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(54) **EXHAUST SILENCER**

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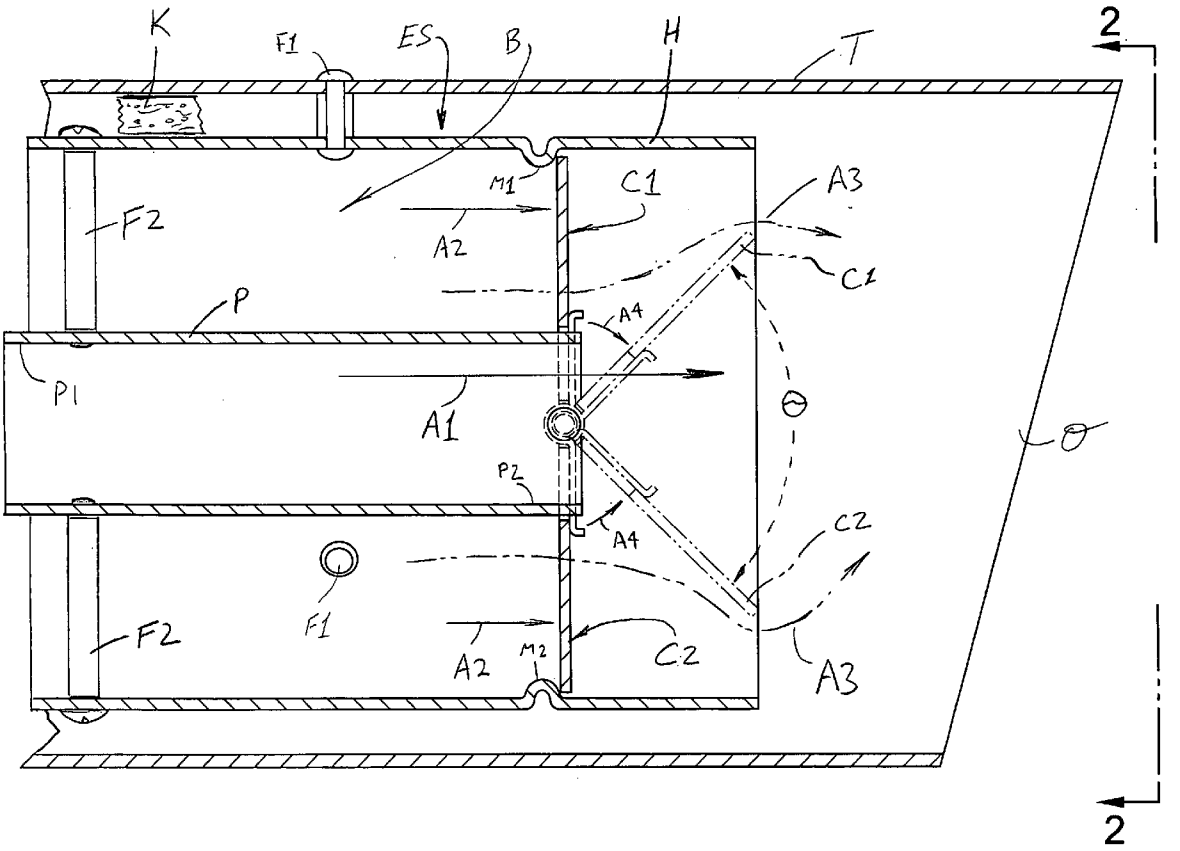
(57) **ABSTRACT**

An exhaust silencer includes a flow pipe supported in a housing. A space is defined between the flow pipe and the housing. At least one movable flap is located in the space and is resiliently biased to a closed position and movable by exhaust gas pressure from said closed position to an opened position. The at least one flap provides less restriction to exhaust gas flow through the space in the opened position as compared to the closed position. The one or more flaps are pivotably supported on a spring-biased hinge assembly or are provided as part of a resiliently deformable baffle plate that uncovers flow apertures under force of exhaust pressure. The baffle plate is selectively removable by an end-user to allow for maximum exhaust flow when desired. The flow pipe can be omitted in a base plate only version.



