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(54) A silencer

(57) A vehicle silencer is described. The silencer includes (2) a substantially hollow bullet (54) extending into the silencer chamber, having a plurality of holes formed in it. The said bullet provides gas communication from the chamber to the outlet (6) and reduces noise level and/or changes noise characteristics over a given rpm range.

The bullet is, preferably, in the form of a sheathed inwardly extending outlet tube (50).

A cavity between the sheath and the outlet tube also assists noise reduction and/or changes noise characteristics of the silencer.

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Description

[0001] The present invention relates to a silencer and, in particular, a silencer for a motor bike exhaust.

[0002] The use of silencers in exhaust systems is a well established and conventional technique for noise reduction. The type of silencer required for any particular application depends upon a number of factors including; the nature of the exhaust gases, the noise level required, the materials used to pack the silencer, the width of the exhaust tube, the rate of delivery of the exhaust gases etc.

[0003] Recent legislation in relation to motor cycle exhaust systems has meant that it has been necessary to further reduce the motor cycle exhaust noise levels.

[0004] The present invention addresses the problem of reducing noise levels in exhaust systems.

[0005] According to the present invention there is provided a vehicle silencer comprising; an inlet adapted to receive exhaust gases, an outlet adapted to provide an exit for the said gases and a walled chamber between the said inlet and the said outlet, the said chamber having sound absorbing characteristics, wherein the chamber includes a substantially hollow bullet extending into the chamber and having a plurality of holes formed therein, the said bullet providing gas communication from the chamber to the outlet.

[0006] Preferably, the vehicle is a motor bike.

[0007] Preferably, the head of the bullet provides a barrier to the exhaust gases by being substantially free of holes. Accordingly, preferably, the holes are formed in the side(s) of the bullet.

[0008] Preferably, the barrier head of the bullet is substantially convex to assist in the deflection of exhaust gases onto the sides of the silencer chamber and the bullet.

[0009] Preferably, the bullet is in the form of a sheathed inwardly extending outlet tube.

[0010] Preferably, in such cases, the sides of the sheath extend into the chamber beyond the limit of inward extension of the outlet tube.

[0011] Preferably, the ratio of the extent of inward extension of the perforated portion of the bullet from the limit of inward extension of the outlet tube to the total inward extension of the outlet tube is between 1:1 to 1:5, more preferably, 1:2 to 1:4, most preferably, substantially 1:3.

[0012] Preferably, the preferred ratio of the extent of inward extension of the perforated portion of the bullet from the limit of inward extension of the outlet tube to the overall length of the walled chamber is between 1/45 to 10/45, more preferably 1/10 to 6/45, most preferably 1/9 to 11/90.

[0013] For the avoidance of doubt, the inward extension of the perforated portion of the outlet bullet does not include any length ascribed to the head of the bullet when the latter is not perforated and a bullet is any extension into the walled chamber, allowing gas communication with the silencer outlet, so that the extension has an effect in lowering noise level output and/or changing noise characteristics of the silencer over a given rpm range.

[0014] The perforated portion of the bullet has an open area of, preferably, between 15-50%, more preferably, 25-40%, not including the area of the non-perforated bullet head.

[0015] Preferably, the ratio of the extent of inward extension of the bullet (including the non-perforated head) to the overall length of the chamber is between 1:5 and 4:5, more preferably 1:4 and 3:4, most preferably 1:3 and 2:3 especially preferred is between 4:9 and 5:9.

[0016] Preferably, the distance from the head of the bullet to the cone inlet is at least 50mm, more preferably, at least 75mm, alternatively, at least 1/10 the length of the chamber, more preferably at least 1/5 the length of the chamber.

[0017] Preferably, a silencer cone is fitted at the inlet to the silencer chamber.

[0018] It will be noted that the portion of the outlet tube extending into the chamber creates a dead space when the outlet tube is not perforated.

[0019] Preferably, the dead space created by the plain outlet tube at the outlet end of the silencer is between 5% and 30% of the available silencer space wherein the available silencer space includes the cone space, more preferably, the dead space is between 10 and 25%, most preferably, 15 and 20% of the available silencer space.

[0020] Preferably, the silencer of the present invention is a motor bike silencer but may also be a silencer for other kinds of vehicle.

