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(54) **FISHBONE STANDARDISED SILENCERS FOR (INTERNAL) COMBUSTION ENGINES**

STANDARDISIERTE FISCHGRÄTSCHALLDÄMPFER FÜR BRENNKRAFTMASCHINEN

SILENCIEUX STANDARDISE DU TYPE ARETE DE POISSON POUR MOTEUR A COMBUSTION (INTERNE)

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Description

The invention relates to silencers.

In conventional silencers with reflection, expansion, absorption cavities & resonator chambers, cross flow and perforated pipe through flow configurations (fig. 7; US - A - 2502709), the gas flow did expand into the spacious cavities, and gas flow velocity and - pressure did fluctuate heavily. Turbulence was generated at the flow variation locations, causing the build-up of high back pressure (as much as 0.25 bars) or head loss.

(Expensive) stuffing did improve this situation slightly, but whatever the (expensive) precautions taken (fine mesh fleece), they did get blown - and sucked out soon, melted, burned or got clogged up, with decline of the acoustic performance, and causing pollution.

The contribution of the stuffing was braking down the gas velocity through the cavities, thus reducing the gas flow expansion into - and contraction out of the cavities, which in itself, generated new noise.

The object of the invention is to provide a silencer with which these drawbacks can be avoided. This object is achieved with a silencer according to claim 1.

In this new design, the gas flow does not expand into the shallow cells, due to their sheer shape, which keeps the (exhaust) gases from flowing into and out of them (cfr. fig. 7 with fig. 1-6).

Gas flow velocity stays constant, and little turbulence occurs at the diaphragm hole edges (depending on the ratio of flow and hole & pipe diameter "**d**").

Self generated noise is avoided.

Back pressure or head loss build-up is close to zero, thanks also to the absence of acoustic jamming.

The sound waves, however, do move into each of the numerous shallow cells, by diffraction ($\lambda > d$),and are converted from frontal waves into concentric ones, which results in axial smoothing out of the sound pressure variations.

The more diaphragms there are, the completer the conversion.

Dissipation of the low frequencies occurs in the stuffing and at the far end of the cells, and absorption into the cell walls for the versions made of porous material (ceramic, sintered f.i.). Hence again the advantage of increasing their surface by raising the number of diaphragms.

Compared to conventional design, noise reduction is intensified for the same overall silencer dimensions.

See fig. 1 to 7

Fig. 1 & 2 : Sample configuration of metallic silencers.

Fig. 3 : Sample configuration of variable cells.

Fig. 4 : Sample configuration of eccentric cross section.

Fig. 5 : Sample configuration of silencers with cartridge.

Fig. 6 : Sample configuration of monolithic silencers.

Fig. 7 : Sample configuration of conventional silencers.

The silencer is composed by an enclosure (1, 2), with preferably a near circular or elliptic cross section, to which the up- (3) and downstream pipes (4) are connected.

This enclosure is subdivided longitudinally into a high number of shallow cells, by transversal diaphragms (5).

The (exhaust) gas flows through (circular) holes in the diaphragms, approx. the same diameter as the up- and downstream pipe diameter, and aligned with these.

A high passage rate perforated pipe or mesh (6) may be running through the diaphragm holes (fig. 1& 2). This perforated pipe would facilitate the assembly and improve further the gas flow, and heat exchange.

Alternatively, the fishbone subdivision may be obtained by the introduction of a cartridge (ceramic, sintered, cast, extruded, etc.) (fig. 5), or the silencer might be produced as a monolithic construction (ceramic, sintered, casting, extrusion, etc.) (fig. 6).

The shallowness of the cells can be defined by the ratio sr

$$sr = \frac{ai}{t}$$

where **t** is the mean enclosure transversal dimension (fig. 1-6) and **ai** the axial dimension of the respective cells.

This ratio sr should be ≤ 0.5.

The high number of diaphragms stiffens the enclosure, and eliminates shell noise (fig. 1, 2, 3).

Metallic silencers of this type have their structure so well cooled that they act as heat exchangers, consequently as extractors, which improves the engine's performance.

Thanks to this feature, they can be made of aluminium alloy.