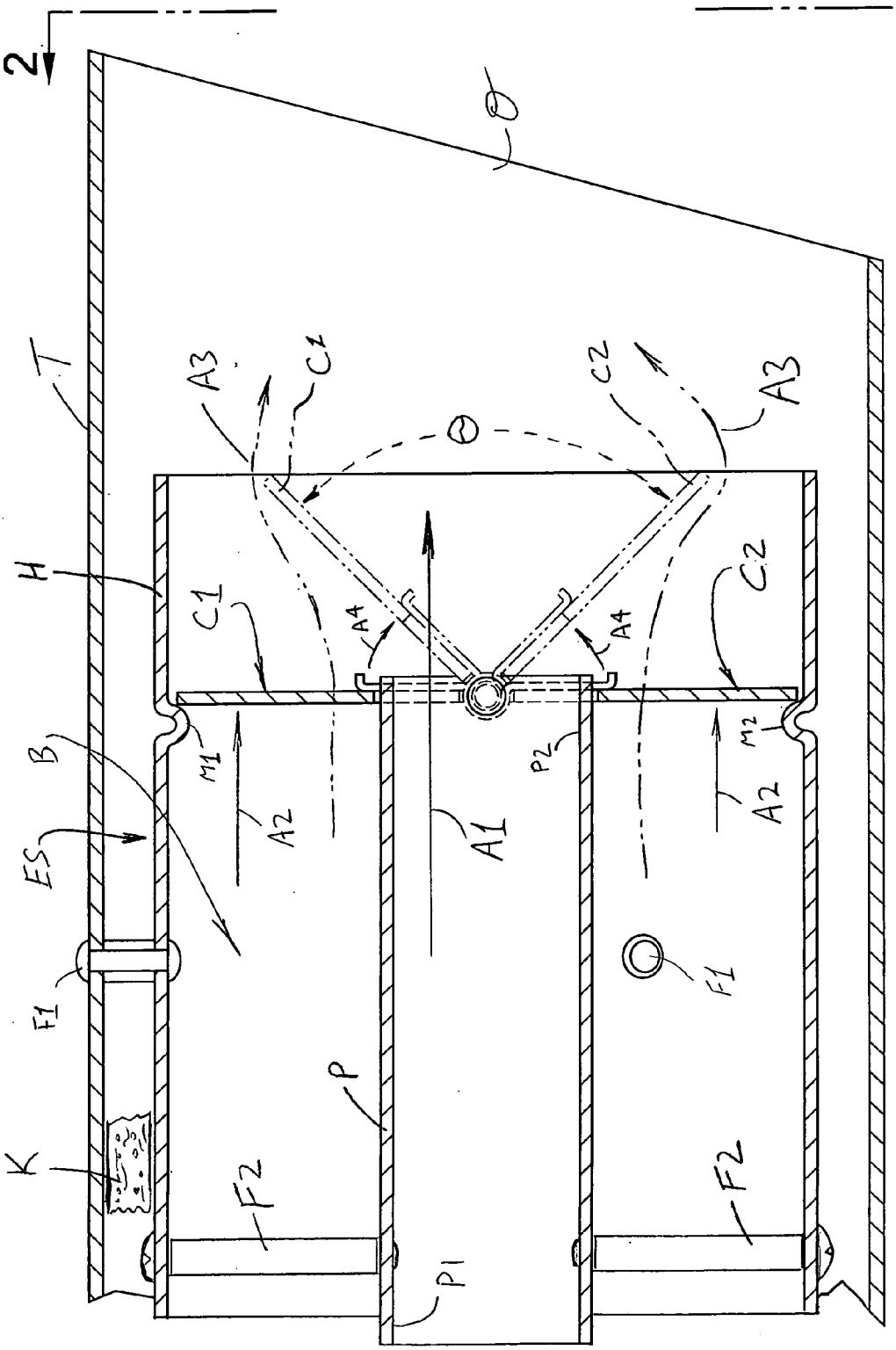


FIG. 1

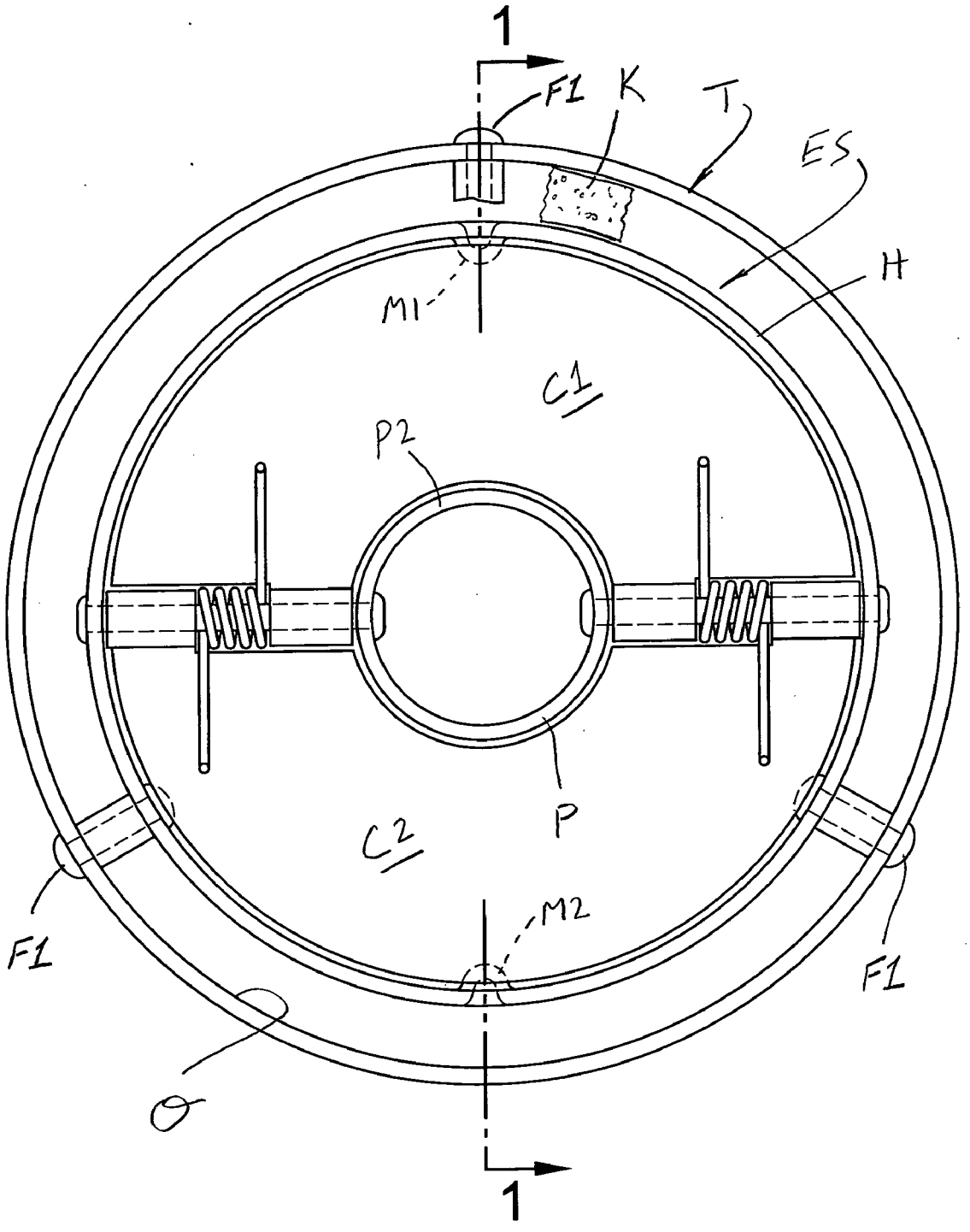


