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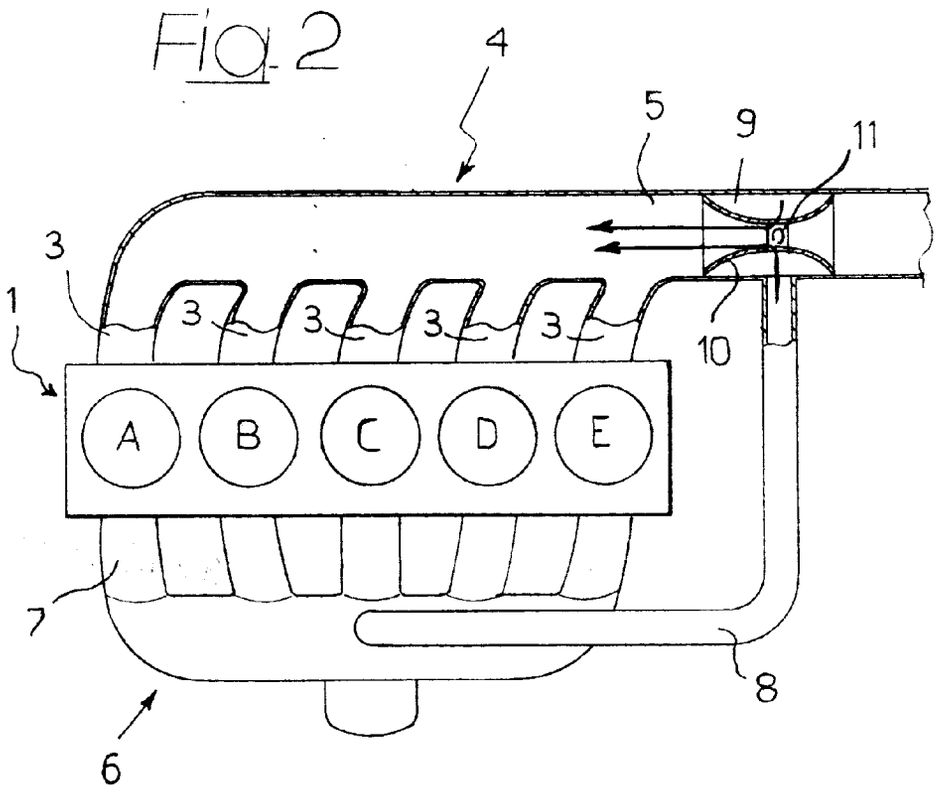
(54) Internal combustion diesel engine with exhaust gases re-circulation, provided with a device for mixing the re-circulation gases

(57) In an internal combustion Diesel engine, a conduit (8) for re-circulation of the exhaust gases into the intake manifold (4) opens on an annular chamber (9) surrounding a portion (10) of the inlet conduit (5) of the intake manifold (4) which is communicated to the latter through a plurality of apertures (11). Preferably this conduit portion (10) of the intake manifold is in form of a Venturi conduit.



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Description

The present invention relates to internal combustion Diesel engines, of the known type comprising:

- a plurality of in-line cylinders,
- an intake manifold, having an intake conduit for the air fed to the engine and a plurality of outlet brackets respectively connected to the engine cylinders,
- an exhaust manifold, for receiving the exhaust gases coming out of the engine cylinders, and
- a re-circulation conduit for the exhaust gases, connecting the exhaust manifold to the inlet conduit of the intake manifold.

