

EUROPEAN PATENT APPLICATION

Application number: **90110810.0**

Int. Cl.⁵: **F01N 3/02**

Date of filing: **02.12.87**

This application was filed on 07 - 06 - 1990 as a divisional application to the application mentioned under INID code 60.

Priority: **05.12.86 IT 6790986**

Date of publication of application:
24.10.90 Bulletin 90/43

Publication number of the earlier application in accordance with Art.76 EPC: **0 270 990**

Designated Contracting States:
BE DE ES FR GB IT NL SE

Applicant: **IVECO FIAT S.p.A.**
Via Puglia 35
I-10156 Torino(IT)

Inventor: **Manfre', Giovanni**
Via Bardonecchia, 11 bis
I-10048 Vinovo(IT)
Inventor: **Giachello, Angelo**
Lungo Dora Firenze, 25
I-10100 Torino(IT)
Inventor: **Cuniberti, Francesco**
Via Breglio 127
I-10100 Torino(IT)

Representative: **Boggio, Luigi et al**
STUDIO TORTA Società Semplice Via Viotti,
9
I-10121 Torino(IT)

Regenerable filter in exhaust gases of an internal-combustion engine.

The filter is formed by a plurality of elongated honey-comb (4) each one including at least a pair of cavities (7) having walls (5,6) made of electrically conductive porous material, which is power supplied for raising the temperature if the residual combustion products of the exhaust gases. Each cavity (7) is provided with an open end and a closed end (8), the

open end of the cavities of each pair communicating one with an inlet duct, and the other with an outlet duct of the filter, thus intercepting said residual combustion products. The cells (4) are arranged in a reticulate structure (12) defined by insulating intersecting flat walls (13) to insulate the cells (4) from each other.

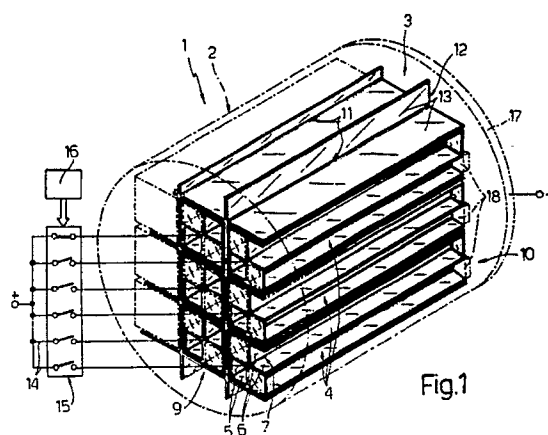


Fig.1

This invention relates to a regenerable filter in the exhaust gases of an internal-combustion engine. In particular, this invention relates to a filter suited to be placed into an exhaust pipe of an internal-combustion engine, comprising a filtering member suited to intercept the residual combustion products contained in the exhaust gases and further comprising means suited to produce the combustion of said residues.

Filters are known in which said means suited to produce the combustion of the residues are of the kind that uses a catalyst for the starting of the combustion at low temperatures, or of the kind that heats the exhaust gases, upstream of the filtering member, to the combustion temperature of said residues.

Said filters suffer from certain drawbacks.

In the case of the entirely catalytic filters, it is not uncommon the so-called "poisoning" of the catalyst, due to the presence in the exhaust gases of chemicals that impair their catalytic activity to the point of completely discontinuing the combustion of the residues; this originates a gradual clogging of the filter, with the resulting attainment of an unacceptable back-pressure on the engine exhaust.

In the case of heating filters, one of which is disclosed in the US-A- 4 276 066, the heating of the exhaust gases usually takes place by means of resistive elements positioned upstream of the filtering member, which, supplied with an electric current, generate thermal power through Joule effect and rise the temperature of the gases that affect then the filtering surface. This solution entails a high consumption of electric power, with the risk of extreme charge losses of the vehicle battery.

A further drawback of the known heating filters is the fact that the filter temperature can increase exceedingly, since the regeneration usually takes place upon rather wide surfaces and so in a scarcely controlled manner; as a result there is the possibility of serious damages or destruction due to exaggerated heatings.