FIG. 2

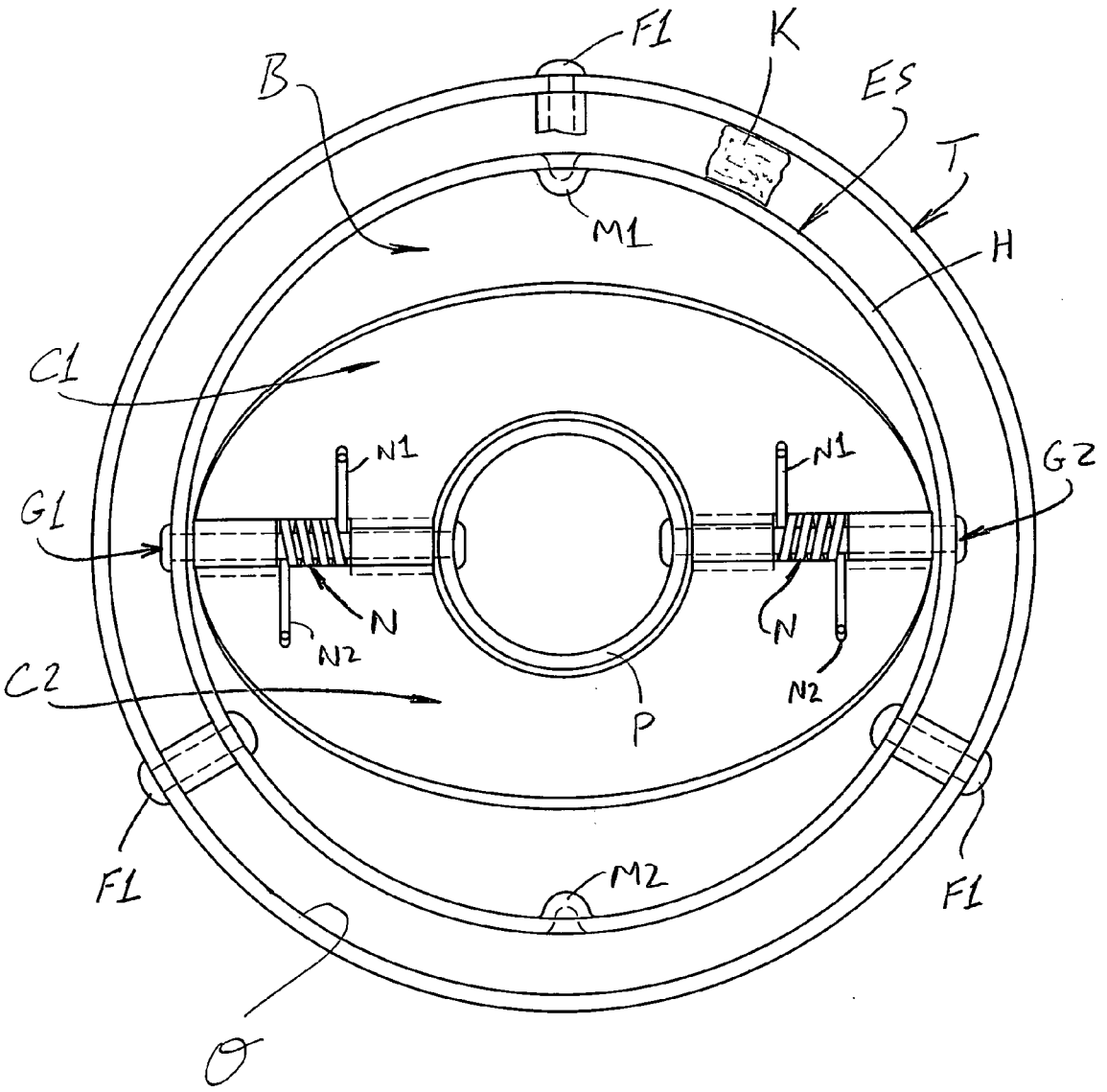


FIG. 3

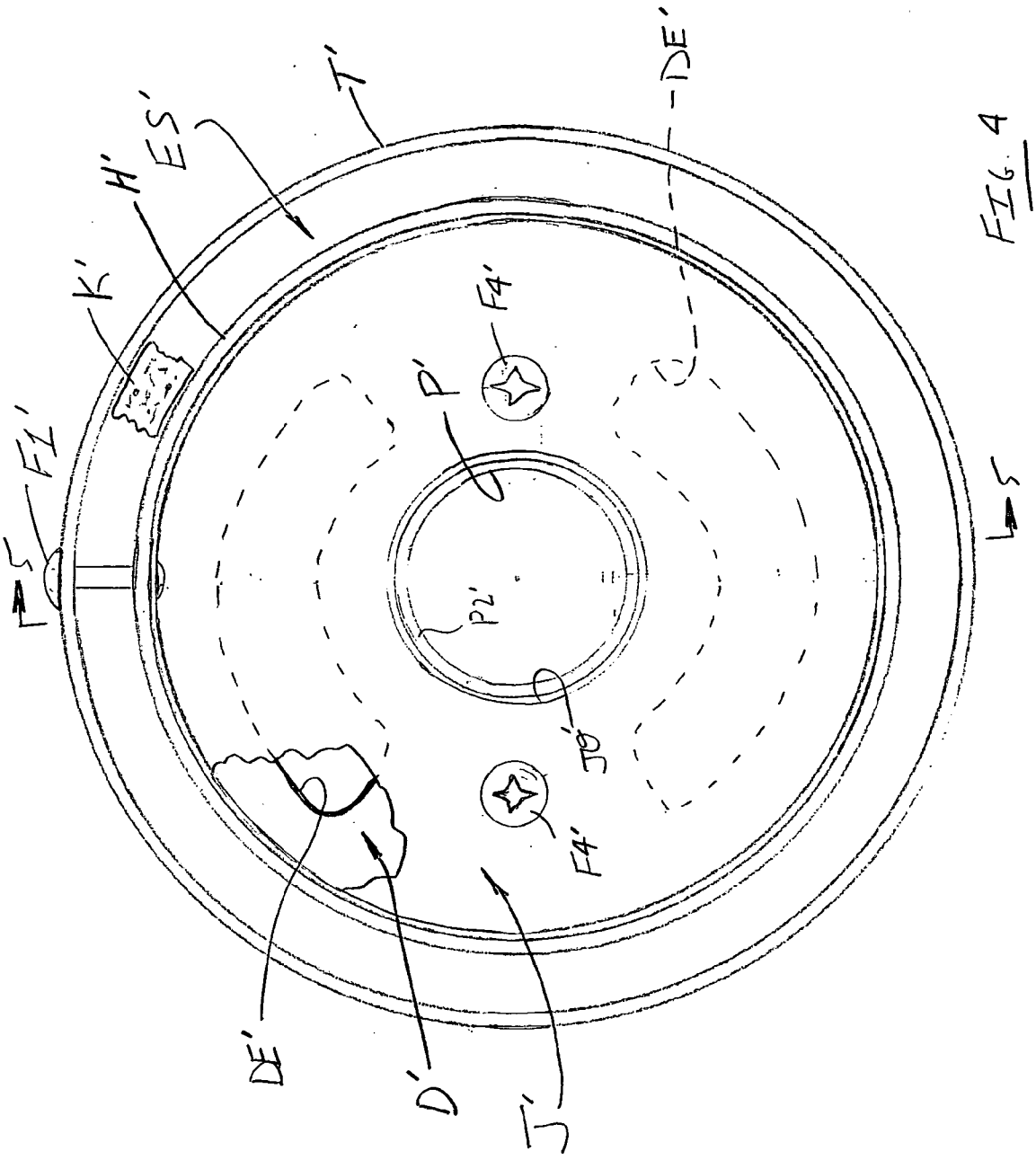