[0021] Advantageously, the dead space prevents immediate pressure build-up at low engine revolutions. Furthermore, at higher revolutions the dead space may be creating back pressure which does not interfere with the outlet provided by the perforated portion of the bullet. This overcomes the problem associated with a baffled outlet, where back pressure build up creates high pressure areas in the gas outlet pathway, causing increased resistance to the gas flow, in turn restricting engine performance.

[0022] Preferably, the bullet is tubular and, most typically, the perforated sheath also extends over the bullet outlet tube.

[0023] Preferably, the perforated sheath overlaps the outlet tube in such a manner as to create a small cavity between the inner wall of the perforated sheath and the outer wall of the outlet tube.

[0024] Advantageously, it has been found that the perforated cavity thus created improves the sound absorbing

characteristics of the silencer and may be acting as a cushion which reduces popping or gas explosion by providing an additional sound absorption surface.

[0025] The perforated cavity may extend along the whole of the length of the outlet tube but, preferably, extends for more than half of the length thereof.

[0026] Preferably, the cone is of the type known to the skilled man which first compresses the gas before allowing the gas to expand into the silencer chamber.

[0027] An embodiment of the invention will now be more particularly described, with reference to the accompanying drawing in which:-

Figure 1 shows a silencer in accordance with the present invention which is conveniently divided into three component parts.

[0028] Referring to figure 1, a silencer 2 has an inlet 4 and an outlet 6 at either end of a cylindrical silencer chamber 8 which comprises a perforated cylindrical inner wall 10 and a co-axial outer wall 12 having an inner radius greater than the outer radius of the concentric inner wall 10 so that an annular cavity 14 is formed between the inner and outer wall 10, 12. In the example shown, the annular cavity is filled with; an annular sheath 16 which is made from stainless steel fibres and is designed to form a close fitting cylindrical envelope around the outside of the inner wall 10; and a needle mat blanket made from E-glass, the needle mat blanket filling the remainder of the annular space 14 between the said inner and outer walls 10, 12. The ends of the respective inner and outer walls are coplanar with each other and substantially coplanar with respective inlet and outlet end caps 18, 20. The rim of each cap has a depending flange 22, 24 designed to extend along the outer chamber and form a friction fit connection over the respective ends of the outer wall 12. The caps have rivet points 26 to further secure the caps to the outer walls of the silencer chamber 8.

[0029] The inlet 4 comprises an inlet pipe 30 terminating at a flange 32 which is itself mounted on the inlet cap 18. The inlet cap 18 comprises a wide but short conical section which terminates in a depending flange 22. A cone silencer component 36 is fitted to the interior of the cap 18. The inlet pipe 30, and the cone 36 are co-axial with each other with the cone being wider than the inlet tube 30. The cone itself is not a cone in the strict geometrical sense but comprises a frustoconical section 40 extending into cylindrical sections at either end thereof, with the wider tubular section extending back towards and being secured to the inlet cap 18 and the narrower tubular section extending into the silencer chamber 8.

[0030] As can readily be seen from figure 1, the effect of the cone is to initially decompress the inlet gas, via the wider cylindrical end 42 of the cone 36 and, thereafter, to compress the incoming gas through the frustoconical section 40 of the cone 36 before passing it through the narrower cylindrical section of the cone 44 before it expands into the chamber 8.

[0031] The outlet cap 20 has a centrally disposed outlet tube 50 which is angled 250° off the axis of symmetry of the silencer 2 and which is sheathed by a concentric, similarly angled wider tube 52 which may act as the exhaust pipe or may provide a mounting for the said pipe (not shown). The tube 50 which is angled off the axis of symmetry on the outside of the cap is angled so that it extends from the cap 20 into the interior of the silencer chamber 8 concentric and parallel with the axis of symmetry of the said silencer. The outlet tube 50 protrudes into the silencer chamber for about a third of the length of the latter and is partially sheathed by a perforated sheath 54 which extends from a point about two fifths of the way along the length of the outlet tube, with respect to the outlet cap 20, to beyond the innermost limit of the end of the said tube in the silencer chamber 8. The head 56 of the perforated tube 54 is non-perforated and presents a convex surface to incoming gases. The effect of the convex, non perforated surface is to deflect the gases onto the surrounding walls of the chamber. The extent to which the outlet tube 50 extends into the silencer chamber 8 determines the amount of dead space between the outlet tube and the inner walls of the chamber at the outlet end of the silencer. The dead space has been found to be important in reducing the exhaust noise, particularly at low engine revolutions. During use, the dead space generates a back pressure against incoming gases and together with the bullet head 56 helps to direct the exhaust gases through the perforations in the perforated sheath 54 which thereby exit the silencer through the outlet tube 50. The provision of a perforated sheath further extending, at least to some extent, along the length of the outlet tube and providing an annular cavity between the said outlet tube and the inner walls of the perforated sheath has been found to improve noise reduction. The mechanism of this noise reduction is not fully understood but it may be connected with the back pressure surrounding this area of the silencer chamber during use.

