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(54) Noise reducer for wayside acoustical barriers

(57) The noise reducer comprises tubular members such as spiral tubes (18), or tubes made of two half-shells (22, 24; 26, 28; 40), having at least partially perforated walls and internally lined with a sound-absorbing material (25; 36), and longitudinally fastened to the top of the barrier. A sound-reflector tube (44) may be nested within each tubular member (40).

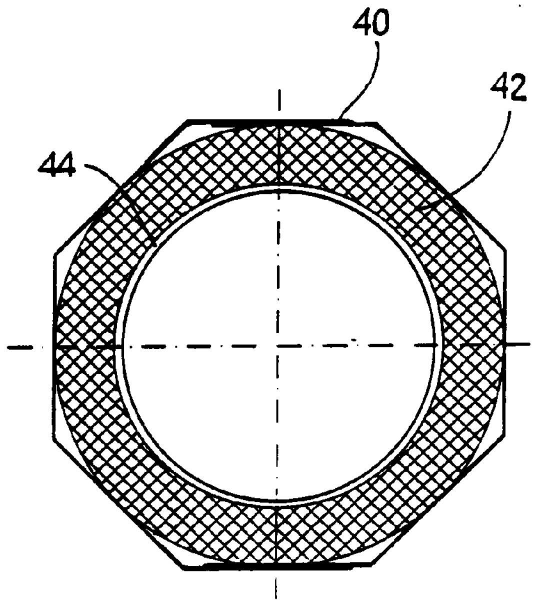

Fig. 6

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Description

This invention is concerned with a noise reducer for acoustical barriers, particularly for protecting dwelling areas from noise coming from highways and railways, although it can be applied for protection from noise generated in industrial yards, quarries, and the like.

Acoustical barriers as presently installed along urban and suburban stretches of highways or the like generally comprise panels of porous concrete or other material, which are erected to form a wall on the side of the highway, which wall partly absorbs and partly reflects the acoustical waves generated by the vehicles in transit. The purpose of such barriers is eliminate or at least attenuate the noise level, or "acoustical pollution", which otherwise would reach the houses placed along the highway, propagating as a spherical acoustical wave from its source, i.e. from the passing vehicle, which is typically only slightly above the highway ground. In order to provide an effective protection, the barrier should therefore extend upwardly to a height intercepting an imaginary line connecting the pavement of the highway to the highest stories of the buildings behind the barrier; the wave diffraction beyond the barrier edge is here disregarded. It is evident that, if buildings have four or five stories or more, the barrier should be several meters tall, say 8 to 10 meters or more, with unacceptable associated costs, and with an unpleasant impact on the environment.

In practice, as known, acoustical barriers are mostly erected in heights not exceeding 2 to 3 meters, thus accepting an acoustical protection which is limited to the lower stories of the buildings which should be protected.

The main object of the invention is therefore to provide a noise reducer for use with conventional acoustic barriers, which will enhance their effectiveness for the same overall height, so that a desired barrier effect is achieved at a lower cost and with a less conspicuous environmental impact than with an equivalent conventional barrier.

Another object is to provide such noise reducer so that it has a excellent weather-resistance so that it can operate for a long time with little maintenance.

A further object is to provide a noise reducer that can be manufactured by processes not requiring dedicated, high-cost equipment.

The above and other objects and advantages, such as will appear from the following disclosure, are achieved by the invention with a noise reducer for improving the effectiveness of an acoustical barrier, characterized in that it comprises tubular members having an at least partly perforated wall and internally lined with sound-absorbing material, which are longitudinally fastenable along the top of the barrier.

A few preferred embodiments of the invention will now be disclosed, by way of non-limiting example, with reference to the attached drawings, wherein:

Fig. 1 is view in front elevation of a acoustical barrier provided with a noise reducer according to a first preferred embodiment of the invention;

Fig. 2 is a view in transverse cross-section made on line A-A of Fig. 1;

Fig. 3 is a view in transverse cross-section, to a enlarged scale, of the noise reducer according to the first embodiment of the invention;

Fig. 4 is a view in transverse cross-section, also to an enlarged scale, of a noise reducer according to a second embodiment of the invention;

Fig. 5 is a view in transverse cross-section, also to an enlarged scale, of a noise reducer according to a third embodiment of the invention;

Fig. 6 is a view in transverse cross-section, also to an enlarged scale, of a noise reducer according to a fourth embodiment of the invention.