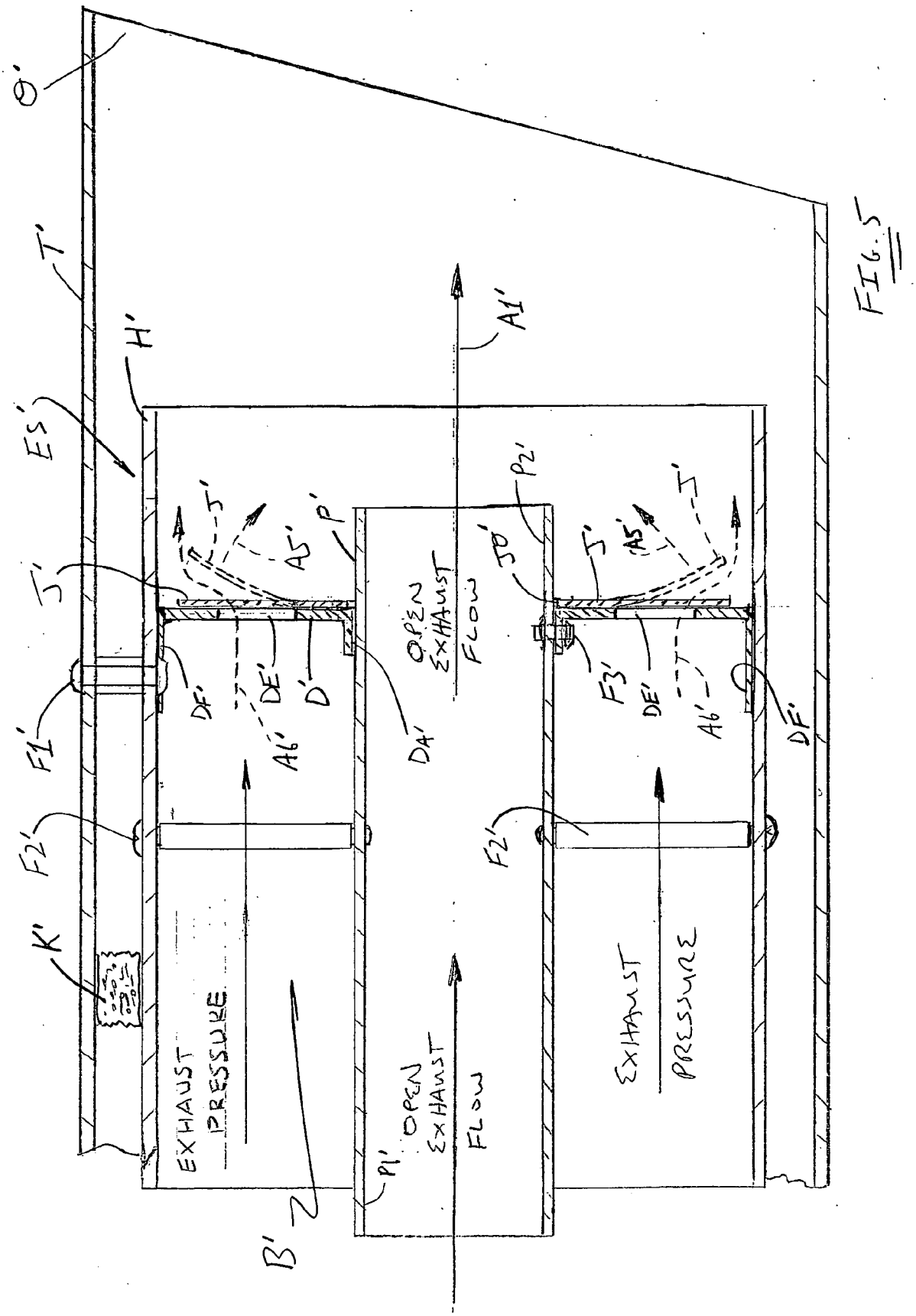
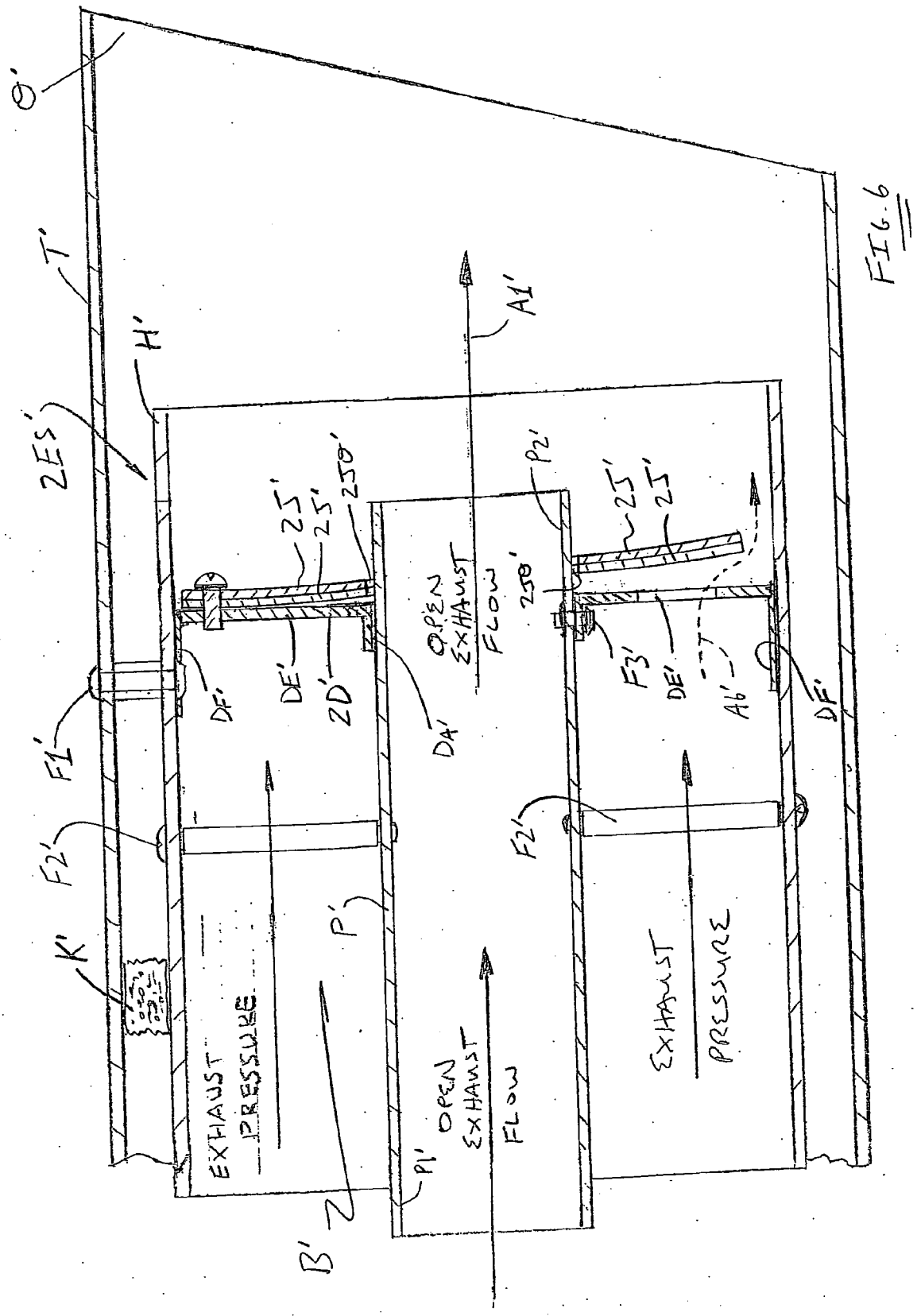