[0032] The extent to which the perforated sheath extends beyond the innermost end of the outlet tube 50 has also been found to affect the noise properties of the silencer.

[0033] Nevertheless, in practice, a compromise will be struck between the amount of dead space required, the amount of overlap between the perforated sheath and the outlet tube 50 and the extent to which the perforated sheath extends beyond the innermost end of the outlet tube 50. The latter feature is also affected by the heat of the exhaust gases coming into the chamber at the inlet end as it is undesirable to allow the cap of the perforated sheath to reach too high a temperature during use.

[0034] It has also been found that the inlet cone and the outlet bullet may be acting synergistically in reducing the

noise level output of the silencer. In particular, it has been found that the combination of the cone and the bullet reduce the noise level output compared with the cone alone or the bullet alone. This effect may be explained by the natural expansion of the compressed gases as they enter the silencer chamber 8 through the neck of the cone 44 causing them to be directed outwardly to the walls of the chamber and towards the dead space created by the inlet tube. This effect will assist the function of the non perforated bullet head 56 and, possibly, this may be one reason for the increased effectiveness of the silencer. The filling material for the silencer and the silencer parts may be made from any suitable material known to the skilled man. Similarly, the method of manufacture of the silencer may take any suitable form known to the skilled man.

[0035] Table 1 shows the noise characteristics of 15 silencers. Silencers 1-8 and 10-15 have been prepared in accordance with the present invention.

L = chamber length
O/L = overall bullet length
H/L = perforated head extension beyond the inward limit of the outlet tube (and excluding the non-perforated dome)
O/D = outer diameter of the chamber.
O/A = open area (ie percentage of the tube surface occupied by the area of the perforations).

[0036] Silencer 9 represents a commercial silencer. As can be seen from silencers 8 and 10-15, the cone/bullet combination and overlapping perforated sheath show a marked improvement in mid range noise and, within the preferred range of the present invention marked improvement both at mid range rpm and high range rpm.

[0037] Generally, it has been discovered that a low H/L chokes the engine response even though this gives quieter output sound. On the other hand a high H/L gives a higher noise output.

[0038] Table 1 shows the improvement in noise output in moving from the MK8 to the MK10 which is significant. A further but less marked improvement is found in moving from 55mm to 52mm in the MK11. However, although engine noise further decreases in silencers tested with H/L < 52 (not shown in Table 1), these outlets were found to be too restricted and engine performance deteriorated.

[0039] With O/L, it has been discovered that shorter lengths increase noise at high rpm but that longer lengths may cause the bullet to overheat. Furthermore, surprisingly, longer lengths have been found to introduce further vibrations and noise into the mid-range rpm which may be due to the head of the bullet entering a region of greater turbulence, this is exemplified by the MK11. A further problem is the proximity of the head to the hot gases at the inlet which causes the head to overheat and this would shorten the life of the silencer.

[0040] However, it was found that shortening the O/L length, from the MK11 caused noise to surprisingly reduce as exemplified by MK's 12-14. With the reduction being most marked in the MK13 and further reductions being less responsive as exemplified by MK14. The reduction in responsiveness being due to a reduction in the dead space which causes poorer flow characteristics, particularly at low rpm.

[0041] Advantageously, the invention provides a quieter silencer at low and mid-range rpm which is acceptable for most driving conditions but, additionally, high noise at high rpm which is attractive to riders of high performance bikes. Furthermore, these advantages are provided without loss in performance compared with conventional silencers.

[0042] The present invention also extends to a method of manufacturing a silencer in accordance with the present invention and to the use of the silencer in accordance with the present invention.