Thanks to the same feature, their service life can be really unlimited, if they are made of the suitable material. This was not possible with state of the art silencers, in which inner partitions are flooded by hot gases, feeding heat on both sides into them, accumulating it, and burning through fmally.

The new silencer is made of one single material (fig. 1-4; fig. 6) or, alternatively, is fitted with (a)cartridge(s), which is (are) easily introduced or exchanged for overhaul (fig. 5).

A cartridge implies a generally cylindrical shape.

Cross sections should be near circular or elliptic, while they are acoustically the stiffest, and allow the thinnest mantle material thickness, avoiding shell noise.

Multiple layer mantles should be avoided, because they reduce the silencer's cooling (in case of use for hot (exhaust) gases).

The diaphragms should be stiff enough and well clamped, not to transmit noise to the next cell by vibrating themselves. They can be simply or doubly curved (stamped) for maximum stiffness and lightness, and acoustical efficiency (fig. 2)

Their clamping can be by heat-shrinking of the mantle around them (either of a complete cylinder which is heated, or by the shrinkage of 1 or 2 longitudinal welds, (1 open shell or 2 part-shells) f.i.

The gas flow channel can be concentric but may be eccentric (fig. 3 & 4).

Claims

1. A silencer consisting of an enclosure (1,2) with entry and exit ducts, within which closely spaced diaphragms form a high number of shallow cells, forming a fishbone subdivision,
   the gas flowing through apertures in the diaphragms,
   the shallowness of the cells being measured by the ratio :

$$\frac{ai}{t}$$

   where :

   ai is the spacing between diaphragms, measured in the direction of gas flow (fig. 1-6).
   t is the mean transversal enclosure dimension (fig. 1-6),

   this ratio being ≤ 0.5,
   the diaphragms being flat (fig. 1, 3, 6), or simply, or doubly curved (fig. 2, 5),
   the gas flow apertures being central to the enclosure (fig. 1, 2, 5, 6) or eccentric (fig. 3, 4),
   there being one (fig. 1-3, 5, 6) or several (fig. 4) gas flows through a single silencer.

2. A silencer according to claim 1, with a perforated pipe running through the apertures belonging to each gas flow.

3. A silencer according to claims 1 and 2, in which the fishbone subdivision is obtained by a cartridge (fig. 5).

4. A silencer according to claims 1 & 2, which is produced as a monolith (fig. 6).

5. A silencer according to claims 1, 2, 3 and 4, which is made of aluminium alloy.

Patentansprüche

1. Ein Schalldämpfer bestehend aus einem Behälter mit Ein- und Auslaßkanälen, innerhalb welcher dicht aneinander angeordnete Diafragmen zahlreiche niedrige Zellen gestalten, dabei eine Fischgräteneinteilung formend, die Gase fließend durch Öffnungen in die Diafragmen,
   die Niedrigkeit der Zellen gekennzeichnet von der Ratio: ai/t ,
   wobei:

   - ai der Abstand zwischen den Diafragmen ist, vermessen in der Richtung der Gasflüsse,
   - t das mittlere Quermaß des Behälters ist,

   diese Ratio $\leq 0,5$ seiend, die Diafragmen flach seiend oder einfach oder doppelt gekrümmt,
   die Gasflußöffnungen zentral sitzend in dem Behälter (Fig. 1, 2, 5, 6) oder exzentrisch (Fig. 3, 4),
   ein (Fig. 1, 2, 3, 5, 6) oder mehrere (Fig. 4) Gasflüsse gebend durch einen einzelnen Schalldämpfer.