Figs. 1, 2 and 3 show a first embodiment of the invention, as applied to a partly transparent barrier. On a row of footstalls 10 sunk in the ground on the side of a highway not shown, respective stakes 12 made of metal beams, say H-beams, are supported by means of flanges 11. Prefabricated panels 14 of porous concrete are arranged between the stakes. Above panels 14 and between stakes 12, respective sheets 15 of transparent polymetacrylate are also arranged, and finally girders 16 fastened through flanges 17 extend between the tops of stakes 12.

According to the invention, a noise reducer is arranged along the top of the barrier, which noise reducer comprises spiral tubes 18 of perforated aluminum plate which is curved helically and is laterally swaged (as is known to a person skilled in the art), of about 300 mm diameter. Tubes 18 lie longitudinally on the top of the barrier and are fastened to the barrier by means of straps 19 having their opposite ends attached to stakes 12 or to girders 16 with bolts 20. The ends of spiral tubes 18 are joined to one another by means of bolted joints 21, which comprise respective enveloping plates or stubs of spiral tube of slightly larger diameter, not shown.

The plate of tubes 18 is riddled with holes of, say, 5 mm diameter, the percentage of riddling being 30 to 35%. Within the tube, fiberglass 25 is placed within the tube as a lining arranged peripherally along its inside wall. The fiberglass has a preferred density of about 80 kg/m^3.

Experiments conducted on a barrier so improved by the addition of the noise reducer as described above have shown that the barrier provides a noise reduction equivalent to a conventional barrier which is 1 to 1.5 m taller. In other words, the noise reducer with 300 mm diameter has a effect equivalent to a barrier raising made conventionally with panels of porous concrete, in a degree of 3 to 4 times its diameter.

A 2-meter high acoustical barrier was subjected to tests in an anechoic room, with and without the noise reducer of 300-mm diameter as described above. As a source of noise, a loudspeaker was used which was encased in a perforated tube lying on the ground at 1.3 meters from the barrier and parallelly to it. A measuring microphone was placed on the other side of the barrier at a height of 4 meters and at several horizontal distances D from the barrier. A white-noise signal in the range 50 to 10,000 Hz was applied to the loudspeaker, at a arbitrary, high volume. The overall sound levels L (50 to 10,000 Hz) were measured with the microphone in dB(A). The following results were obtained:

Table I

D (meters)	3	4	5	6
L (dBA)				
conventional barrier	75.7	73.1	71.2	69.7
barrier with spiral noise reducer	71.2	68.8	67.3	66.5

It can be seen that the attenuation improvement brought about by the noise reducer of the invention is 3 to 4 dB, which amounts to a halving (or more) of the sound level with respect to the conventional barrier.

Fig. 4 shows a second embodiment of noise reducer according to the invention. The reducer is similar to the first embodiment, and is mounted on the barrier in the same way, but it is formed from octagonal tubes of perforated aluminum plate rather than from spiral tubes.

Preferably, each octagonal tubes is fabricated by bending two rectangular plates 22, 24 with four longitudinal bends, to obtain respective half-shells each comprising five pans angled at 45° to one another, so that the two end pans are parallel. The half-shells 22, 24 are then frontally approached and their respective end pans are overlapped and then rivetted together to obtain the completed tube. The tube is then internally lined with a layer of fiberglass 25 similar to the fiberglass of Fig. 3.

The plate of half-shells 22, 24 is perforated in its intermediate pans with holes of 3 mm diameter, with a percentage of perforation 25 to 30% of the overall surface.

Tests made in an anechoic room, identically to the tests described above, but with a 300 mm size reducer, manufactured according to the second embodiment of the invention, have led to the following results:

Table II

D (meters)	3	4	5	6
L (dBA)				
conventional barrier	75.7	73.1	71.2	69.7
barrier with octagonal noise reducer	72.0	70.4	68.4	67.2

The octagonal tube has the advantage that it can be manufactured with simple bending machines, and does not require the more expensive equipment for the manufacture of spiral tube. Moreover, in the octagonal tube the portion of the plate facing upwards may be left solid (i.e. non-perforated), so that fiberglass is partly protected from rain and snow.