The engines of the above indicated type are able to decrease the nitrogen oxide emissions efficiently, due to the re-circulation of a portion of the exhaust gases into the intake manifold. By mixing the exhaust gases and the intake air the oxygen fraction is reduced, as well as the maximum temperatures reached during combustion, which are both factors important for the formation of nitrogen oxides. The reduction of the oxygen fraction in the intake add mixture generally causes an increase of the smoke emitted by the engine. For this reason, it is necessary to carefully control the level of the exhaust gases re-circulation. In particular, it is necessary to meter the total re-circulation level correctly as well as to assure a uniform distribution of the re-circulation gases cylinder by cylinder. The electronic control systems of Diesel engines which are presently known are able to fulfil well the former function, i.e. the control of the general level of exhaust gases re-circulation. The proper distribution of the re-circulation gases cylinder by cylinder is instead a problem involving fluid dynamic aspects. The two gases (air and exhaust gases) have very different temperatures and densities and are mixed with each other with difficulty. With reference to figure 1 of the annexed drawings, which diagrammatically shows a Diesel engine with exhaust gas re-circulation of a known type, numeral 1 generally designates a Diesel engine comprising a plurality of cylinders, A, B, C, D, E in-line, which receive the intake air from respective brackets 3 of an intake manifold 4, having an inlet conduit 5. Reference numeral 6 generally designates the exhaust manifold, comprising a plurality of brackets 7 which receive the exhaust gases coming out of the engine cylinders and from which there extends a conduit 8 for exhaust gas re-circulation having one end connected to the exhaust manifold 6 (through a valve of a known type, not shown, which is electronically controlled to assure the proper quantity of exhaust gas re-circulation) and the other end opening into the inlet conduit 5 of the intake manifold 4. As it is clearly apparent, in the conventional solutions, the flow of re-circulated gas is introduced into the inlet portion of the intake manifold 4 directly. Therefore, the gases tend to remain separate, above all in conditions of high speed, from the intake air, while staying adjacent to the portion of the wall of conduit 5 which is located on the side opposite with respect to the area where conduit 8 opens. The gases tend to remain adjacent to this wall until they reach the opposite end of the intake manifold, without mixing with the air. As a result of this, the re-circulation exhaust gases tend to fill more the cylinders of the engine which are more far away with respect to the area where the re-circulation conduit 8 opens, while filling less those cylinders which are closer to this area. This solution is shown in the diagram of figure 5 which shows the re-circulation percentage for each cylinder and for each average value of re-circulation of the exhaust gases into the engine. The various lines in the diagram relate to the various cylinders and show how the re-circulation of the exhaust gases is lower in the cylinders which are closer to the merging point of the re-circulation conduit 8.

The object of the present invention is that of overcoming the above-mentioned drawback.

In view of achieving this object, the invention provides an internal combustion Diesel engine of the type indicated at the beginning, characterized in that the end of the re-circulation conduit for the exhaust gases which is connected to the intake manifold opens on an annular chamber surrounding a portion of the inlet conduit of the intake manifold which is communicated thereto through a plurality of apertures.

Preferably, the above-mentioned apertures are uniformly distributed along the circumferencial wall of said portion of the inlet conduit of the intake manifold.

Due to the above-mentioned features, the exhaust gases which merge into the intake manifold are compelled to mix with the air at the inlet of the intake manifold before proceeding further towards the cylinders, so that the uniformity of gas re-circulation into the various cylinders of the engine is assured.

In a preferred embodiment, in order to minimize the load losses in the intake manifold and to facilitate the flow of re-circulation gases, the above-mentioned portion of the inlet conduit of the intake manifold which is surrounded by the annular chamber on which the re-circulation conduit opens is provided in form of a Venturi conduit.

Thus, beyond the improvement in the distribution of the re-circulation gases among the cylinders, also an increase of the re-circulation capability is achieved. Indeed, the vacuum which is generated at the throttling section of the Venturi conduit increases the amount of re-circulation of the exhaust gases without adding further devices (such as throttling valves in the intake manifold) as it is sometimes done according to the prior art. A further advantage of the above-mentioned solution lies in the reduction of the noise coming from the intake, which is a per se known feature deriving from the use of a Venturi nozzle located at the inlet of the manifold.

Further features and advantages of the invention will become apparent from the description which follows with reference to the annexed drawings, given purely by

way of non limiting example, in which:

figure 1 is a diagrammatic view of a Diesel engine according to the prior art,
figure 2 is a diagrammatic view of an embodiment of the engine according to the invention,
figure 3 is a cross-sectional view at an enlarged scale of the mixing device forming part of the engine according to the invention, according to a preferred embodiment,
figure 4 shows a variant of the mixing device,
figure 5 is a diagram which shows the distribution of the re-circulation gases among the various cylinders of an engine according to the prior art, and
figure 6 is a diagram similar to that of figure 5 which shows the same situation in the case of the engine according to the invention.

