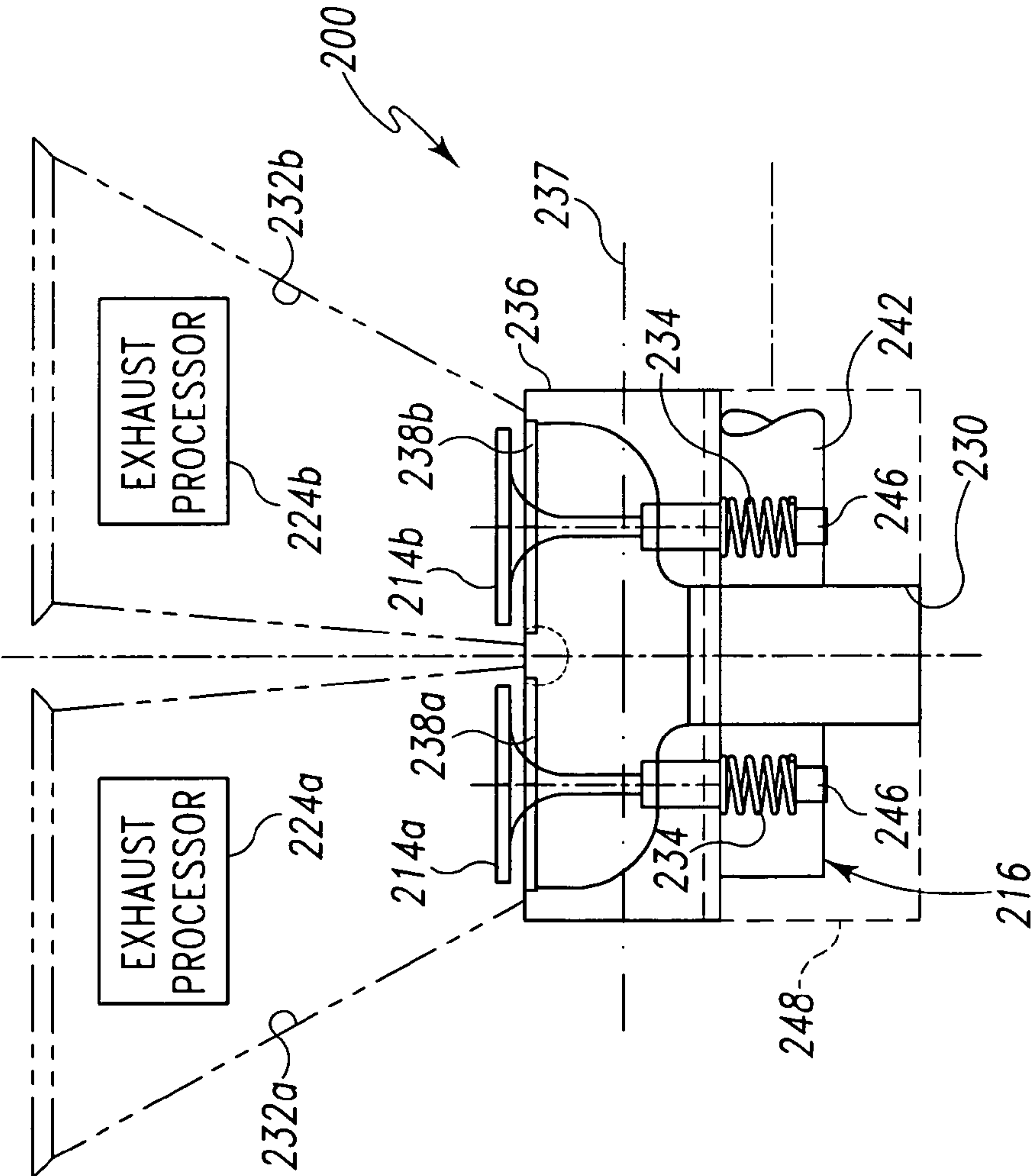


Fig. 7

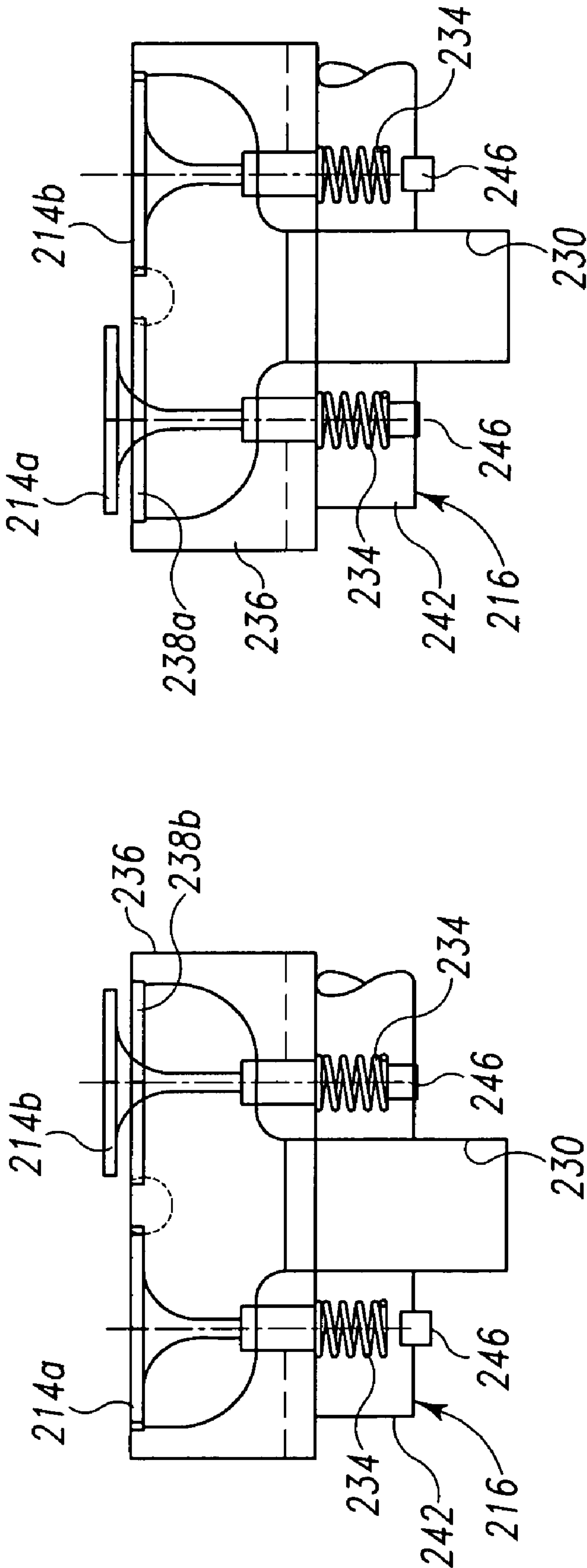


Fig. 8

Fig. 9

EXHAUST SYSTEM WITH CAM-OPERATED VALVE ASSEMBLY AND ASSOCIATED METHOD

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to methods and apparatus for controlling flow in exhaust systems.

BACKGROUND OF THE DISCLOSURE

[0002] Exhaust systems are used with engines to manage exhaust gas discharged therefrom. Exhaust systems may include a number of valves to control flow in the exhaust system.

SUMMARY OF THE DISCLOSURE

[0003] According to an aspect of the present disclosure, there is provided an exhaust system for use with an engine. The exhaust system comprises at least one valve adapted to be located downstream from the engine to control flow in the exhaust system. The at least one valve is discrete from each intake valve of the engine and each exhaust valve of the engine. A camshaft is configured to operate the at least one valve. The at least one valve may comprise a plurality of valves operated by the camshaft. An associated method is disclosed.

[0004] The at least one valve and the camshaft are parts of a valve assembly which may be used for a variety of purposes. For example, the valve assembly may be used to control the flow of exhaust gas, a regenerative agent, air, or other fluid of the exhaust system. Further, the valve assembly may be used with a variety of exhaust processors including, but not limited to, sound abatement devices and/or emission abatement devices embodied, for example, as any one or more of an SCR catalyst (i.e., a selective catalytic reduction catalyst) and/or an emissions traps in the form of, for example, a NOx (i.e., nitrogen oxides) trap or a particulate trap.