2. Ein Schalldämpfer gemäß Anspruch 1 mit einem perforiertem Rohr laufend durch die Öffnungen jedem Gasfluß angehörend.

3. Ein Schalldämpfer gemäß Ansprüchen 1 und 2 in welchem die Fischgrateinteilung von einem Einsatz dargestellt wird.

4. Ein Schalldämpfer gemäß Ansprüchen 1 und 2 welcher als Monolith hergestellt wird (Fig. 6).

5. Ein Schalldämpfer gemäß Ansprüchen 1, 2, 3 und 4, welcher aus Aluminiumlegierung hergestellt wird.

Revendications

1. Un silencieux composé d'un enclos (1,2) ,avec des conduites d'entrée et de sortie,a l'intérieur duquel des diaphragmes rapprochés forment un grand nombre de cellules basses,constituant une subdivision en arête de poisson,les gaz coulant à travers des ouvertures dans les diaphragmes,
   la bassesse des cellules étant caractérisée par le rapport

$$\frac{ai}{t}$$

   où

   - ai est la distance entre les diaphragmes,mesurée dans la direction d'écoulement des gaz . (fig. 1-6).
   - t est la dimension transversale moyenne de

l'enclos, (fig. 1-6),

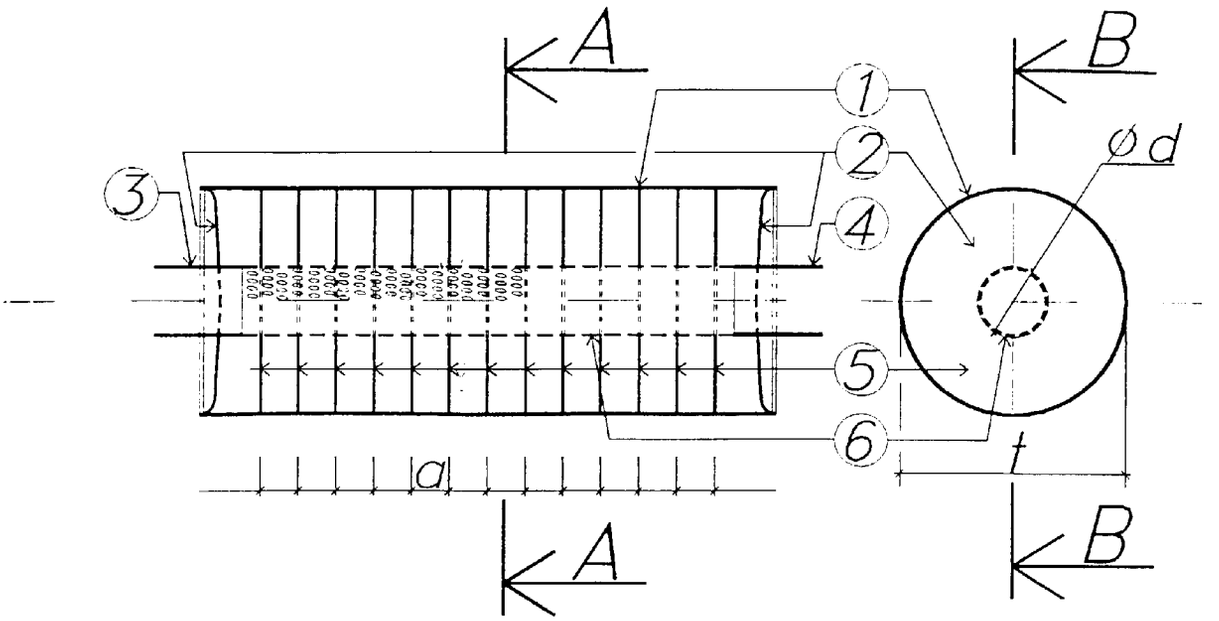
ce rapport devant être ≤ 0.5 ,
les diaphragmes étant plans,(fig. 1,3,6), ou à simple, ou à double courbature (fig. 2,5) , les ouvertures de flux de gaz étant centraux dans l'enclos (fig. 1,2,5,6),ou excentriques (fig. 3,4) ,
avec un (fig. 1,3,5,6) ou plusieurs flux à travers un seul silencieux.

2. Un silencieux selon revendication 1, avec un tube perforé passant à travers les ouvertures appartenant à chaque flux de gaz.

3. Un silencieux selon revendications 1 et 2 dans laquel la subdivision en arête de poisson est obtenue par une cartouche (fig. 5).