Fig. 5 shows a third preferred embodiment of a noise reducer according to the invention. Here the noise reducer comprises a tube of aluminum plate shaped as an irregular, elongated hexagon, having a narrow base pan, two wide, slightly diverging lateral pans, two narrow, sharply converging pans, and finally a horizontal, closing top pan. Only the lateral diverging pans are perforated, e.g. with 6-mm holes, with a perforation percentage of 30 to 35%.

Preferably, the tube of Fig. 5 is made from two half-shells of metal plate, a lower half-shell 26 and an upper half-shell 28. Upper half-shell 28 has bent edges 30 coupling with the edges of lower half-shell 26 and rivetted to them. The lateral diverging pans are preferably provided with stiffening creases 32, and, moreover, a metal C-section 34 is internally rivetted to the upper half-shell, also for stiffening purposes. The internal surfaces of the diverging pans are lined with respective fiberglass mattresses 36, similarly as described above.

Other tests were conducted, similar to the tests reported above. However, here the barrier was 1 meter high, and the microphone was placed at a height of 3.15 meters, at several distances, with a conventional barrier, with a barrier provided with the two first embodiments of noise reducer as described above (300 mm diameter), and with a barrier provided with hexagonal-tube reducer, for an overall height of 400 mm . The results obtained are as follows:

Table III

D (meters)	3	4	5	6
L (dBA)				
conventional barrier	83.6	79.6	77.7	76.0
barrier with spiral noise reducer	79.9	77.3	76.0	74.3
barrier with octagonal noise reducer	79.6	76.2	75.5	74.3
barrier with hexagonal noise reducer	77.9	75.3	73.0	71.4

It can be seen that also the third embodiment of reducer gives similar results with those of the previous embodiments, in fact slightly better. Moreover, the hexagonal-tube reducer has the advantage of a practically complete protection of the fiberglass from the weather, due to to the upper half-shell extending over the entire width of the reducer.

The physico-acoustical mechanism which accounts for the effect provided by the noise reducer is not fully understood. However, the explanation is believed to lie essentially in the alteration of the diffraction phenomenon which the sound wave undergoes while passing over the top of the barrier. In the conventional barrier, the transition from the stiff material of the barrier to the air is sharp, and the diffraction, which deviates a portion of the acoustical power downwards, is therefore considerable. On the other hand, when the noise reducer is operating, the transition between the two propagation media (barrier-air) is more gradual, and it is assumed that the wave striking the top edge is diffracted to a lower degree. In other words, the fraction of power which, with the conventional barrier, would overcome the barrier by diffraction, now will enter the holes in the plate and be absorbed by the sound-absorbing material. However, other, less evident effects may possibly contribute.

Moreover, in the case of a noise reducer using a hexagonal tube, the enhancement of its effectiveness is probably also aided by the reflected power fraction being deviated toward the ground by the inclination of the operative surfaces of the reducer.

Fig. 6 shows the fourth embodiment of the invention, which is similar to the second embodiment shown on Fig. 4, inasmuch as it comprises an octagonal tube 40 of perforated plate which is internally lined with fiberglass 42. However, this embodiment also comprises a tube 44 with non-perforated wall, placed floating in the space left empty by the fiberglass lining. Tube 44 may be a spiral tube with a thin wall (e.g. 0.5 mm) of galvanized steel, which is kept in position by the fiberglass mattress.

The effect of the solid-walled tube 44 is to reflect back the fraction of sound power which, having entered the outside tube, crosses the fiberglass barrage. This power, if the internal tube were missing, would emerge from the holes of tube 18 on the opposite side, though further damped by the interposed fiberglass. In other words, tube 44 forms, together with outside tube 40, an annular space where the acoustic power is trapped and is damped progressively while it bounces between both tubes.

Although aluminum plate is the preferred material for the manufacture of the tubes because of its lightweight, the invention also envisages using steel plate in all the listed cases, and in this case welding might be more expedient instead of rivetting.

The person skilled in the art will understand that the noise reducer according to the invention, in its various forms an materials envisaged, can be manufactured without any special, expensive equipment being required, such as moulds and the like, but rather by use of only conventional, well available machines, such as benders, rivetters and the like.

The preferred embodiments disclosed above have been given by way of example, and the teachings of the invention can be carried out in numerous other forms. The tubular members may be manufactured by other technologies and have other geometries. In manufacturing the half-shells, the plates could curved rather than bent with sharp angles. Moreover, another sound-absorbing material might be used instead of fiberglass, such as rock wool or other. The fastening means might also be different. In particular, say in the third embodiment shown, it might be advantagaous to attach the noise reducer to the underlying barrier by means of bolts crossing the base pan of the lower half-shell, and to assemble the upper half-shell onto it only after installation on the barrier.