[0043] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0044] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0045] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0046] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

TABLE 1

VER	Ext Dims	Pipe Dimensions	Pack	Flow path	Idle	Characteristics
Mk1	460mm L 125mm O/D	48 mm 30% O/A Single perforated pipe	Stainless steel E-glass	Straight through	1000	Good breathing at all rpm, throb at low rpm, noise at higher rpm.
Mk2	460mm L 125mm O/D	48mm 30% O/A Single perforated pipe	E-glass	Straight through	1000	Good breathing with throb. V noisy from mid-range rpm upwards.
Mk3	460mm L 125mm O/D	78mm 30% O/A 150x32 mm t/pipe insert	E-glass	Straight through	900	Pronounced rasp at low rpm. V noisy in mid-range upwards. Roughness with rasping noise at higher rpm.
Mk4	460mm L 125mm O/D	150x78mm 30% O/A 310x48mm 30% O/A 150x32mmt/pipe insert	Stainless steel E-glass	Collard Bullet 50mm head	1000	Good breathing at low rpm. Relatively quiet & smooth in mid-range. High rpm rasping indicated restricted breathing.
Mk5	460mm L 125mm O/D	48mm 30% O/A Dimpled perforated pipe	Stainless steel E-glass	5'Offset in Perforated/pipe	1200	Good breathing. Throb at low rpm. Mid-range smooth. Noisy at higher rpm.
Mk6	460mm L 125mm O/D	185x90/48mm cone 275x48mm 30% O/A	Stainless steel E-glass	Straight through	1200	Good breathing, low rpm throb. Noisy in mid-range upwards. Popping on o/run.
Mk7	450mm L 125mm O/D	130x80/45 asym cone 400x80mm 40% O/A	Stainless steel E-needle mat	2 Offset Rose Baffles (80mm)	1500	Excellent breathing and relatively quiet at 5000 rpm. Very driveable, but still rather noisy above 6000 rpm.
Mk8	450mm L 125mm O/D	130x80/45 asym cone 400x78mm 30% O/A 60x45mm 30% O/A 160 x 35mm plain outlet (non-perforated inwardly extending pipe)	Stainless steel E-needle mat	30% O/A bullet 60 H/L,200 O/L	1500	Excellent breathing. Reasonably quiet to 5000 rpm. Noisier than Mk7 at 6000+ rpm.

Mk9		Honda VFR 400 fitted with Micron S/Through Silencer				Very noisy over all ranges.
Mk10	450mm L 125mm O/D	Development of Mk8 150x42mm I/D 30% O/A 175x35mm plain outlet	Stainless steel E-needle mat	30% O/A bullet 55 H/L 195 O/L	Reset 1000	Equal performance to top commercial units to 5000 rpm. Excellent breathing. Noisy at 9000+ rpm.
Mk11	450mm L 125mm O/D	Development of Mk10 75,42mm I/D 30% O/A 225x35mm plain outlet	Stainless steel E-needle mat	30% O/A Bullet 52 H/L, 250 O/L	1000	Noisier than Mk10 in mid-range.
Mk12	450mm L 125mm O/D	Development of Mk11 75x42mm I/D 30% O/A 210x35mm plain outlet	Stainless steel E-needle mat	30% O/A bullet 52 H/L, 235 O/L	1000	Good breathing at all rpm. Improvement on Mk10, but some popping on o/run.
Mk13	450mm L 125mm O/D	Development of Mk12 150x42mm I/D 30% O/A 200x35mm plain outlet	Stainless steel E-needle mat	30% O/A bullet 52 H/L, 225 O/L	1000	Good performer at all rpm. Significant improvement on Mk12.
Mk14	450mm L 125mm O/D	Development of Mk13 150x42mm I/D 30% O/A 190x35mm plain outlet	Stainless steel E-needle mat	30% O/A bullet 52 H/L 215 O/L	1000	Less responsive than Mk13.
Mk15	450mm L 125mm O/D	Development of Mk14 150x42mm I/D 30% O/A 180x35mm plain outlet	Stainless steel E-needle mat	30% O/A bullet 52 H/L 205 O/L	1000	Not assessed.

Claims

1. A vehicle silencer comprising; an inlet adapted to received exhaust gases, an outlet adapted to provide an exit for the said gases and a walled chamber between the said inlet and the said outlet, the said chamber having sound absorbing characteristics, wherein the chamber includes a substantially hollow bullet extending into the chamber and having a plurality of holes formed therein, the said bullet providing gas communication from the chamber to the outlet.

2. A vehicle silencer according to claim 1, wherein the vehicle is a motor bike.

3. A vehicle silencer according to any preceding claim, wherein the head of the bullet provides a barrier to the exhaust gases by being substantially free of holes.