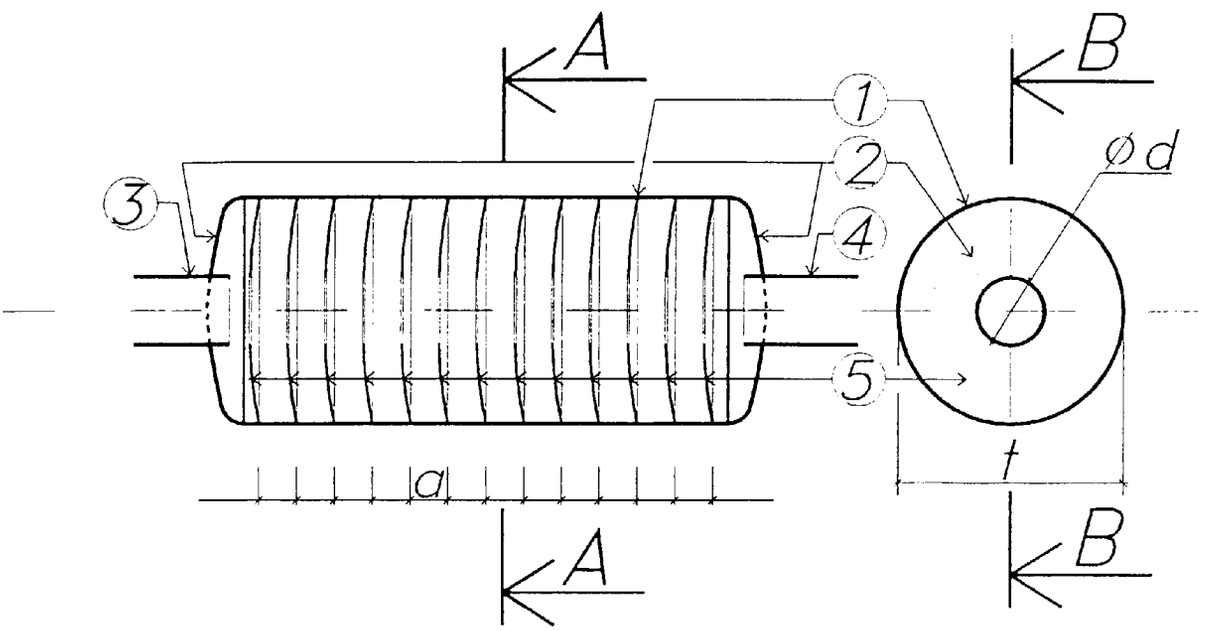
4. Un silencieux selon revendications 1 et 2 ,qui est produit comme un monolith (fig. 6).