[0005] The above and other features of the present disclosure will become apparent from the following description and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a diagrammatic view of an exhaust system with at least one valve to be operated by a camshaft;

[0007] FIG. 2 is a plan view of a valve assembly for use in the exhaust system of FIG. 1;

[0008] FIG. 3 is a side elevation view of the valve assembly of FIG. 2;

[0009] FIGS. 4 and 5 are plan views showing different operational configurations of the valve assembly of FIG. 2;

[0010] FIG. 6 is a plan view of another valve assembly for use in the exhaust system of FIG. 1;

[0011] FIG. 7 is a side elevation view of the valve assembly of FIG. 6; and

[0012] FIGS. 8 and 9 are plan views showing different operational configurations of the valve assembly of FIG. 6.

DETAILED DESCRIPTION OF THE DRAWINGS

[0013] While the concepts of the present disclosure are susceptible to various modifications and alternative forms,

specific exemplary embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the disclosure to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives following within the spirit and scope of the invention as defined by the appended claims.

[0014] Referring to FIG. 1, there is shown an exhaust system 10 for use with an internal combustion engine 12. The exhaust system 10 has at least one valve 14 (e.g., poppet valve) configured to control flow in the exhaust system 10. The at least one valve 14 is discrete from each intake valve 13a of the engine 12 and each exhaust valve 13b of the engine 12. A camshaft 16 is configured to operate the at least one valve 14. A shaft rotator 18 secured to the camshaft 16 and under the control of a controller 20 via an electrical line 22 or wireless communication may be used to rotate the camshaft 16 continuously, discretely, or as needed to open and close or otherwise adjust the at least one valve 14 to control flow in the system 10.

[0015] The at least one valve 14 operated by the camshaft 16 may be used to control flow to at least one component 24. The at least one component 24 may take the form of a variety of exhaust system components, a few of which are listed in FIG. 1. For example, the cam-operated valve(s) 14 may be used to control flow to one or more exhaust processors and/or a burner. The category of exhaust processors includes, but is not limited to, emission abatement devices (e.g., SCR catalysts and/or emissions traps such as NOx traps and/or particulate traps) and sound abatement devices (e.g., mufflers, and/or resonators). A combustion device may be embodied as any type of combustion device including, but not limited to, a burner and/or a fuel reformer in the form of, for example, a plasma fuel reformer and/or a catalyst.

[0016] The cam-operated valve(s) 14 may be used to control flow to any one or more of such components arranged in any combination. For example, there may be two valves 14 operated by the camshaft 16 to control exhaust gas from the engine 12 to any two of the emission abatement devices, sound abatement devices, and/or combustion devices. In the case where there are two emissions traps (e.g., both NOx traps, both particulate traps, or one of each), the two valves 14 may be used to control flow of exhaust gas between the two emissions traps. Further, there may be two more valves 14 operated by the camshaft 16 to control flow of an agent such as a regenerative agent (e.g., hydrocarbons, H₂, CO) from an agent supplier 26 to the emissions traps such that, while one emissions trap is "on line" to trap emissions present in exhaust gas, the other emissions trap may be "off line" receiving the regenerative agent to remove emissions trapped thereby. In the case where there is an SCR catalyst, a valve 14 operated by the camshaft 16 may be used to control flow of urea or other NOx reductant from the agent supplier 26.

[0017] In another example, there may be two valves 14 and two sound abatement devices, one valve 14 for each sound abatement device to control exhaust gas flow thereto in a cylinder deactivation scheme. In such a case, the controller 20 may be embodied as a cylinder deactivation unit coupled electrically to the engine 12 via an electrical line 28 to control the number of operational cylinders of the

engine 12. The controller 20, acting through the shaft rotator 18 and the camshaft 16, may cause the first valve 14 to open and the second valve 14 to close to direct exhaust gas to the first sound abatement device when a non-zero first number of cylinders is operation and may cause the first valve 14 to close and the second valve 14 to open to direct exhaust gas to the second sound abatement device when a non-zero second number of cylinders is operational.

[0018] In the case where there is a combustion device, there may be a valve 14 to control flow of exhaust gas from the engine 12 to the combustion device, a valve 14 to control flow of fuel from the supplier 26 to the combustion device, and/or a valve 14 to control flow of air from the supplier 26 to the combustion device. The camshaft 16 may be used to control each of the valves 14.