Claims

1. Noise reducer for improving the effectiveness of a acoustical barrier (10, 12, 14, 15), characterized in that it comprises a plurality of tubular members (18; 22, 24; 26, 28; 40) each having an at least partly perforated wall and each being internally lined with sound-absorbing material (25; 36; 42), which tubular members are longitudinally fastenable along the top of the barrier.

2. The noise reducer of claim 1, characterized in that a tubular reflector (44) is arranged within each of said tubular members (40) so that it adheres to the sound-absorbing material (42).

3. The noise reducer of claim 2, characterized in that said tubular reflector (44) has a non-perforated wall.

4. The noise reducer of any of claims 1 to 3, characterized in that said tubular members (18; 22, 24; 26, 28; 40) and said tubular reflectors (44) are made of metal plate.

5. The noise reducer of claim 4, characterized in that said tubular members are spiral-plate tubes (18).

6. The noise reducer of claim 4, characterized in that said tubular members each comprise two opposed half-shells (22, 24; 26, 28) of bent plate.

7. The noise reducer of claim 6, characterized in that the half-shells forming each tubular member are identical to each other, and each of them comprises a C-bent rectangular plate (22, 24).

8. The noise reducer of claim 7, characterized in that each half-shell comprises a rectangular plate (22, 24) which is bent with four bends to form a plurality of angled pans, of which the two end pans are parallel, two half-shells being opposed so that their respective opposite end pans overlap.

9. The noise reducer of claim 8, characterized in that the two half-shells (22, 24) of each tubular member are perforated only in the pans which are intermediate between the end pans.

10. The noise reducer of claim 8 or 9, characterized in that the half-shells (22, 24) of each tubular member are joined by rivetting together the overlapping pans.

11. The noise reducer of claim 6, characterized in that each tubular member comprises a lower half-shell (26) with two bends defining an intermediate, narrow pan and two lateral, diverging, wide and perforated pans, and an upper half-shell (28) with two bends defining three non-perforated pans, with bent outside edges (30) coupling with the respective edges of said lateral pans of the lower half-shell (26).

12. The noise reducer of claim 11, characterized in that the bent edges (30) of the upper half-shell (28) are rivetted to the edges of the lower half-shell (26).

13. The noise reducer of any of the preceding claims, characterized in that said plate is aluminum.

14. The noise reducer of any of the preceding claims, characterized in that said plate is steel

15. The noise reducer of any of the preceding claims, characterized in that said sound-absorbing material (32; 36; 44) is fiberglass.