In figure 2, parts corresponding to those of figure 1 described above have been designated by the same reference numeral. As clearly apparent from a comparison of these figures, the main features of the engine according to the present invention lies in that the conduit 8 for re-circulation of the exhaust gases does not open directly on the inlet conduit 5 of the intake manifold 4, as in the case of the engine according to the prior art shown in figure 1. In the case of the engine according to the invention shown in figure 2, the conduit 8 opens on an annular chamber 9 surrounding a portion 10 of conduit 5. The annular chamber 9 communicates with the inner passage of conduit 10 through a plurality of apertures 11 (see also figure 3) uniformly distributed in the circumferencial direction. In this manner, the exhaust gases coming from conduit 8 are compelled to be mixed with the intake air at the inlet of manifold 4 before proceeding further towards the cylinders of the engine, so that a uniform distribution of the exhaust gases among the various cylinders is assured.

As shown in figure 2 and figure 3, the preferred embodiment of the invention provides a conduit 10 in form of a Venturi conduit. In this manner, as indicated already above, the load losses in the intake manifold are minimized and the flow of the re-circulation gases is facilitated. The minimum cross-section of the Venturi conduit is not to jeopardize the volumetric efficiency of the engine and not to reduce the maximum performance.

Figure 3 shows the case in which the Venturi conduit 10 is made by an insert mounted within the section 12 of the intake manifold, in which there is formed a transverse hole 13 for inserting the re-circulation conduit 8. However, it is clearly apparent that the Venturi conduit 10 could be made in one piece with the intake manifold. Also, in the example illustrated in figure 3, the apertures 11 are in number of four, each extending throughout an angle of a little less than 90° along the circumferencial direction of the throttling section of the Venturi conduit 10. However, it is clearly apparent that any other shape of conduit 10 and apertures 11 is possible.

By way of example, figure 4 shows the case of a conduit 10 which is not in form of Venturi and has a plurality of circular apertures 11 which are angularly distributed along circumferencial direction.

Figure 6 is a diagram corresponding to that of figure 5 which has been already described above, which is made by testing the engine according to the invention. As shown, the lines corresponding to the re-circulation of the exhaust gases in the various cylinders of the engine are substantially coincident.

As clearly apparent from the foregoing description, the engine according to the invention solves therefore simply and efficiently the problem of uniform distribution of the re-circulation of the exhaust gases in the various cylinders of a Diesel engine, while obtaining, in the case of the preferred embodiment which makes use of a Venturi conduit, an increase of the re-circulation capability, due to the vacuum which is generated at the Venturi throttling section, without adding further devices, and while reducing the noise coming from the intake.

Naturally, while the principle of the invention remains the same, the details of construction and the embodiments may widely vary with respect to what has been described and illustrated purely by way of example, without departing from the scope of the present invention.

Claims

1. Internal combustion Diesel engine comprising:

   - a plurality of in-line cylinders (A-E),
   - an intake manifold (4), having an inlet conduit (5) for the engine intake air and a plurality of outlet brackets (3) respectively connected to the cylinders of the engine (A-E),
   - an exhaust manifold (6), for receiving the exhaust gases coming out of the cylinders of the engine, and
   - a conduit (8) for re-circulation of the exhaust gases, which connects the exhaust manifold (6) to the inlet conduit (5) of the intake manifold (4),

   characterized in that the end of the conduit (8) for re-circulation of the exhaust gases which is connected to the intake manifold (4) opens on an annular chamber (9) surrounding a portion (10) of the inlet conduit (5) of the intake manifold (4) and which is communicated to the latter through a plurality of apertures (11).

2. Internal combustion engine according to claim 1, characterized in that the above-mentioned apertures (11) are uniformly distributed along the circumferencial wall of said portion (10) of the inlet conduit (5) of the intake manifold (4).