[0019] According to another example, a valve 14 operated by the camshaft 16 may be used to control recirculation of exhaust gas back to the engine 14.

[0020] In another example, a valve 14 operated by the camshaft 16 may be used to warm the engine 14. In particular, the camshaft 16 may close or only partially close the valve 14 to restrict exhaust gas flow so as to apply backpressure to the engine 14 and thereby increase its operating temperature during, for example, engine start-up and/or before "light-off" of a catalyst in the exhaust system. Moreover, engine heat generated by such application of backpressure to the engine 14 may be used to warm an emission abatement device such as, for example, an SCR catalyst, a NOx trap, and/or a catalyzed particulate trap to its "light-off," activation temperature to enable operation of such device(s) throughout all engine operating conditions without the use of a supplemental heat source.

[0021] The shaft rotator 18 may be configured in a variety of ways. For example, the shaft rotator 18 may include a solenoid valve, an air valve, and/or a motor (e.g., an electric motor) to effect rotation of the camshaft 16. In the case of a motor, the motor may operate through a gear box and/or other connectors (e.g., belt and pulley) to rotate the camshaft 16.

[0022] Referring to FIGS. 2 and 3, there is shown a valve assembly 100 for use in the exhaust system 10. The valve assembly 100 is configured to control flow of exhaust gas from the engine 12 to first and second emissions traps configured, for example, as NOx traps 124a, 124b and to control flow of a regenerative agent in the form of, for example, a NOx reductant from the agent supplier 26 to the NOx traps 124a, 124b.

[0023] The illustrative valve assembly 100 has first and second exhaust valves 114a, 114b and first and second reductant valves 115a, 115b. Illustratively, each valve 114a, 114b, 115a, 115b is configured as a poppet valve.

[0024] The first and second exhaust valves 114a, 114b are configured to control flow of exhaust gas from the engine 12 to the traps 124a, 124b, respectively. More particularly, the exhaust valves 114a, 114 are configured to control flow of exhaust gas from a first upstream passageway 130a to first and second downstream passageways 132a, 132b containing the traps 124a, 124b, respectively.

[0025] The first and second reductant valves 115a, 115b are configured to control flow of the NOx reductant from the

supplier 26 to the traps 124a, 124b to remove NOx trapped thereby to regenerate the traps 124a, 124b for further use thereof. More particularly, the reductant valves 115a, 115b are configured to control flow of NOx reductant from a second upstream passageway 130b to the first and second downstream passageways 132a, 132b containing the traps 124a, 124b, respectively.

[0026] Each of the valves 114a, 114b, 115a, 115b is biased by a spring 134 to a closed position against a block 136. The block 136 defines exhaust valve ports 138a, 138b and reductant valve ports 140a, 140b through which the valves 114a, 114b, 115a, 115b extend, respectively. It is within the scope of this disclosure for one or more of the valves 114a, 114b, 115a, 115b to be biased to an open position.

[0027] A camshaft 116 is configured to operate the valves 114a, 114b, 115a, 115b in response to operation of the shaft rotator 18. The camshaft 116 has a shaft 142 rotatable about an axis 143 and a plurality (e.g., four) of lobes or cams 144 secured thereto and extending radially outwardly therefrom. Each cam 144 is configured to pivot a rocker arm 146 associated with a respective valve 114a, 114b, 115a, 115b to open and close that valve 114a, 114b, 115a, 115b.

[0028] A cover 148 may be used to cover one side of the valve assembly 100 to prevent dirt and debris from entering the valve assembly 100. In such a case, the cover 148 may be secured to the block 136 to cover the camshaft 116, the rocker arms 146, the springs 134, and a portion of the valves 114a, 114b, 115a, 115b on the same side of the block 136 as the camshaft 116, the rocker arms 146, and the springs 134.

[0029] Positioning the camshaft 116, the rocker arms 146, the spring 134, and the portion of the valves 114a, 114b, 115a, 115b on the same side of the block 136 facilitates the serviceability of the valve assembly 100. Further, the valves 114a, 114b, 115a, 115b are positioned in a common plane 137 to facilitate manufacture of the valve assembly 100.