For the double object of limiting the average temperature of the filter and reducing the electric power used, filters have been realized in which the filtering member is cyclically heated in relation with consecutive portions; the continuity of the filtering member nevertheless can allow the starting of wide and intense combustions. Furthermore, since the known filters of this kind the heating of the consecutive portions of the filtering member is obtained through convection and radiation, the electric power overall supplied, is always substantially higher than the equivalent of the thermal power actually needed to locally start the combustion of the residues.

Solutions in which diesel oil or other fuel burners in substitution for said resistive elements are

used, are also known; said solutions have however high costs and dimensions together with said problems connected with the regeneration.

An object of the present invention is to realize a regenerable filter for the exhaust gases of an internal-combustion engine, that lacks in the drawbacks connected with the above mentioned and known filters, and is particularly simple, practical, and removes the risks of clogging or self-destruction due to exaggerated heating.

Said object is attained by the present invention in that it relates to a regenerable filter in the exhaust gases of an internal-combustion engine, comprising an outer casing provided with at least an inlet duct and at least an outlet duct, filtering means housed into said outer casing and including a set of pairs of cavities having walls made of porous material, each one of said cavities being provided with an open end and a closed end, one cavity of each pair being provided with its open end communicating with said inlet duct, the other cavity of each pair being provided with its open end communicating with said outlet duct, whereby said porous material is apt to intercept the residual combustion products of said gases, electric heating means associated with said pairs of cavities for raising the temperature of said products, and selectively and/or cyclically operable control means for electrically supplying said heating means, characterized by a plurality of elongated honey-comb cells of a prismatic shape, each one including at least one pair of said cavities, said porous material being electrically conductive, said plurality of cells being arranged in a reticulate structure defined by two orders of intersecting flat walls made of an electrically and thermally insulating material to insulate said cells from each other, the two ends of the cavities of each cell being electrically connected to said control means to be selectively and/or cyclically electrically supplied by the intermediary of said control means.

For a better understanding of the present invention, a preferred embodiment is described below, as a non limiting example and referring to the accompanying drawings, in which:

- figure 1 is a perspective view of a regenerable filter according to the present invention;

- figure 2 is a front view, partial and in enlarged scale of a detail of figure 1.

Referring in particular to figures 1 and 2, it is designated generally by 1 a regenerable filter for an internal-combustion engine, in particular of the compression-ignition type.

The filter 1 comprises a cylindric outer casing 2, schematically shown in dotted line in figure 1, and a filtering member 3 housed into said casing 2.

The filtering member 3 comprises a plurality of honey-comb cells 4, suitably obtained from a po-

rous and electrically conductive meal, for instance of the ceramic type. Each cell 4, having an elongated prismatic shape with square section, comprises four side walls 5 and two inner division walls 6, mutually orthogonal and located along the middle planes of the cell 4, so as to define four square section cavities 7. Cavities 7 are closed at one end by a front wall 8, and open at the opposite end; in particular, two diagonally opposed cavities 7 of each cell are open at one end 9, the other two cavities of the same cell 4 being open at an opposite end 10.

According to the present invention, each cell 4 is arranged into a corresponding seat 11 of a reticulated structure 12, realized in an electrically and thermally insulating material, defined by two orders of flat, parallel and equidistant walls 13, perpendicularly intersecting one another.

Cells 4 are connected at one end 9 by means of respective electric cables 14, to the positive pole of the vehicle battery; said connection is subject to the action of interruption means 15, for instance controlled diodes, controlled by a conventional control exchange 16. The opposite ends 10 of cells 4 are connected to a metal plate 17 of the casing 2, which is provided with apertures 18 facing corresponding apertures of the cells 4 themselves, and is in electric connection with a negative pole of the vehicle battery.

The operation of the filter is as follows.