3. Internal combustion engine according to claim 1, characterized in that the above-mentioned conduit portion (10) is in form of a Venturi conduit.

Fig. 1

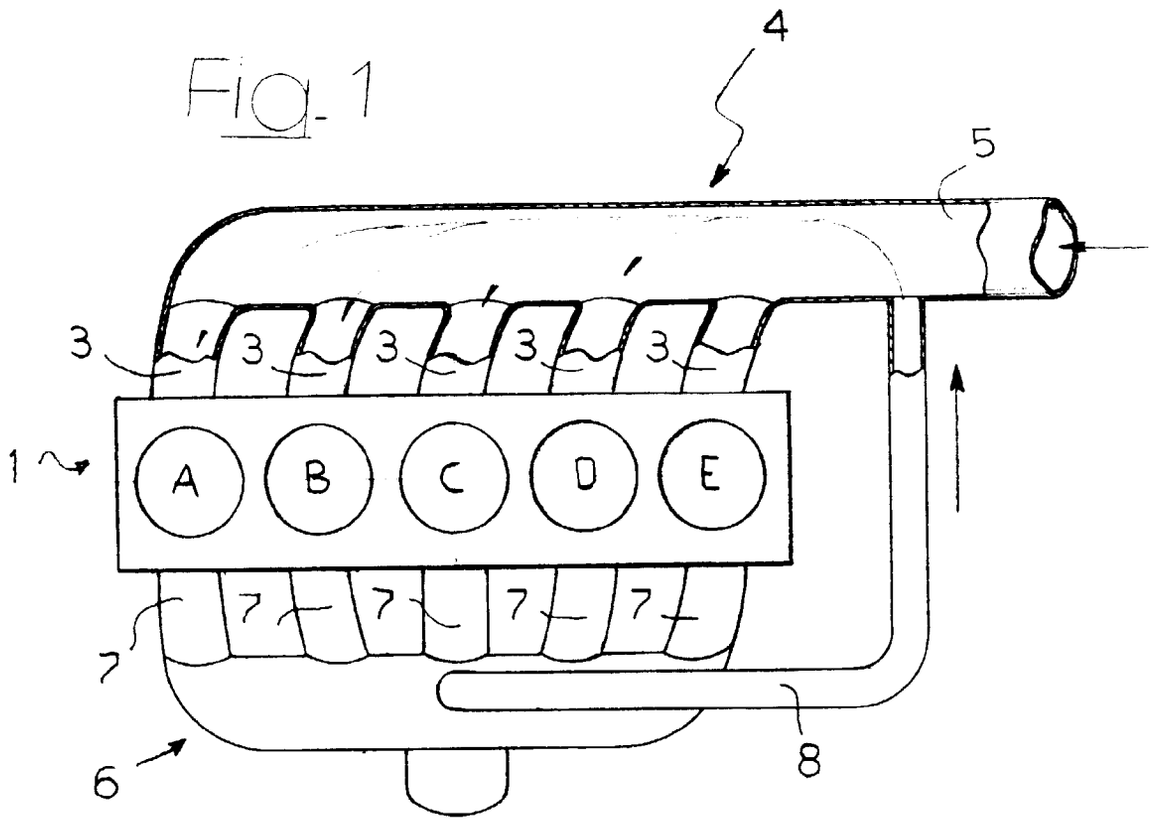

Fig. 2

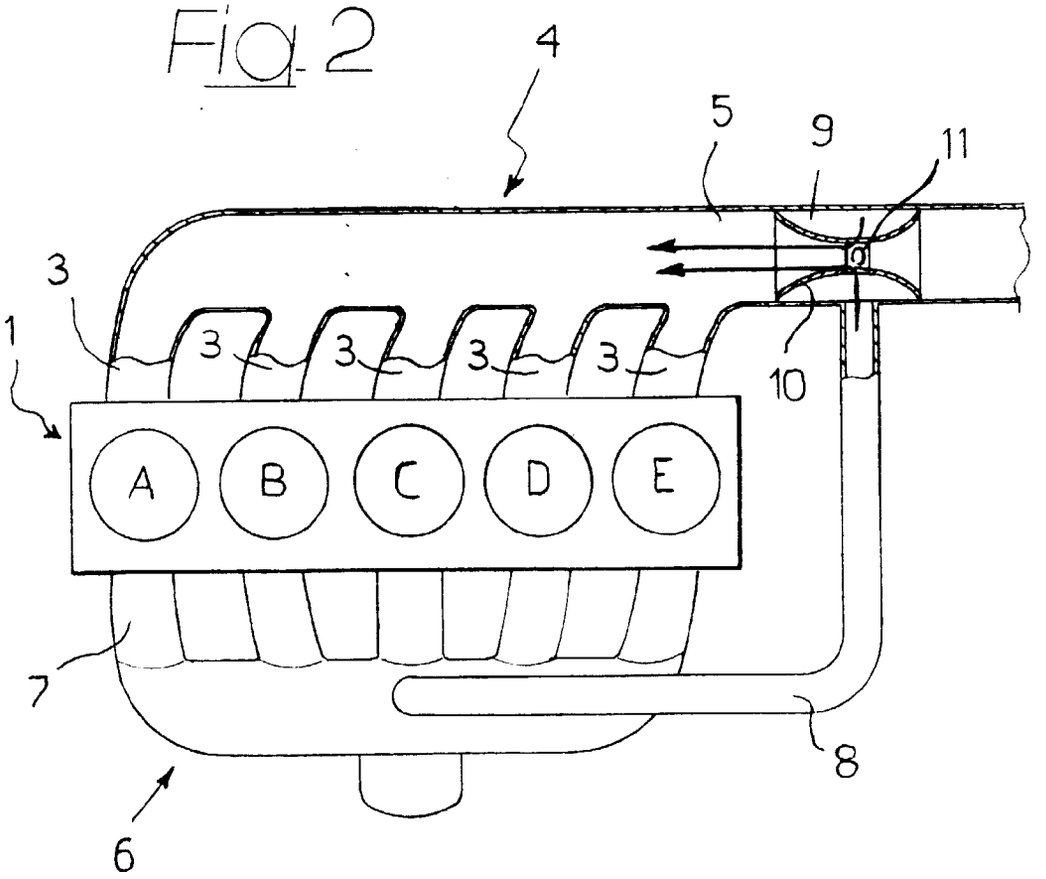

Fig. 3