[0030] In operation, the valves 114a, 114b, 115a, 115b are used to control flow of exhaust gas and reductant to the traps 124a, 124b to alternate the traps 124a, 124b between on-line and off-line states. In the on-line state, the subject trap 124a, 124b receives exhaust gas from the engine 12 to remove and trap NOx present in the exhaust gas while being cut off from the agent supplier 26. In the off-line state, the subject trap 124a, 124b receives reductant from the agent supplier 26 for reduction of the trapped NOx while being cut off from the engine 12.

[0031] The camshaft 116 is operated to alternate the traps 124a, 124b between the on-line and off-line states. In particular, rotation of the camshaft 116 alternately opens and closes the exhaust valves 114a, 114b so as to alternate advancement of exhaust to the traps 124a, 124b and alternately opens and closes the valves 115a, 115b so as to alternate advancement of the reductant to the traps 124a, 124b. As such, to establish the trap 124a in the on-line state and the trap 124b in the off-line state, the camshaft 116 opens the exhaust valve 114a and the reductant valve 115b and closes the exhaust valve 114b and the reductant valve 115a, as shown in FIG. 4. To establish the trap 124b in the on-line state and the trap 124a in the off-line state, the camshaft 116 opens the exhaust valve 114b and the reductant valve 115a and closes the exhaust valve 114a and the reductant valve 115b, as shown in FIG. 5.

[0032] Referring to FIGS. 6 and 7, there is shown a valve assembly 200 for use in the exhaust system 10. The valve assembly 200 is provided for use with a cylinder deactivation unit 20 to control flow of exhaust gas from the engine 12 to first and second exhaust processors 224a, 224b in response to a change in the number of operational engine cylinders from a non-zero first number (e.g., four cylinders) to a non-zero second number (e.g., eight cylinders) by the unit 20. Each of the exhaust processors 224a, 224b may include a sound abatement device, a catalytic converter, and/or other exhaust processor.

[0033] The illustrative valve assembly 200 has first and second exhaust valves 214a, 214b. Illustratively, each valve 214a, 214b is configured as a poppet valve.

[0034] The first and second exhaust valves 214a, 214b are configured to control flow of exhaust gas from the engine 12 to the processors 224a, 224b, respectively. More particularly, the exhaust valve 214a is configured to control flow of exhaust gas from an upstream passageway 230 to a first downstream passageway 232a containing the exhaust processor 224a. The exhaust valve 214b is configured to control flow of exhaust gas from the upstream passageway 230 in communication with the engine 12 to a second downstream passageway 232b containing the exhaust processor 224b.

[0035] Each of the valves 214a, 214b is biased by a spring 234 to a closed position against a block 236. The block 236 defines exhaust valve ports 238a, 238b through which the valves 214a, 214b extend, respectively.

[0036] A camshaft 216 is configured to operate the valves 214a, 214b in response to operation of the shaft rotator 18. The camshaft 216 has a shaft 242 rotatable about an axis 243 and a plurality (e.g., two) of lobes or cams 244 secured thereto and extending radially outwardly therefrom. Each cam 244 is configured to pivot a rocker arm 246 associated with a respective valve 214a, 214b to open and close that valve 214a, 214b.

[0037] A cover 248 may be used to cover one side of the valve assembly 200 to prevent dirt and debris from entering the valve assembly 200. In such a case, the cover 248 may be secured to the block 236 to cover the camshaft 216, the rocker arms 246, the springs 234, and a portion of the valves 214a, 214b on the same side of the block 236 as the camshaft 216, the rocker arms 246, and the springs 234.

[0038] Positioning the camshaft 216, the rocker arms 246, the spring 234, and the portion of the valves 214a, 214b on the same side of the block facilitates the serviceability of the valve assembly 200. The valves 214a, 214b are positioned in a common plane 237 to facilitate manufacture of the valve assembly 200.

[0039] In operation, the valves 214a, 214b are used to control flow of exhaust gas to the processors 224a, 224b. For example, in some engine modes (four-cylinder mode), the valve 214a may be opened while the valve 214b is closed in order to direct exhaust gas only to the exhaust processor 224a, as shown in FIG. 8. In other engine modes (e.g., eight-cylinder mode), the valve 214b may be opened while the valve 214a is closed in order to direct exhaust gas only to the exhaust processor 224b, as shown in FIG. 9. In still other engine modes, it may be desirable for the exhaust gas to be directed to both processors 224a, 224b. In such a case, both valves 214a, 214b may be opened, as shown in FIG. 6.