FIG. 4


O'
T'
H'
ES'
A1'
J'
J'
A5'
P'
P2'
J0'
J'
A5'
J'
F1'
DF'
DE'
D'
A6'
D4'
OPEN EXHAUST FLOW
F3'
DE'
A6'
DF'
F2'
F2'
K'
EXHAUST PRESSURE
P1'
OPEN EXHAUST FLOW
EXHAUST PRESSURE
B'
FIG. 5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T'
H'
2ES'
A1'
25'
25'
250'
P2'
OPEN EXHAUST FLOW
250'
25'
25'
F1'
F2'
K'
DF'
DE'
2D'
D4'
F3'
DE'
A6'
DF'
F2'
P'
EXHAUST PRESSURE
P1'
OPEN EXHAUST FLOW
EXHAUST PRESSURE
B'

FIG. 6

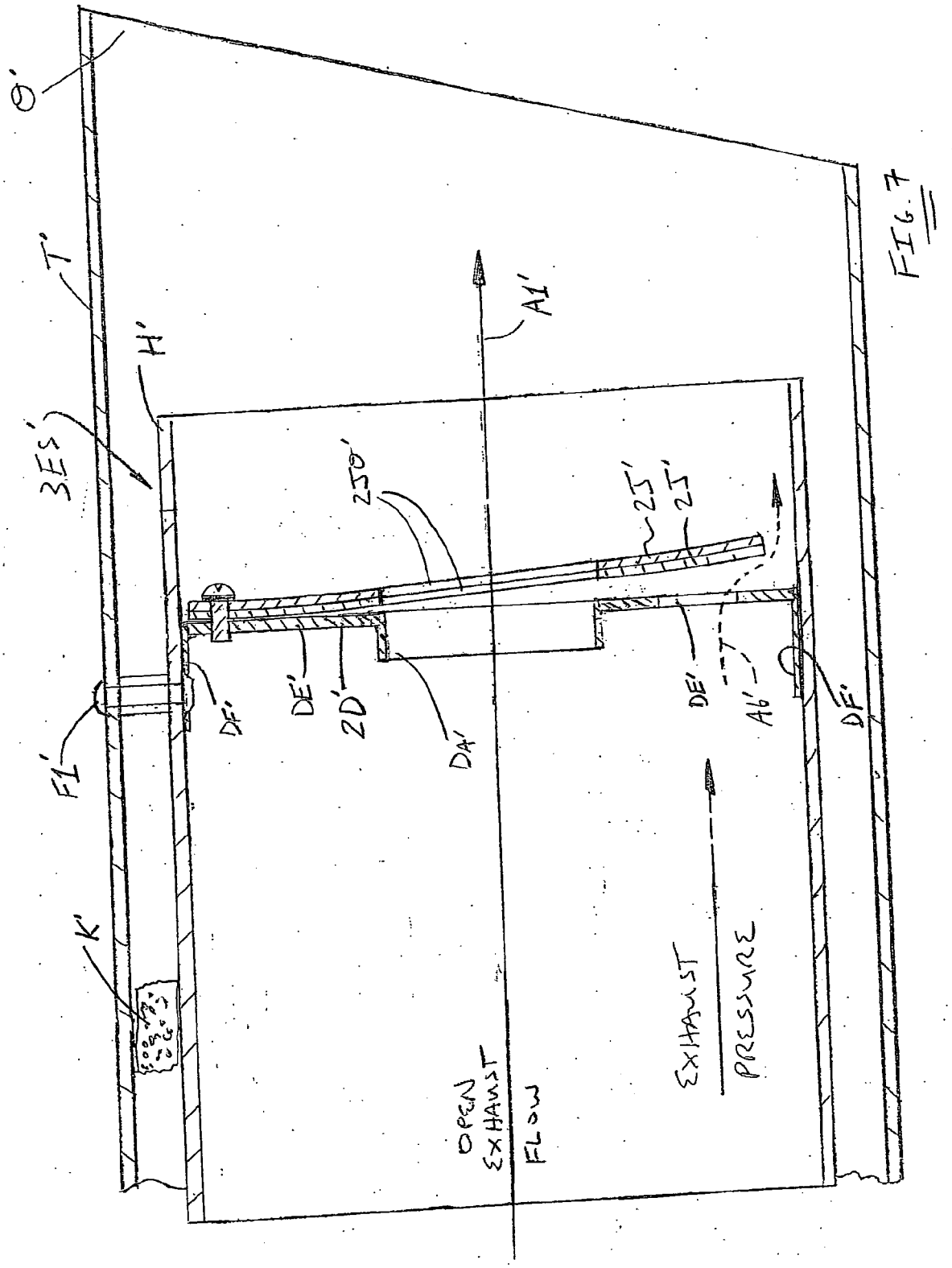
O'
T'
H'
3ES'
A1'
23D'
2J'
2J'
F1'
K'
DF'
DE'
2D'
DA'
DE'
A6'
DF'
OPEN EXHAUST FLOW
EXHAUST PRESSURE

FIG. 7

EXHAUST SILENCER

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from and benefit of the filing date of U.S. provisional application Ser. No. 60/724,460 filed Oct. 7, 2005, and said provisional application is hereby incorporated by reference into the present specification.

BACKGROUND

[0002] Silencers for automobile exhaust systems are known. One type of silencer is known as an active silencer due to its capacity to adjust in response to pressure of exhaust gases in the system. As such, at low engine revolutions per minute (RPM) with correspondingly low exhaust pressure, the silencer remains substantially closed to increase exhaust backpressure and reduce noise, while increase in engine RPM causes a corresponding increase in exhaust gas pressure which, in turn, is used to open the silencer against the closing force of a biasing spring to reduce backpressure which causes an increase in exhaust noise and engine power. While known active silencers are superior to passive silencers, which merely restrict exhaust flow by constant amount, known active silencers have also been deemed deficient for complexity, cost, insufficient backpressure reduction when opened, reliability and other reasons. As such, a need has been identified for a new and improved active exhaust silencer.

SUMMARY

[0003] In accordance with one aspect of the present invention, an exhaust silencer includes a housing and a flow pipe supported in the housing. A space defined between the flow pipe and the housing. At least one movable flap is located in the space and is resiliently biased to a closed position and movable by exhaust gas pressure from the closed position to an opened position. The flap provides less restriction to exhaust gas flow through the space in the opened position as compared to the closed position.