5. Un silencieux selon revendications 1,2,3 et 4, qui est fabriqué en alliage d'aluminium.



SECTION B–B SECTION A–A

FIG. 1



SECTION B–B SECTION A–A

FIG. 2

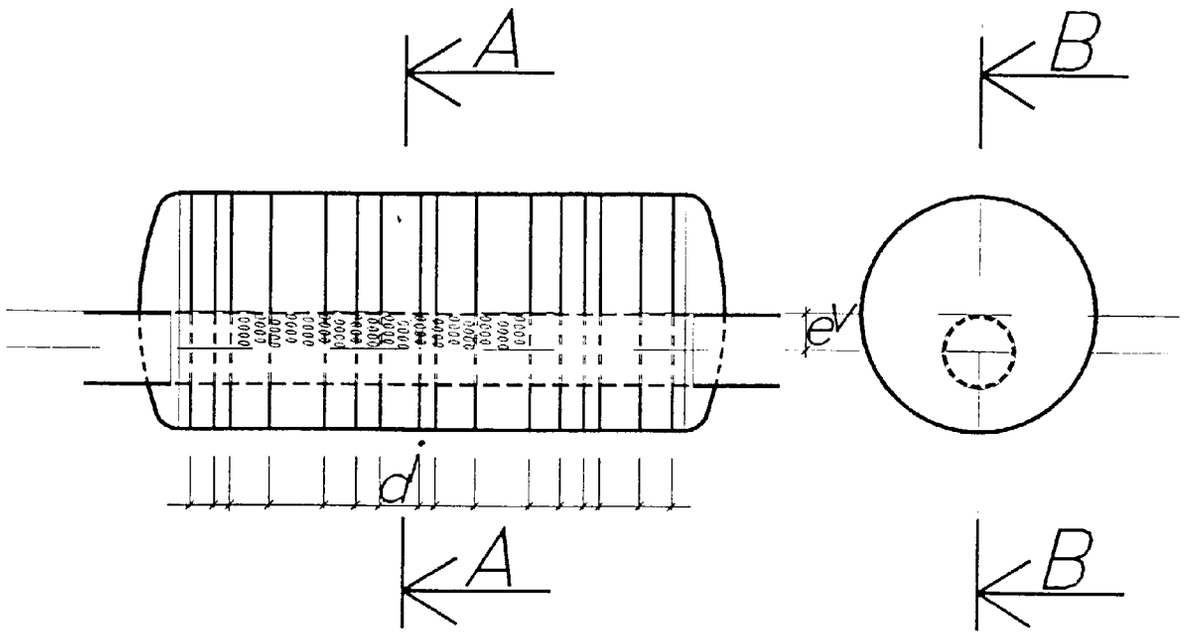


FIG.3

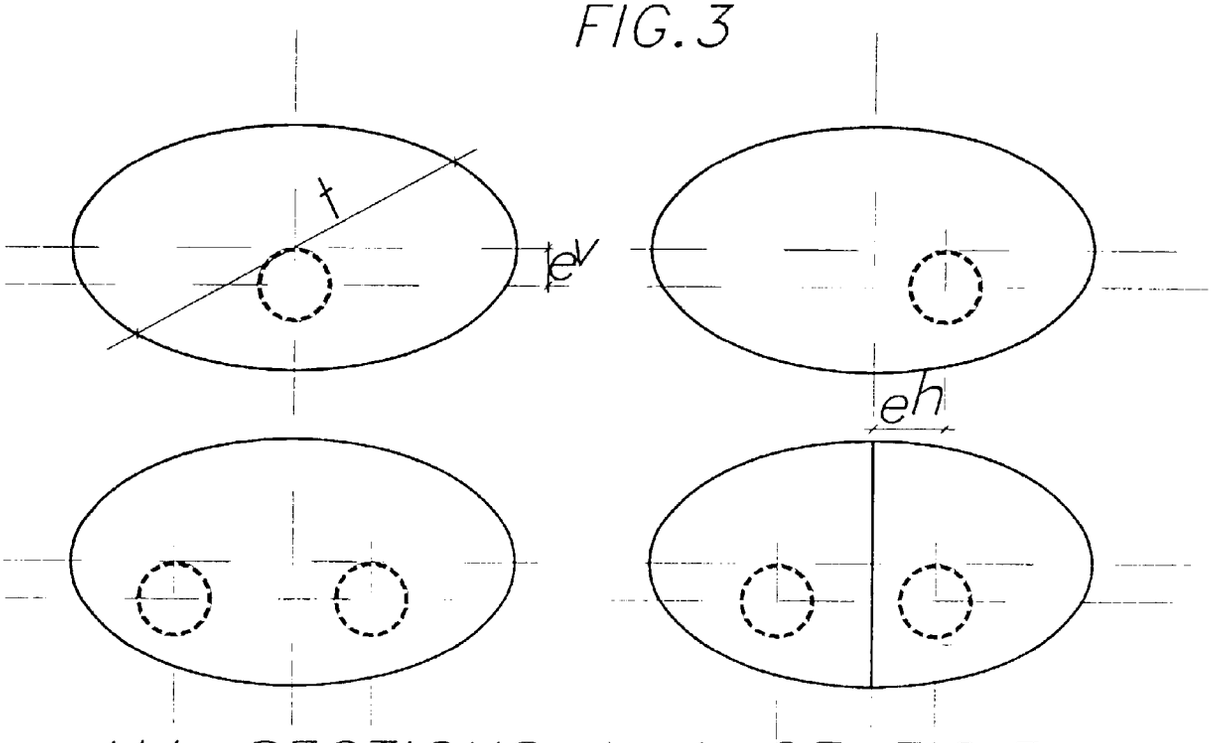
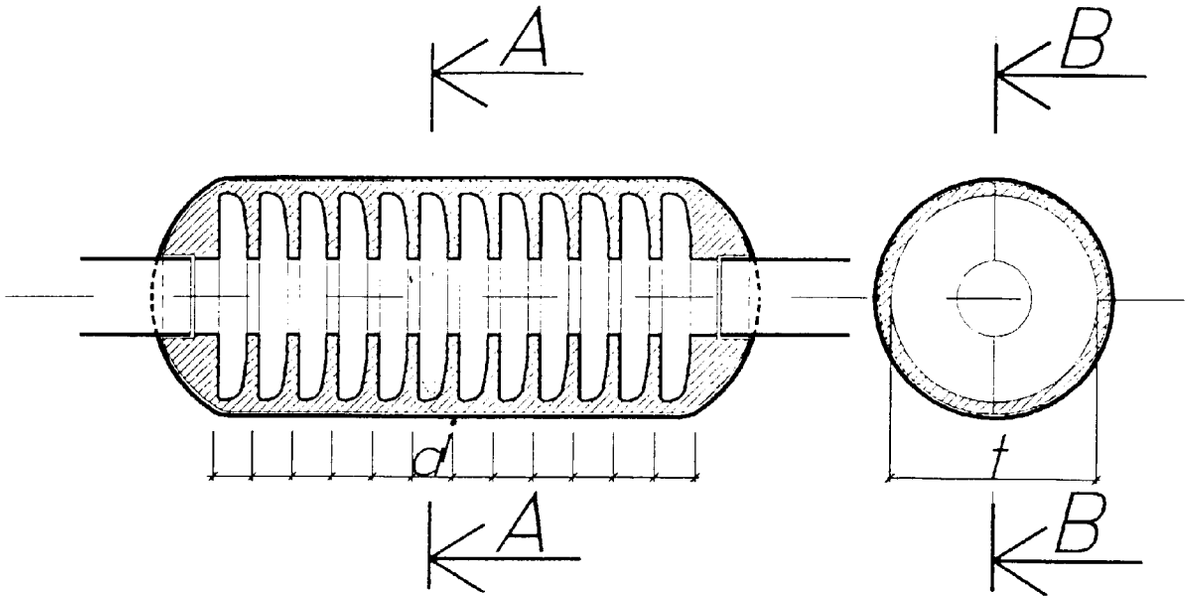
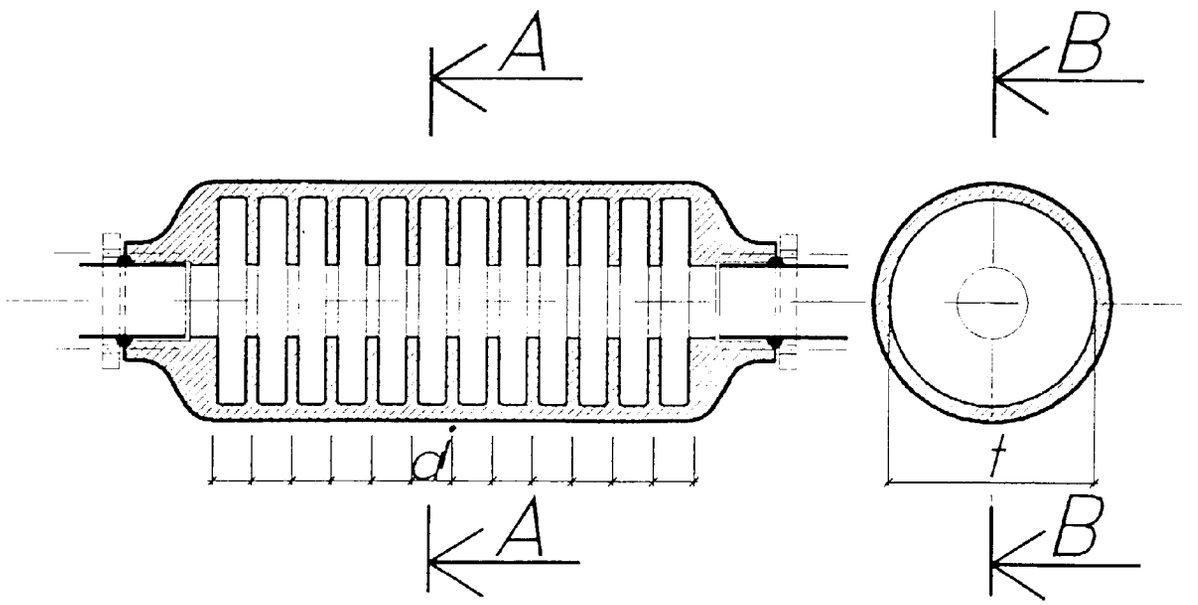