The exhaust gases emitted by the engine are conveyed in a known manner into the casing 2 of the filter 1 and enter in the cavities 7 open on the side of the end 9. Since these cavities are closed at the opposite end by the front walls 8, gases are constrained to pass through the walls 6, which intercept the residual combustion products, in order to go in the adjacent cavities 7 which are open on the side of the end 10 and allow the discharge of gases from filter 1 through the apertures 18 of the plate 17. The build-up of residues in the walls 6 originates a gradual clogging of the filter, creating a back-pressure in the engine exhaust. The control exchange 16, as a result of a signal received, for instance, from a pressure sensor detecting the pressure difference of the exhaust gas between inlet and outlet from the filter 1, causes the closing of one of the switches 15. Consequently one of the cells 4 is electrically supplied through the circuit formed by the respective cable 14, the cell 4 and the plate 17. The flow of electric current through the walls 5 and 6 of the cell 4 gives rise to a heating by Joule effect of the walls till the combustion temperature of the residues is attained, which are oxidized and gassified freeing the porosity of the cell.

Subsequently, the control exchange 16 disconnects the supply to the cell 4 and supplies the

subsequent cell 4. All the cells are supplied in sequence, according to an order and for a time predetermined or governed from time to time by the control exchange 16. For instance, the exchange 16 can control the intensity of current and the heating time of each cell 4 as a function of the revolutions of the engine and of the rate of flow of the air passing through the filter 1 by the action of an appropriate device, for instance a fan or a positive-displacement pump.

From an examination of the features of the filters realized according to the present invention, the advantages they allow to attain are obvious.

First of all, the conductive portions 4 of the filtering members 3 are mutually insulated. This enables to obtain a selective and cyclic heating of the portions, with the advantage of reducing the electric power used and keeping under control the temperature of the filtering elements 3, without any risk of clogging or of destruction due to overheating. Further, the heating of the residues takes place through conduction, that is through direct contact between the residues themselves and the conductive portions 4, which enables to exploit the most of the power supplied for the starting of the combustion, without great losses due to convection.

The ceramic filtering members 3 can have a good resistance to thermal shocks, since they are subdivided in a plurality of cells 4 having reduced dimensions and being mutually thermally insulated.

In this connection, the fibers used are suitably subjected to pre-treatments apt to avoid the embrittlement and/or the possible breakage due to phase transformation or anyway to other phenomena produced by thermal shocks. The pre-treatments can be of chemical and/or physical nature, and depending on the type of fiber used said treatments consist in the introduction or extraction of ions through diffusion in the material of the fiber.

It is then obvious that to the filter 1, described can be introduced changes or variations, without departing from the scope of the present invention. In particular, the shape, the arrangement and the composition of the conductive portions 4 and of the relative insulating portions 12 can change.

The filtering member can be produced with a combination of ceramic fabrics, felts or boards. For instance, the filtering member can comprise a series of stratified felt members; in particular, the single layers of the filtering member can be provided with pores having a geometric distribution, different dimensions and shapes, and arranged according to a porosity gradient. The electrification of the various elements can be carried out introducing in such elements electrically conductive fibers or threads. This solution enables to reduce the effect of the thermal shocks, in that the thermal con-

ductivity is increased.

It can further be fixed upon a sliding element substantially arranged on a central plane of an inner chamber of the filter, in this case suitably formed with a quadrangular cross-section, and which can readily be introduced and extracted from the outer casing of the filter.

It is possible to change the logic of the control of the exchange 16, than can control switches 15 in response to signals received from the user and/or from process sensors (for instance temperature or pressure sensors) arranged inside or outside the filter; the electric current supplying the conductive portions 4 can be modulated according to the temperature levels established in the filter.

Means for the introduction of air into the filter can be provided, in order to assure a sufficient partial pressure of oxygen in the exhaust gases and so a complete combustion of the residues.

At last catalysing additives can be provided suited to aid and optimize the combustion of the solid unburned particles. In particular said additives can suitably comprise a mixture of one or more metal-oxides, for instance CuO , Cu_2O , MnO_2 , Mn_3O_4 , PbO , CeO_2 or the respective oxygenated salts, for instance $\text{Cu}(\text{NO}_3)_2$, CuSO_4 , and of one or more chlorides of an alkaline or alkaline-earth metal for instance NaCl , KCl , LiCl , CuCl , CuCl_2 , MgCl_2 , BaCl_2 , possibly also in the hydrated form; preferably said mixture comprises CuO and NaCl . Said mixture can be in a solid form (powder) or in the form of a solution in water or other solvent, and is deposited on the filtering member in the more convenient manner, such as insufflation, spraying or immersion.