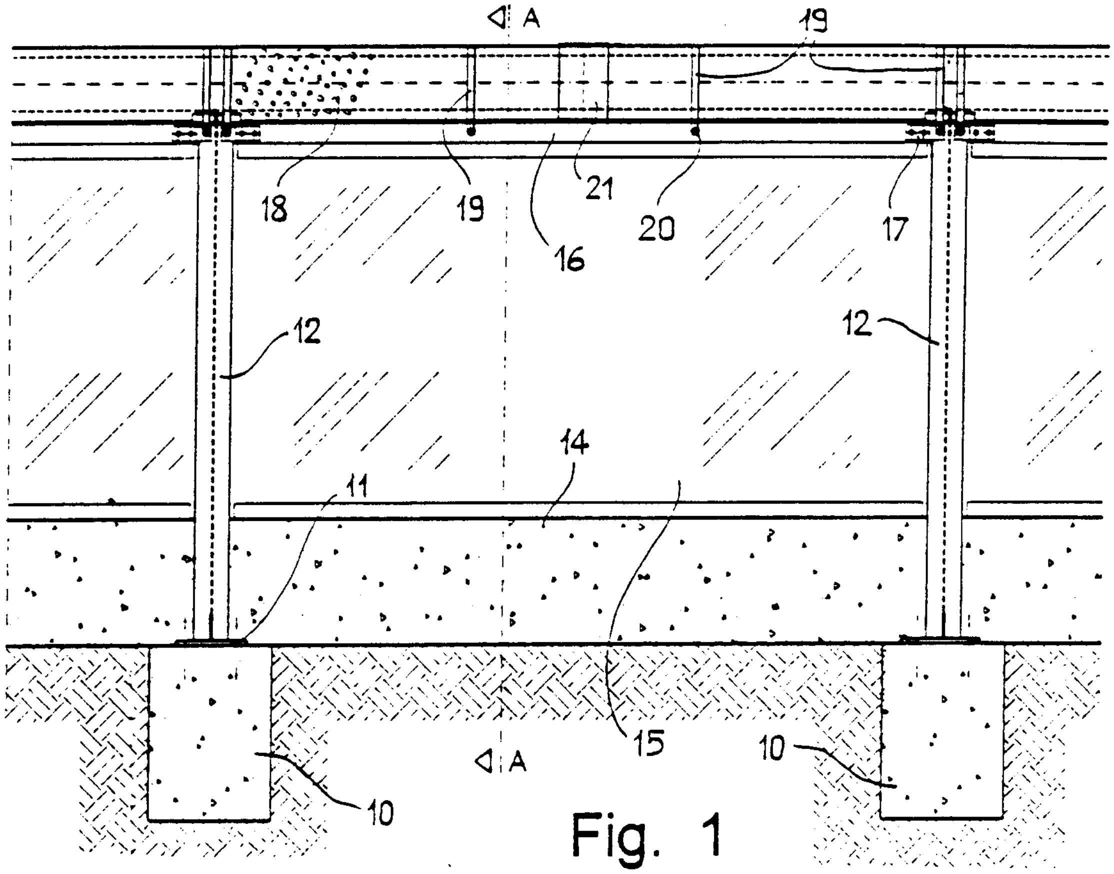


Fig. 1

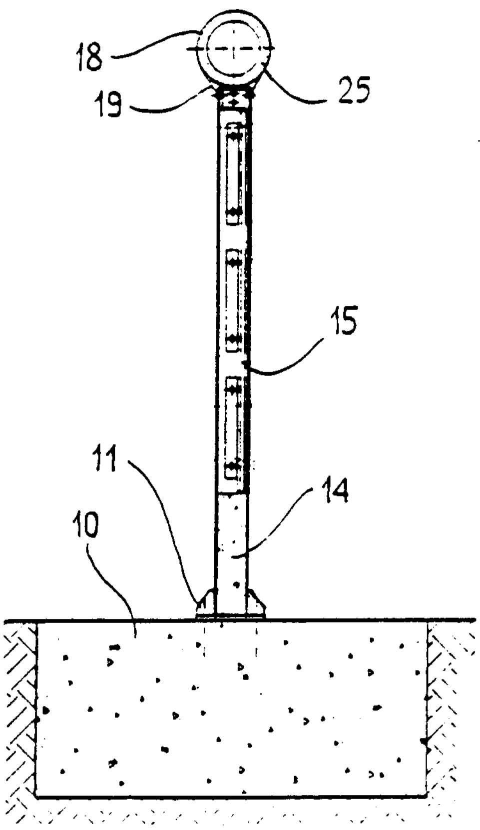


Fig. 2

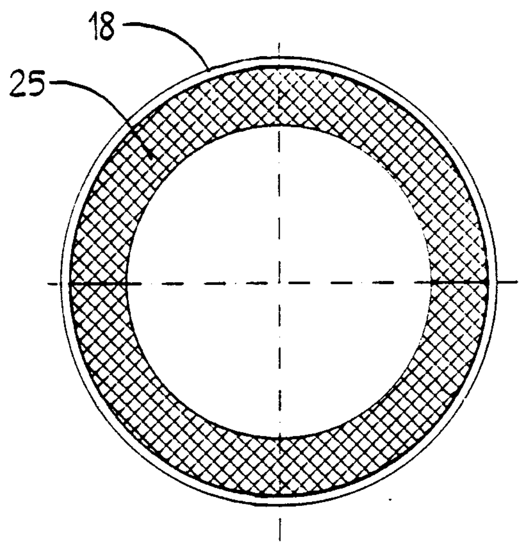
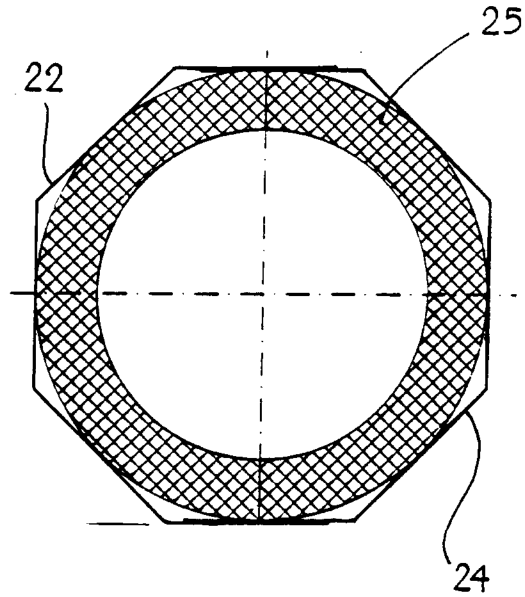