[0004] In accordance with another aspect of the present invention, and exhaust silencer includes a housing and a base plate secured in the housing. The base plate defines at least one main flow opening and at least one secondary flow opening. At least one flexible metal baffle is secured to the base plate and is normally resiliently biased to a closed position where it covers the secondary flow aperture. The baffle is resiliently movable by exhaust gas pressure from its closed position to an opened position where it moves away from the secondary flow opening(s) to allow exhaust gas flow therethrough.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** is a cross-sectional view of an exhaust silencer formed in accordance with the present development;

[0006] FIG. **2** is an end view of the exhaust silencer taken along view line **2-2** of FIG. **1** and shows the silencer in its closed state (note that in FIG. **2**, the exhaust silencer is not sectioned as in FIG. **1**);

[0007] FIG. **3** is an end view that corresponds to FIG. **2**, but shows the exhaust silencer in its opened state;

[0008] FIG. **4** is an end view similar to FIG. **2**, but shows an exhaust silencer formed in accordance with an alternative embodiment (a portion of the baffle is broken away to reveal an underlying baffle base plate);

[0009] FIG. **5** is a sectional view of the exhaust silencer of FIG. **4**, as taken along line **5-5** of FIG. **4**;

[0010] FIG. **6** is a sectional view that is similar to FIG. **5**, but shows an alternative embodiment of an exhaust silencer formed in accordance with the present development.

[0011] FIG. **7** is a sectional view that is similar to FIG. **6**, but shows another alternative embodiment of an exhaust silencer formed in accordance with the present development.

DETAILED DESCRIPTION

[0012] FIGS. **1-3** illustrate an exhaust silencer ES formed in accordance with a first embodiment of the present development for use in silencing/tuning the exhaust of an internal combustion engine such as used to propel a vehicle such as an automobile, boat, etc. or for some other purpose.

[0013] As illustrated herein, the silencer ES is intended to be retro-fitted into an existing exhaust tailpipe T using one or more fasteners F**1** such as a bolt, rivet, screw, etc., or by other means such as welding, friction-fit or the like to secure the silencer to the tailpipe T. In particular, the exhaust silencer ES comprises an outer housing tube H that is fitted into the tailpipe T, and the fasteners F**1** or other means are used to fixedly secure the housing tube H relative to the tailpipe T. If necessary and/or desired, a spacer or gasket K can be used to surround the housing tube H to fill any space defined between the tailpipe T and housing tube H. In some cases, such as when the silencer ES is supplied as original equipment, the tailpipe T, itself, provides the housing tube H, and the fasteners F**1** are not needed.

[0014] At least one open flow pipe P is located, preferably concentrically, in the housing tube H and secured therein by rivets, bolts, screws and/or other fasteners F**2** (FIG. **1**) that engage the housing tube H and open flow pipe P. This open flow pipe P has an upstream end P**1** and a downstream end P**2** and allows free-flow of exhaust gases therethrough from the upstream end P**1** to the downstream end P**2** so that exhaust gases can flow from an upstream position in the tailpipe T toward the outlet O of the tailpipe T as indicated by arrow A**1** in FIG. **1**.

[0015] An annular space B is defined between the pipe P and the housing H. First and second flow-control flaps C**1**,C**2** are located in the annular space B, near an outer end thereof. These flaps C**1**,C**2** move between a closed position (FIGS. **1** and **2**) where they are arranged at a 180 degree angle relative to each other or are otherwise arranged to substantially block the flow of exhaust gases through the annular space B from an upstream location in the tailpipe T to the tailpipe outlet O (see arrows A**2**), and an opened position (FIG. **3** and phantom lines of FIG. **1**) where they define an included angle Θ of less than 180 degree or are otherwise arranged so as to allow flow of exhaust gases through the annular space B from an upstream location in the tailpipe T to the tailpipe outlet O (see arrows A**3**). The flaps C**1**,C**2** are located near the downstream/outer end P**2** of the pipe P so that the pipe P does not interfere with pivoting movement of the flaps C**1**,C**2**.

[0016] As is easily seen in FIG. 3, the flow-control flaps C1,C2 are pivotally connected to the housing tube H and the open flow pipe P. In particular, first and second hinges G1,G2 defined by pins or the like and extend between the housing tube and pipe P in diametrically opposed locations, and the flaps C1,C2 are each pivotally connected to both hinges G1,G2. At least one of the hinges G1,G2 comprises a torsion spring N or the like that includes feet N1,N2 that are engaged respectively with the flaps C1,C2 to bias the flaps C1,C2 to their closed positions (FIG. 2) where they obstruct the flow of exhaust gases through the annular space B (as shown, each hinge G1,G2 comprises a separate spring N). The spring(s) N is (are) selected so that the flaps C1,C2 are able to pivot against the spring(s) N as shown by arrows A4 when the exhaust gas pressure in the annular space B exceeds a select threshold, which will vary depending upon the desired performance characteristics and the particular vehicle or other application. In one embodiment, the flaps are intended to stay closed during idle of an automobile, to open slightly (i.e., move 10 degrees or so from vertical) during normal vehicle acceleration, and open substantially (i.e., move at least 30 degrees from vertical) during hard acceleration.

[0017] When the exhaust gas pressure in the annular space B subsides, the springs N1,N2 return the flaps C1,C2 toward and/or fully to their closed positions. Stops M1,M2 are provided and engage the flaps C1,C2, respectively, when the flaps are closed to prevent movement of the flaps C1,C2 beyond their closed positions under force of springs N1,N2. As shown, the stops M1,M2 are defined by indented portions of the housing tube H, but can be defined by rivets, tabs, screws or other suitable fixed member that extends into the annular space B.

[0018] Those of ordinary skill in the art will recognize that when the flaps C1,C2 are closed, exhaust gas flow and noise are restricted owing to the fact that the only path for the exhaust gases to flow to the tailpipe outlet O is via pipe P (except for any leakage around flaps C1,C2). When the flaps C1,C2 open under exhaust pressure, the exhaust gas flow and engine performance and noise increase, because the exhaust gases are able to flow to the tailpipe outlet O through the pipe P and also through the annular space B. As such, the exhaust silencer ES provides a self-adjusting capability that is responsive to exhaust gas pressure that varies with driving habits or other causes of variations in exhaust gas pressure.

[0019] Except for the optional gasket K, the components of the exhaust silencer are preferably defined from a metal such as steel or stainless steel using grades and alloys that are known in the exhaust arts. The springs N1,N2 are preferably metal and defined from suitable spring wire such as (by way of example only) stainless steel, Inconel, or other metal with sufficient resistance to elevated temperature creep and fatigue.

[0020] FIGS. 4 and 5 illustrate an alternative exhaust silencer ES' formed in accordance with the present development. The silencer ES' is intended for the same application and use and to perform the same function as the silencer ES, but includes a different silencing mechanism. Components of the silencer ES' that correspond to components of the silencer ES are labeled with reference characters that correspond to those used in FIGS. 1-3, but include a primed (') suffix.