The valves 214a, 214b may be only partially closed from time to time (such as at engine start-up) so as to restrict the flow of exhaust gas and thereby increase the engine back-pressure in order to elevate the exhaust gas temperature to facilitate light-off of a catalytic converter which may be included in either processor 224a, 224b. Rotation of the camshaft 216 opens and closes the exhaust valves 214a, 214b so as to advance exhaust to the processors 224a, 224b as desired.

[0040] It is to be understood that the connection between the camshaft 16, 116, 216 and the valves 14, 114a, 114b, 115a, 115b, 214a, 214b may be configured in a variety of ways. Use of rocker arms and/or rods extending between the cams and the rocker arms or valves may provide such a connection.

[0041] It is within the scope of this disclosure to actuate any valve disclosed herein without the use of any rocker arm. It is further within the scope of this disclosure to actuate any one or more of the valves disclosed herein directly, i.e., without the use of a camshaft.

[0042] Further, the controller 20 may be integrated into or discrete from the engine control unit of the engine 12, any brake control unit, or other control unit onboard the vehicle. In addition, the controller 20 may be integrated into or discrete from the hardware, software, or firmware of any such onboard control unit. In any case, the controller 20 may have a processor and a memory unit that is electrically coupled to the processor and has stored therein a plurality of instructions which, when executed by the processor, cause the processor to control operation of the shaft rotator 18 in response to any number of inputs representative of engine operation, emissions (e.g., present in the exhaust gas or trapped by an emissions trap), and/or sound levels, to name just a few.

[0043] While the concepts of the present disclosure have been illustrated and described in detail in the drawings and foregoing description, such illustration and description is to be considered as exemplary and not restrictive in character, it being understood that only illustrative embodiments have been shown and described and that all changes and modifications that come within the spirit of the disclosure are desired to be protected.

[0044] There are a plurality of advantages of the concepts of the present disclosure arising from the various features of the systems described herein. It will be noted that alternative embodiments of each of the systems of the present disclosure may not include all of the features described yet still benefit from at least some of the advantages of such features. Those of ordinary skill in the art may readily devise their own implementations of a system that incorporate one or more of the features of the present disclosure and fall within the spirit and scope of the invention as defined by the appended claims.

1. A method of operating an exhaust system associated with an engine, the method comprising the steps of:

rotating a camshaft of the exhaust system, and

operating at least one valve of the exhaust system in response to rotation of the camshaft so as to control flow in the exhaust system, the at least one valve being

discrete from each intake valve of the engine and each exhaust valve of the engine.

2. The method of claim 1, wherein:

the at least one valve comprises first and second valves, and

the operating step comprises operating the first and second valves in response to rotation of the camshaft, the first and second valves being discrete from each intake valve of the engine and each exhaust valve of the engine.

3. The method of claim 1, wherein:

the at least one valve comprises an exhaust valve and an agent valve,

the operating step comprises (i) operating the exhaust valve in response to rotation of the camshaft so as to control flow of exhaust gas to an emissions trap, and (ii) operating the agent valve in response to rotation of the camshaft so as to control flow of regenerative agent to the emissions trap.

4. The method of claim 1, wherein:

the at least one valve comprises first and second exhaust valves and first and second agent valves,

the operating step comprises (i) alternately opening and closing the first and second exhaust valves so as to alternate advancement of exhaust gas between first and second emission abatement devices in response to rotation of the camshaft, and (ii) alternately opening and closing the first and second agent valves so as to alternate advancement of regenerative agent between the first and second emission abatement devices in response to rotation of the camshaft.

5. The method of claim 1, wherein:

the at least one valve comprises first and second valves,

the operating step comprises alternately opening and closing the first and second valves so as to alternate advancement of exhaust gas between first and second exhaust processors in response to rotation of the camshaft.

6. The method of claim 1, further comprising the step of changing the number of operational engine cylinders of the engine from a non-zero first number to a non-zero second number, wherein:

the at least one valve comprises first and second exhaust valves,

the operating step comprises (i) opening the first valve with the camshaft so as to advance exhaust gas to a first sound abatement device in response to the changing step, and (ii) closing the second valve with the camshaft so as to block advancement of exhaust gas to a second sound abatement device in response to the changing step.