Claims

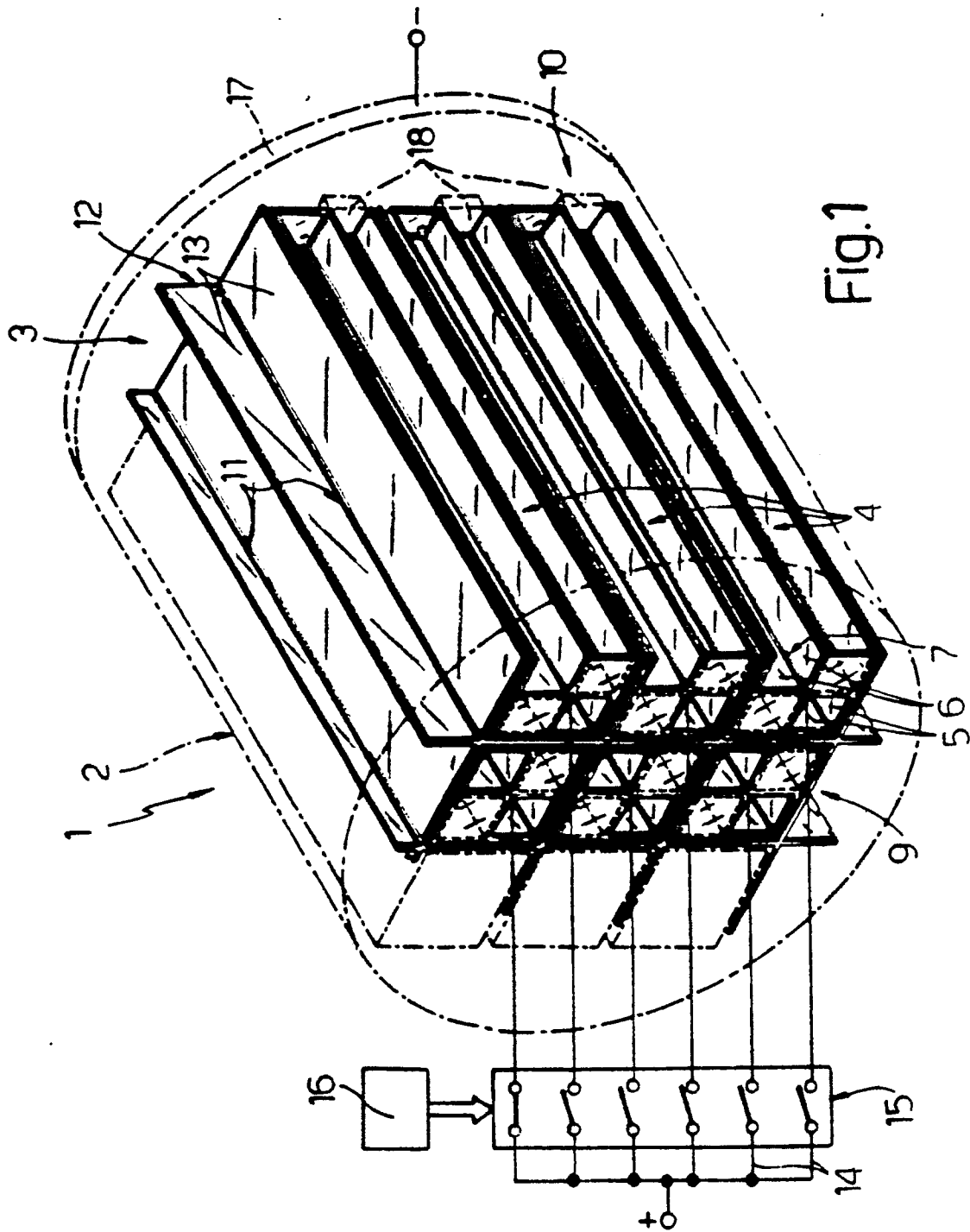
1. A regenerable filter in the exhaust gases of an internal-combustion engine, comprising an outer casing provided with at least one inlet duct and one outlet duct, filtering means housed into said outer casing and including a set of pairs of cavities (7) having walls (5,6) made of a porous material, each one of said cavities being provided with an open end and a closed end, one cavity of each pair being provided with its open end communicating with said inlet duct, the other cavity of each pair being provided with its open end communicating with said outlet duct, whereby said porous material is apt to intercept the residual combustion products of said gases, electric heating means associated with said pairs of cavities for raising the temperature of said products, and selectively and/or cyclically operable control means (15,16) for electrically supplying said heating means, characterized by a plurality of elongated honey-comb (4)