FIG.4



SECTION B–B SECTION A–A

FIG.5



SECTION B–B SECTION A–A

FIG.6

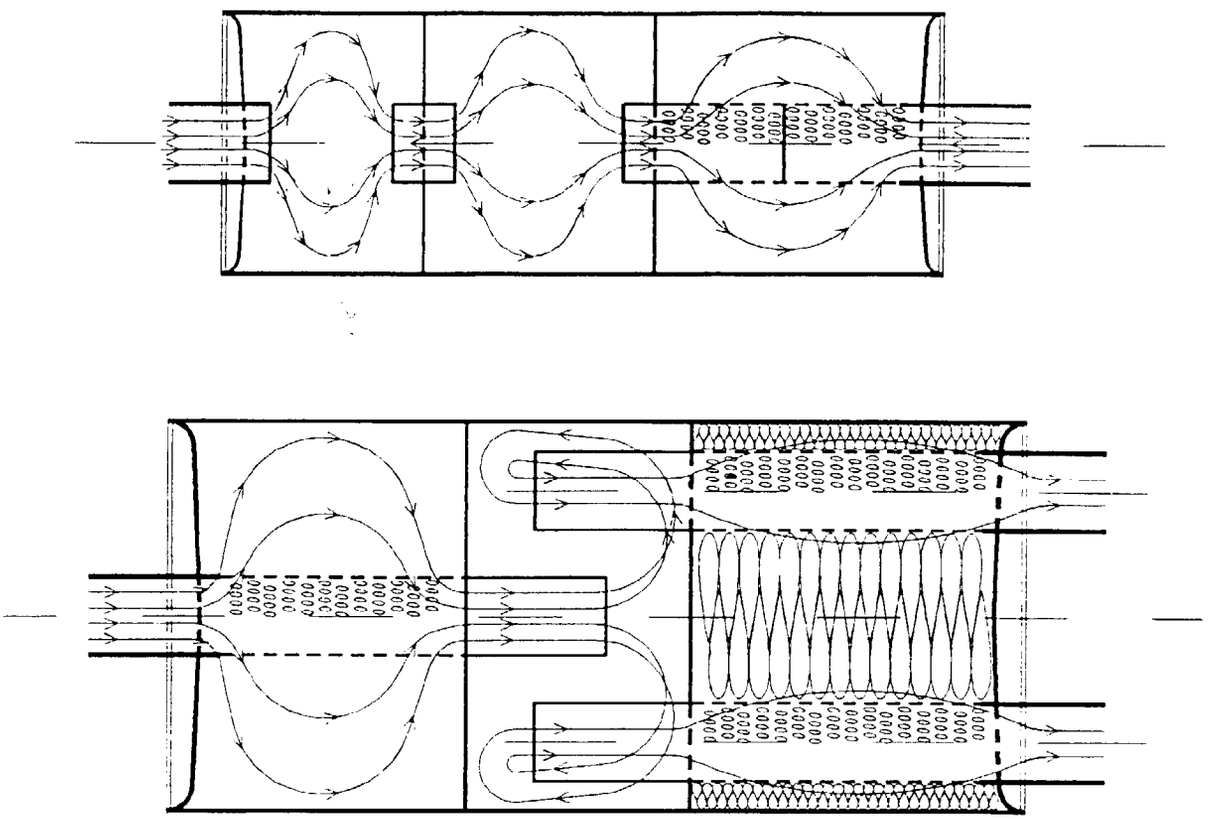


FIG. 7