Fig. 3

Fig. 4



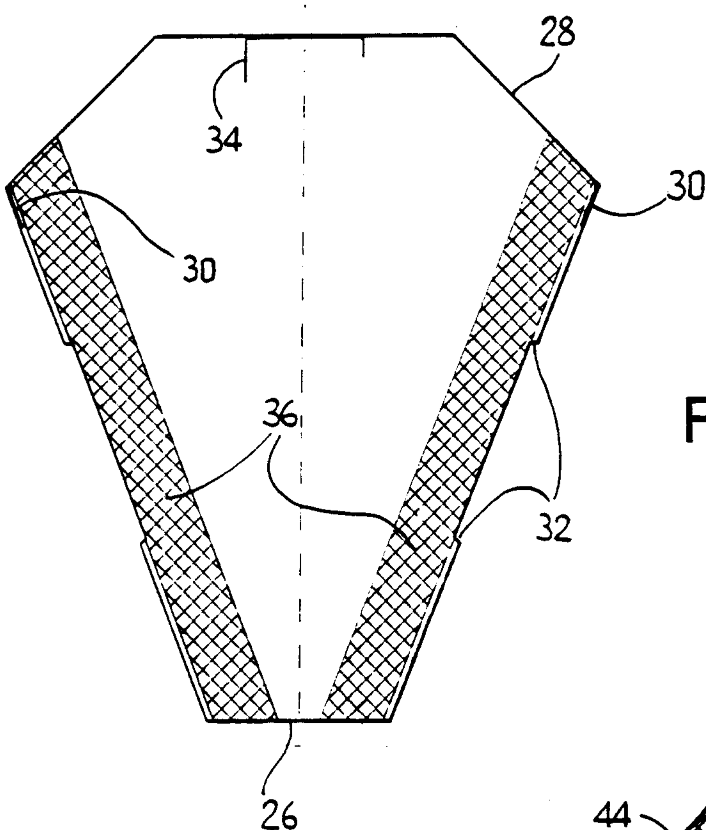
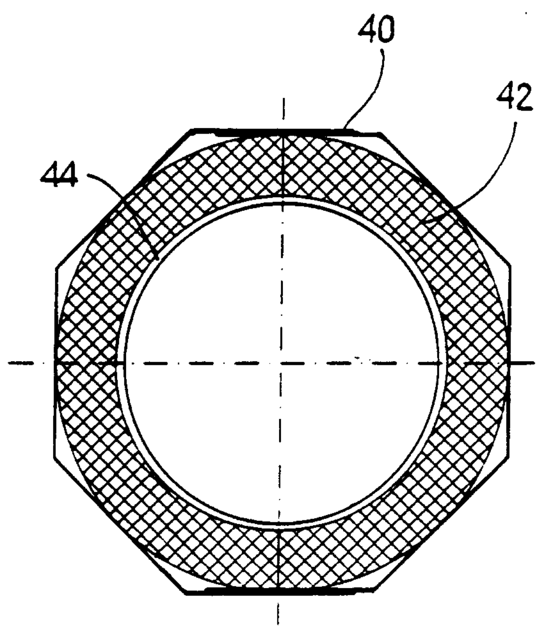


Fig. 5

Fig. 6



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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 1207

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y A	EP-A-0 560 200 (L. CARDIN) * column 2, line 20 - line 50; figure 3 *	1,15 2-4 5	E01F8/00
Y	FR-A-2 226 910 (SOC. ÉLASTOMÈRES ET PLAST.) * page 2, line 24 - line 34; figure 1 *	2-4	
A	EP-A-0 315 710 (NITTO BOSEKI)		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

E01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 September 1996	Verveer, D

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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