cells of a prismatic shape, each one including at least one pair of said cavities (7), said porous material being electrically conductive, said plurality of cells being arranged in a reticulate structure (12) defined by two orders of intersecting flat walls (13) made of an electrically and thermally insulating material to insulate said cells from each other, the two ends (9,10) of the cavities (7) of each cell (4) being electrically connected to said control means (15,16) to be selectively and/or cyclically electrically supplied by the intermediary of said control means.

2. A filter as claimed in claim 1, characterized in that each one of said cells (4) is provided with outer walls (5) and is internally divided by longitudinal inner walls (6), said outer walls and said inner walls being formed of said porous and electrically conductive material and constituting the walls of a group of at least two pairs of said cavities (7).

3. A filter as claimed in claim 1 or 2, characterized in that said cells (4) and said cavities (7) have a polygonal cross-section.

4. A filter as claimed in any preceding claim, characterized in that said porous and electrically conductive material is scattered with a mixture of at least one metallic oxide or one oxygenated salt suited to produce said metallic oxide and of at least one chloride of an alkaline or alkaline-earth metal.



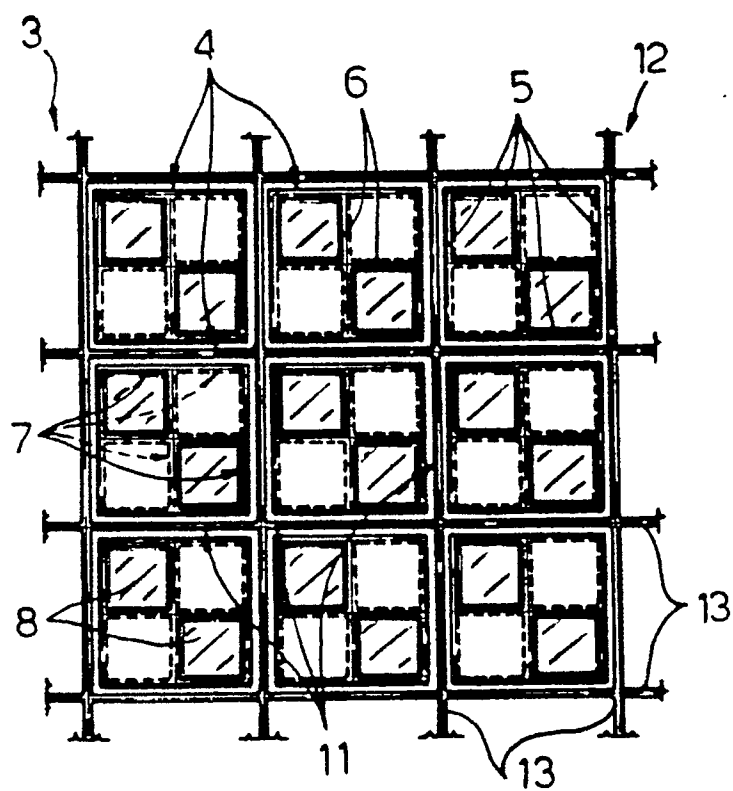


Fig.2