[0021] The silencer ES' is intended to be retro-fitted into an existing exhaust tailpipe T' using one or more fasteners F1' such as a bolt, rivet, screw, etc., or by other means such as welding, friction-fit or the like that engage the tailpipe T' and housing tube H'. In particular, the exhaust silencer ES' comprises an outer housing tube H' that is fitted into the tailpipe T', and the fasteners F1' or other means are used to fixedly secure the housing tube H' relative to the tailpipe T'. If necessary and/or desired, a gasket K' can be used to surround the housing tube H' to fill any space defined between the tailpipe T' and housing tube H'. In some cases, such as when the silencer ES' is supplied as original equipment, the tailpipe T', itself, provides the housing tube H', and the fasteners F1' are not needed.

[0022] At least one open flow pipe P' is located, preferably concentrically, in the housing tube H'. The pipe P' is secured in this position by one or more rivets, bolts, screws and/or other fasteners F2' that engage the housing tube H' and open flow pipe P'. This open flow pipe P' has an open upstream end P1' and an open downstream end P2' so as to allow free-flow of exhaust gases therethrough from an upstream position in the tailpipe T' toward the outlet O' of the tailpipe T' as indicated by arrow A1'. An annular space B' is defined between the flow pipe P' and the housing tube H'.

[0023] A baffle base plate D' is closely fitted in the housing tube H' and is secured in this position. As shown, the baffle base plate D' includes an outer flange DF' that is engaged by the fasteners F1' or welding or the like to secure the baffle base plate D' in its operative position in the housing tube H'. The baffle base plate D' also defines a central pipe-support aperture DA' through which the open flow pipe P' extends. An optional fastener F3' or a spot weld, or other means is used to secure the pipe P' to the baffle base plate D'. The baffle base plate D' defines one or more flow apertures DE' that provide a path for exhaust gases to flow from an upstream location in the tailpipe T', through the annular space B' and through the base plate D' to the tailpipe outlet O'.

[0024] To regulate the flow of exhaust gases through the flow apertures DE' of the base plate D', at least one flexible baffle J' is secured adjacent the downstream side of the base plate D'(facing tailpipe outlet O'). The baffle J' is preferably defined by a flexible metal sheet that includes an opening JO' through which the flow pipe P' is loosely received. As shown, the baffle J' is secured directly to the base plate D' by one or more rivets, screws or other fasteners F4'. In some cases, the fasteners F4' are preferably non-removable and in others, the fasteners F4' are screws or other removable fasteners that allow a user to change baffles J' or add (by stacking) additional baffles J' to control exhaust flow. As is shown in FIG. 4 and in solid lines in FIG. 5, the baffle J' has a natural flat shape when relaxed or in a free state so that the baffle J' is in a closed position and covers the flow apertures DE' of the base plate D' and inhibit or substantially block flow of exhaust gases therethrough from the annular space B' to the tailpipe outlet O'. The baffle J' is flexible and bends under force of exhaust pressure in the annular space B' to an opened position, as shown in broken lines in FIG. 5 and as indicated by arrows A5' where the flow apertures DE' are at least partially uncovered by flaps C1',C2' of the baffle J' to allow flow of exhaust gases through the annular space B from an upstream location in the tailpipe T to the tailpipe outlet O (see broken arrows A6' in FIG. 5). Those of

ordinary skill in the art will recognize that the first and second flaps C1',C2' of the baffle J' correspond to the flaps C1,C2 of the exhaust silencer ES illustrated in FIGS. 1-3. In the closed position, the flaps are arranged at an angle of 180 degrees relative to each other and, when opened, are moved inward toward each other against the natural bias of the baffle J'. As shown herein, the flaps C1',C2' are part of a one-piece baffle J'. Alternatively, the baffles C1',C2' can be part of separate baffles J', each of which is secured to the base plate D'.

[0025] The baffle J' is selected so that it bends to the opened position to allow exhaust gas flow through the flow apertures DE' when the exhaust gas pressure in the annular space B exceeds a select threshold, which will vary depending upon the desired performance characteristics and the particular vehicle or other application. In one embodiment, the baffle J' is intended to stay closed during idle of an automobile, to open slightly and partially uncover the apertures DE' during normal vehicle acceleration, and to open fully during hard acceleration to at least substantially uncover the apertures DE'. When the exhaust pressure in the annular space B' subsides, the baffle J' resiliently returns to its normally closed position, which is a relatively flattened (not necessarily completely flat) state relative to the opened position.

[0026] Those of ordinary skill in the art will recognize that when the baffle J' is closed, exhaust gas flow and noise are restricted owing to the fact that the only path for the exhaust gases to flow to the tailpipe outlet O' is via open pipe P' (except for some leakage around the baffle base plate D' and/or leakage through flow apertures DE'). When the baffle J' opens, the exhaust gas flow and engine performance and noise increase, because the exhaust gases are able to flow to the tailpipe outlet O' through both the pipe P' and also through the annular space B' via apertures DE'. As such, the exhaust silencer ES' provides a self-adjusting capability that is responsive to exhaust gas pressure that varies with driving habits or other causes of variations in exhaust gas pressure.

[0027] Except for the optional gasket K, which can be a heat/fire resistant insulation material, components of the exhaust silencer ES' are preferably defined from a metal such as steel or stainless steel using grades and alloys that are known in the exhaust arts. The baffle J' is preferably defined from metal such as (by way of example only) stainless steel, Inconel, or other metal with sufficient resistance to elevated temperature creep and fatigue, having a thickness, e.g., in the range of 0.005 inches to 0.015 inches (the thickness is varied to control the exhaust pressure required to flex the baffle J' to its opened position). If desired, the user can selectively remove the baffle ' to allow full exhaust flow under all conditions by removing screws F4'. Also, the baffle J' can be changed by a user to control the opening pressure (by replacing a baffle J' with another having different flexibility), and multiple baffles J' (of same or varied thickness/flexibility) can be stacked against the base plate D' if desired to increase the pressure required to open the flow apertures DF'.