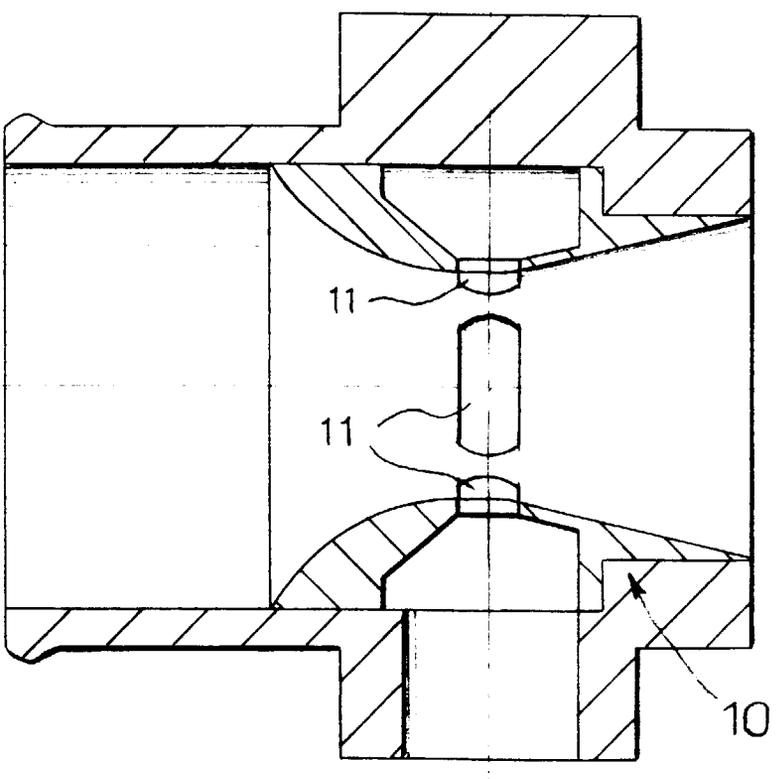

Fig.4

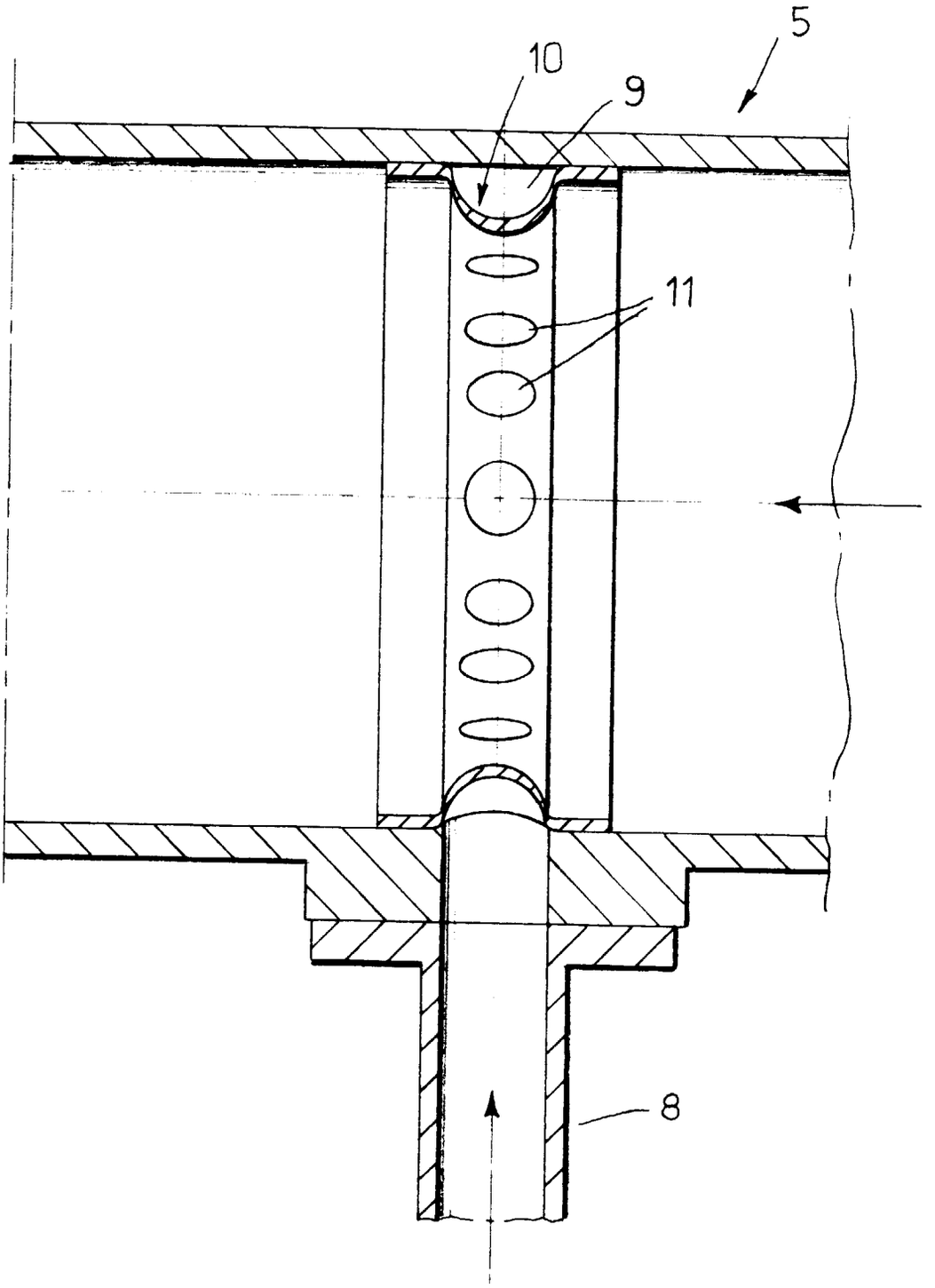

Fig.5

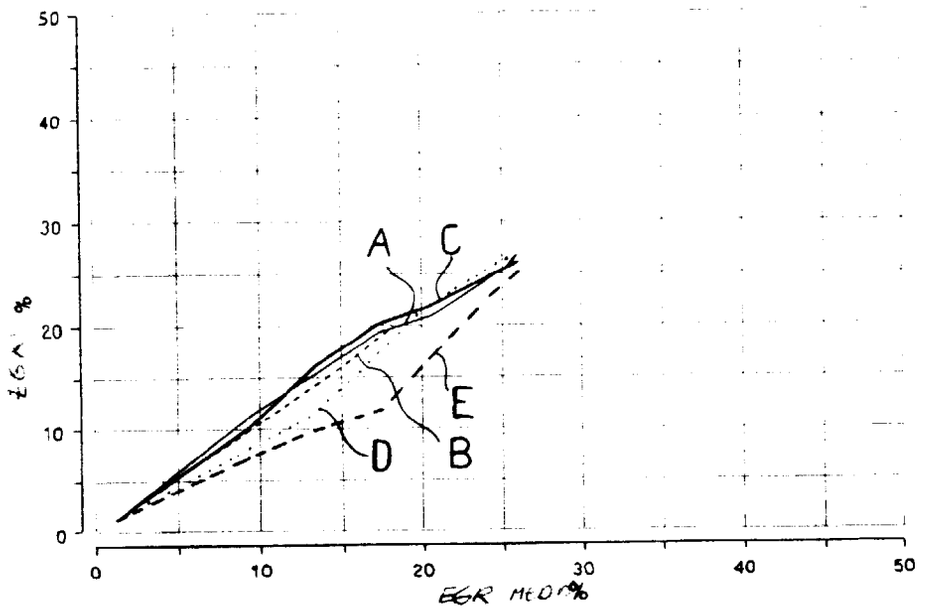