4. A vehicle silencer according to any preceding claim, wherein the holes are formed in the side(s) of the bullet.

5. A vehicle silencer according to any preceding claim, wherein the barrier head of the bullet is substantially convex to assist in the deflection of exhaust gases onto the sides of the silencer chamber and the bullet.

6. A vehicle silencer according to any preceding claim, wherein the bullet is in the form of a sheathed inwardly extending outlet tube.

7. A vehicle silencer according to any preceding claim, wherein the sides of the sheath extend into the chamber beyond the limit of inward extension of the outlet tube.

8. A vehicle silencer according to any preceding claim, wherein the ratio of the extent of inward extension of the perforated portion of the bullet from the limit of inward extension of the outlet tube to the total inward extension of the outlet tube is between 1:1 to 1:5.

9. A vehicle silencer according to any preceding claim, wherein a silencer cone is fitted at the inlet to the silencer chamber.

10. A vehicle silencer according to any preceding claim, wherein the dead space created by the plain outlet tube at the outlet end of the silencer is between 5% and 30%.

11. A vehicle silencer according to any of claims 7-10, wherein the perforated sheath also extends over the bullet outlet tube.

12. A vehicle silencer according to any preceding claim, wherein the perforated sheath overlaps the outlet tube in such a manner as to create a small cavity between the inner wall of the perforated sheath and the outer wall of the outlet tube.

13. A vehicle silencer according to any preceding claim, wherein the cone is of the type known to the skilled man which first compresses the gas before allowing the gas to expand into the silencer chamber.

14. A method of manufacturing a silencer comprising the steps of:-
fitting a bullet in accordance with claim 1 to a silencer part during production of the said silencer.

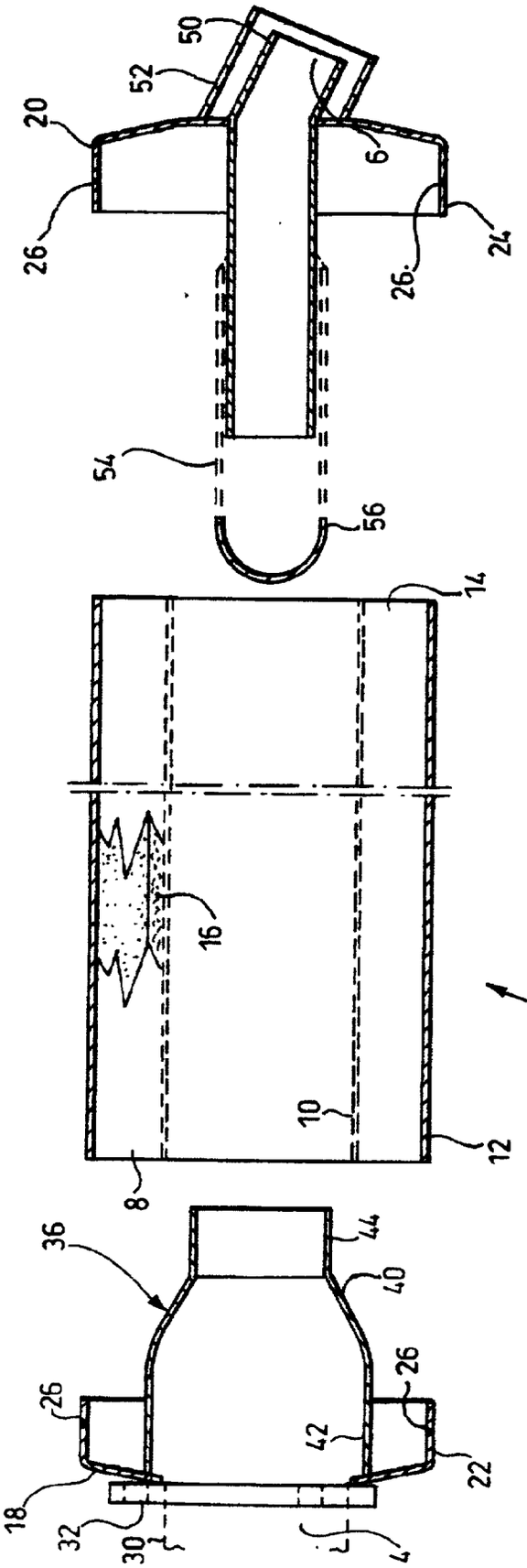

FIG.1.