[0028] FIG. 6 is a sectional view that is similar to FIG. 5, but shows an alternative embodiment of an exhaust silencer 2ES' formed in accordance with the present development. The exhaust silencer 2ES' is identical to the silencer ES' except as shown and/or described herein. Specifically, in the silencer 2ES', the base plate 2D' includes only a single flow aperture DE'. One or more baffles 2J' (two as shown in FIG. 6) are stacked adjacent each other and secured to the base plate 2D' by on or more fasteners F4', preferably located as shown, on an opposite side of the flow pipe P' relative to the flow aperture DE', e.g., at a 180 degree angle relative to the center of the flow aperture DE', or at least spaced sufficiently far from the aperture(s) DE' so that the one or more baffles 2J' can flex away from the base plate 2D' as shown. Each baffle 23' is identical to the baffle J' disclosed above, except for the location of the fastener F4'. The opening 2JO' of each baffle 2J' loosely accommodates the outer end P2' of the flow pipe P' so that the baffles 2J' can move relative to the flow pipe as described and shown herein. FIG. 6 shows the baffles 2J' in the flexed, opened position, spaced from flow aperture DE' to allow exhaust flow through the flow aperture DE' as indicated by arrow A6'. When exhaust pressure in the space B' subsides, the baffles 2J' will move naturally by their own resilient nature to a closed position where they cover the flow aperture DE' to impede exhaust flow through the space B', which closed position is a relatively flattened (not necessarily completely flat) state for the baffles 2J' relative to their opened position. Using one or more like baffles 2J', a user can adjust the exhaust pressure required to open/close the baffle(s) 2J', which is desirable to adjust for different horsepower engines, etc. Thus, for example, for a lower horsepower engine, the user can choose to use a single baffle 2J' that will more easily flex to the opened position, while two or more baffles 2J' can be used for a higher horsepower engine so that the baffles are more resistant to moving to the opened position, requiring more exhaust pressure in the space B' to do so.

[0029] In another alternative embodiment 3ES' as shown in FIG. 7, the flow pipe P' of FIGS. 4 and 5 or of FIG. 6 is not used. The base plate aperture DA' is left open to define a main opening for unrestricted exhaust flow A1' through the housing H' to the tailpipe outlet O', while the base plate flow aperture(s) DE' provide a secondary opening for exhaust flow only when the baffle(s) 2J' (or J') are flexed from the closed to the opened position by exhaust pressure as described herein. The opening 2JO' in the baffle(s) 2J' is registered with the base plate aperture DA' so that the baffle(s) 2J' do not block exhaust flow therethrough (i.e., through the main opening) even when the baffle(s) 2J' are in the closed position.

[0030] While considerable emphasis has been placed on the preferred embodiments, it will be appreciated that other embodiments can be made and that many changes can be made in the preferred embodiments without departing from the principles of the invention, and it is intended that the following claims be construed literally and/or according to the doctrine of equivalents as broadly as possible.

1. An exhaust silencer comprising:

a housing;

a flow pipe supported in said housing;

a space defined between said flow pipe and said housing;

at least one movable flap located in said space and resiliently biased to a closed position and movable by exhaust gas pressure from said closed position to an opened position, wherein said at least one flap provides

less restriction to exhaust gas flow through said space in said opened position as compared to said closed position.

2. The exhaust silencer as set forth in claim 1, wherein said at least one flap pivots between said closed and opened positions.

3. The exhaust silencer as set forth in claim 2, wherein said at least one flap comprises first and second separate flaps that each pivot between said closed and opened positions.

4. The exhaust silencer as set forth in claim 3, further comprising at least one spring engaged with said first and second flaps to bias said first and second flaps to their respective closed positions.

5. The exhaust silencer as set forth in claim 4, further comprising first and second hinges that extend between said flow pipe and said housing, wherein said first and second flaps are each connected to both said first and second hinges, and wherein said at least one spring is a torsion spring connected to one of said first and second hinges.

6. The exhaust silencer as set forth in claim 5, wherein said at least one spring comprises first and second springs respectively connected to said first and second hinges, wherein each of said first and second springs is engaged with both of said first and second flaps.

7. The exhaust silencer as set forth in claim 6, further comprising first and second stops located between said housing and said flow pipe, said first and second stops abutting said first and second flaps, respectively, when said first and second flaps are in their respective closed positions.

8. The exhaust silencer as set forth in claim 7, wherein said first and second flaps define a 180 degree angle therebetween when the first and second flaps moved to their closed positions, and wherein said first and second flaps define therebetween an angle of less than 180 degrees when the first and second flaps are moved their respective opened positions.

9. The exhaust silencer as set forth in claim 7, wherein said flow pipe is located centrally in said housing so that said space defined between said housing and said flow pipe is an annular space that encircles said flow pipe.

10. The exhaust silencer as set forth in claim 9, wherein said first and second hinges are arranged in diametrically opposed locations relative to each other.

11. The exhaust silencer as set forth in claim 10, wherein said flow pipe defines an unobstructed flow path from an open upstream end to an open downstream end thereof.

12. The exhaust silencer as set forth in claim 1, wherein said at least one flap is defined as part of a flexible metal baffle that is secured in said space, wherein said at least one flap moves from said closed position to said opened position by resilient deformation of said metal baffle under force of exhaust gas pressure in said space, and wherein said at least one flap resiliently moves from said opened position to said closed position when said exhaust gas pressure in said space subsides.

13. The exhaust silencer as set forth in claim 12, wherein said at least one flap comprises first and second flaps.

14. The exhaust silencer as set forth in claim 13, wherein said first and second flaps are defined by said metal baffle as a one-piece construction.

15. The exhaust silencer as set forth in claim 12, further comprising a base plate secured in said space between said flow pipe and said housing, said base plate defining at least one flow aperture, wherein said metal baffle is secured to said base plate and occludes said at least one flow aperture when in said closed position and moves away from said at least one flow aperture when in said opened position.

16. The exhaust silencer as set forth in claim 15, wherein said metal baffle is secured to said base plate by at least one removable fastener that allow for selective separation of said baffle from said base plate for maximum exhaust flow.

17. The exhaust silencer as set forth in claim 16, wherein said base plate comprises an outer flange that is secured to said housing and comprises a pipe support aperture through which said flow pipe extends, and wherein said baffle comprises an opening through which said flow pipe extends.

18. The exhaust silencer as set forth in claim 12, wherein said metal baffle comprises a flexible metal sheet.

19. The exhaust silencer as set forth in claim 1, wherein said at least one flap is defined by a stack of at least two flexible metal baffles that are secured in said space, wherein said at least one flap moves from said closed position to said opened position by resilient deformation of said stack of metal baffles under force of exhaust gas pressure in said space, and wherein said at least one flap resiliently moves from said opened position to said closed position by relative flattening of said stack of metal baffles when said exhaust gas pressure in said space subsides.

20. The exhaust silencer as set forth in claim 20, further comprising a base plate secured in said space between said flow pipe and said housing, said base plate defining at least one flow aperture, wherein said stack of metal baffles is secured to said base plate and occludes said at least one flow aperture when in said closed position and moves away from said at least one flow aperture when in said opened position.

21. An exhaust silencer comprising:

a housing;

a base plate secured in the housing, the base plate comprising at least one main flow opening and at least one secondary flow opening;

at least one flexible metal baffle secured to the base plate and normally resiliently biased to a closed position where it covers the secondary flow aperture, wherein said baffle is resiliently movable by exhaust gas pressure from said closed position to an opened position where it moves away from the at least one secondary flow opening to allow exhaust gas flow through the at least one secondary flow opening.

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