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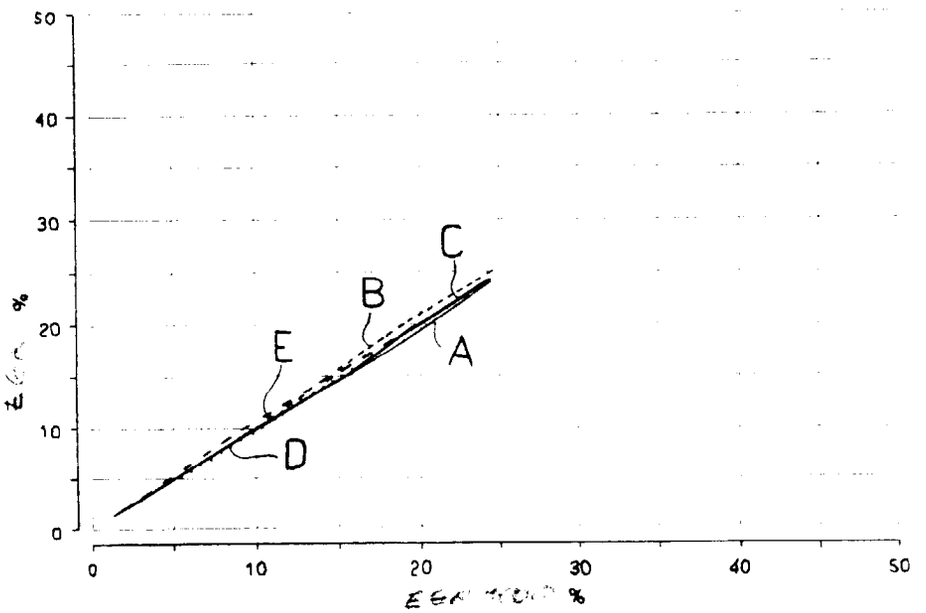
Fig.6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