7. The method of claim 1, wherein the operating step comprises (i) at least partially closing the at least one valve with the camshaft so as to restrict exhaust gas flow in the exhaust system, and (ii) applying backpressure to the engine in response to the closing step.

8. The method of claim 1, wherein the operating step comprises controlling flow of air with the at least one valve in response to rotation of the camshaft.

9. The method of claim 1, wherein the operating step comprises controlling flow of a NOx reductant to an SCR catalyst with the at least one valve in response to rotation of the camshaft.

10. An exhaust system for use with an engine, comprising:

at least one valve configured to control flow in the exhaust system, the at least one valve being discrete from each intake valve of the engine and each exhaust valve of the engine, and

a camshaft configured to operate the at least one valve.

11. The exhaust system of claim 10, wherein:

the at least one valve comprises first and second valves, and

the camshaft is configured to operate both of the first and second valves.

12. The exhaust system of claim 11, further comprising an upstream passageway and first and second downstream passageways, wherein:

the first valve is positioned fluidly between the upstream passageway and the first downstream passageway to control flow from the upstream passageway to the first downstream passageway in response to operation of the camshaft, and

the second valve is positioned fluidly between the upstream passageway and the second downstream passageway to control flow from the upstream passageway to the second downstream passageway in response to operation of the camshaft.

13. The exhaust system of claim 11, further comprising first and second upstream passageways and a downstream passageway, wherein:

the first valve is positioned fluidly between the first upstream passageway and the downstream passageway to control flow from the first upstream passageway to the downstream passageway in response to operation of the camshaft, and

the second valve is positioned fluidly between the second upstream passageway and the downstream passageway to control flow from the second upstream passageway to the downstream passageway in response to operation of the camshaft.

14. The exhaust system of claim 11, further comprising a cylinder deactivation unit, a shaft rotator secured to the camshaft to rotate the camshaft, and first and second sound abatement devices, wherein:

the first valve is configured to control flow of exhaust gas to the first sound abatement device,

the second valve is configured to control flow of exhaust gas to the second sound abatement device, and

the cylinder deactivation unit is configured to operate the shaft rotator in response to a change in the number of operational engine cylinders of the engine from a non-zero first number to a non-zero second number.

15. The exhaust system of claim 11, further comprising first and second emission abatement devices, a regenerative agent supplier configured to supply regenerative agent for use in regeneration of the first and second emission abatement devices, wherein:

the first valve is configured to control flow of exhaust gas of the engine to the first emission abatement device,

the second valve is configured to control flow of exhaust gas of the engine to the second emission abatement device,

the at least one valve comprises a third valve configured to control flow of regenerative agent from the regenerative agent supplier to the first emission abatement device and a fourth valve configured to control flow of regenerative agent from the regenerative agent supplier to the second emission abatement device, and

the camshaft is configured to control operation of the first, second, third, and fourth valves.

16. The exhaust system of claim 10, further comprising a block defining a port in which the at least one valve extends, wherein a portion of the at least one valve and the camshaft are positioned on the same side of the block.

17. The exhaust system of claim 16, further comprising a cover covering the portion of the at least one valve and the camshaft.

18. The exhaust system of claim 10, further comprising a NOx reductant supplier and an SCR catalyst, wherein the at least one valve is positioned fluidly between the NOx

reductant supplier and the SCR catalyst to control flow of NOx reductant from the NOx reductant supplier to the SCR catalyst in response to operation of the camshaft.

19. The exhaust system of claim 10, further comprising an air supplier, wherein the at least one valve is fluidly coupled to the air supplier to control introduction of air into the exhaust system in response to operation of the camshaft.

20. An exhaust system, comprising:

first and second NOx traps,

first and second exhaust valves, the first exhaust valve for controlling flow of exhaust gas to the first NOx trap, the second exhaust valve for controlling flow of exhaust gas to the second NOx trap,

first and second reductant valves, the first reductant valve for controlling flow of NOx reductant to the first NOx trap, the second reductant valve for controlling flow of NOx reductant to the second NOx trap, and

a camshaft for controlling operation of the first and second exhaust valves and the first and second reductant valves.

* * * * *