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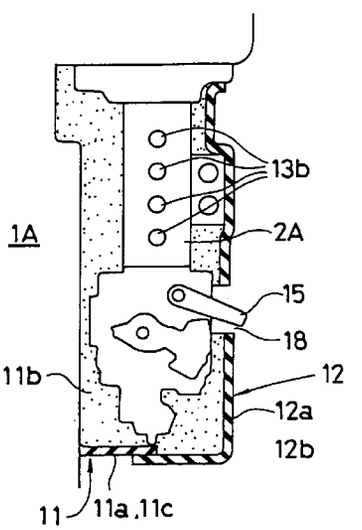
(54) Low-noise engine and its assembling method

(57) An engine (10) having sound absorbing members (11b,12b) capable of reducing the noise of the engine effectively, and a method of assembling an engine (10) having sound absorbing members (11b,12b) by covering a noise generating engine component (2a) with cover members (11a,11c,12a) through sound absorbing members, comprising the steps of: applying an unfoamed foaming material (31) to one or both of the inner face of the cover members (11a,11c,12a) and the component; covering the component with the cover members; heating the component to foam the foaming material thereby to expand the sound absorbing members; and assembling the integrated component with the engine body (10).

Fig. 1



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Description

BACKGROUND OF THE INVENTION:

The present invention relates to a structure for preventing the noise of an engine by reducing the noise produced by a fuel injection pump itself of the engine and accounting for a large ratio of the engine noise, the noise due to the standing wave between the fuel injection pump and the cylinder block of the engine, and a method of assembling the engine.

In the prior art, the engine noise is a serious problem in the manufacture of a comfortable automobile. There are the noise produced from the engine, the noise due to a standing wave in which the sounds between the cylinder block of the engine and the fuel injection pump are amplified by each other, and the sound produced by the fuel injection pump itself. These noises are generally called engine noise.

In order to keep the car compartment quiet and calm, there has been investigated in recent years a method of reducing the engine noise. Specifically, a noise preventing device has been proposed, as shown in Fig. 10, in Japanese utility model application Kokai publication No. 4-95631. According to this proposal, the gap G between a cylinder block 1 and a fuel injection pump 2 is sealed at its upper and lower portions by metal covers 4a and 4b which are attached to the side of the cylinder block 1 and the side of the fuel injection pump 2 through seal members 3. This gap G is sealed with a sound absorbing material 5 such as glass wool or a foaming resin such as foaming urethane. However, this device can prevent the aforementioned standing wave but not the noise which is produced from the fuel injection pump 2 itself. There is another problem that the noise is secondarily generated by the vibrations of the metal covers 4a and 4b.

Another noise preventing device, as shown in Fig. 11, is proposed in Japanese utility model application Kokai publication No. 3-95072. This device is equipped with a casing of a damping steel sheet which has the sound absorbing member 5 such as glass wool bonded to the inner side of the front face of the fuel injection pump 2. In this device, however, not only a gap g is left between the cylinder block 1 and the fuel injection pump 2, but also a spatial portion 7 is left between the sound absorbing member 5 bonded to the casing 6 of the front portion and the fuel injection pump 2, thus making it impossible to sufficiently prevent not only the noise due to the standing wave but also the noises produced from the cylinder block 1 and the fuel injection pump 2 itself. On the other hand, the casing 6 is made of a metal to raise a problem that secondary noise is generated by the vibration of the casing 6.

When a foaming resin is used as the sound absorbing member, moreover, there are two methods. One method is forming a fitting type sound absorbing member by producing a mold from both the fuel injection pump and the metallic cover or casing and heating the foaming polyurethane to 40 to 50°C in the mold to foam and shape it; the other is forming a filling type sound absorbing member by injecting and foaming a liquid foaming material after assembling the fuel injection pump and the metallic cover or casing.

In the method of forming the fitting type sound absorbing member, due to the deformation of the sound absorbing member or due to the variation of the shape of the mounting portion on the engine component side, the sound absorbing member and the mounting portion may fail to conform completely in their shapes, thus causing a problem that the sound absorbing member cannot be assembled in the mounting portion and a gap is established after the assembly to lower the sound absorbing effect.

When the sound absorbing member has a complicated shape, on the other hand, its mold has to be divided and resultantly the number of molds increase. In addition, a new mold is required for molding the new sound absorbing member in accordance with the change in the shape of the mounting portion, thus raising a problem that the production cost is raised.

The method of forming the filling type sound absorbing member is proposed to solve the aforementioned problem of the fitting type sound absorbing member. According to the proposal of Japanese utility model application Kokai publication No. 5-64443, for example, the foamed silicone sheet to be mounted on the side surface of the cylinder block of the engine is formed by injecting a liquid foaming silicone resin into the gap between the side portion of the cylinder block and a reinforcing plate and by foaming and setting the resin at a predetermined temperature to form the side cover.

However, the engine components such as the fuel injection pump often have complicated shapes so that the spatial portion to be formed between the component and a cover member such as the metal cover or the casing is complicated to have narrow and wide portions, making it difficult to form a guide passage leading to the back of the fuel injection pump for guiding the foaming liquid.

In the method of forming the filling type sound absorbing member, therefore, it is difficult to charge the entire region of the spatial portion with the foaming liquid, and it is impossible to distribute the foaming liquid by adjusting the amount in accordance with the local width and volume of the spatial portion. As a result, cavities and density irregularity are liable to occur in the foamed sound absorbing member, thus causing a problem that the sound absorbing effect of the foaming material cannot be exhibited to the maximum.

In order to inject the liquid foaming material after the assembly, moreover, an injection port has to be formed in a position to inject the foaming liquid into the spatial portion for forming the sound absorbing member, and an opening unnecessary to prevent the noise, has to be formed, raising a problem that the noise pre-

venting effect is insufficient. In addition, openings such as for the control lever other than the injection port existing in the cover member have to be closed to prevent the foaming liquid from leaking out, raising a problem that the jig and works for clogging those openings are additionally required.

SUMMARY OF THE INVENTION:

An object of the present invention is to provide an engine which can prevent the noise, produced by a fuel injection pump itself, and the noise, due to the standing wave between engine components such as the fuel injection pump and the cylinder block of the engine, and which can partially reduce the noise produced by the cylinder block.

Another object of the present invention is to provide a method of assembling an engine equipped with a sound absorbing member for preventing the noise of the engine, in which by a simple work the sound absorbing member can be formed substantially evenly without any cavity between the cover member and the engine component and in the entire region of the spatial portion between the noise generating portion of the engine and the engine component, thereby reducing the engine noise effectively.

In order to achieve the above-specified objects, according to a first invention, there is provided a low-noise engine comprising shielding members substantially covering the surface of the fuel injection pump which is fixed with a clearance on the side of the cylinder block of an engine, the shielding members including surface cover members covering the noise generating face of the fuel injection pump, and sound absorbing members filled between the fuel injection pump and the cover members.

Those shielding members may preferably cover the entire surface and the fuel injection pump substantially except for such small openings or gaps, e.g., a control portion, a piping lead-out portion or a heat radiation window which can be neglected with respect to prevention of the noise.

In this shielding structure, the cover members constituting the shielding members are made of such a material, as heat resisting rubber not making any noise nor transmit the sound therethrough, and the sound absorbing members are made of such a material as a foaming material of a synthetic resin attenuating the noise coming from the sound source.

In the shielding structure, moreover, there is provided a low-noise engine having a structure for shielding a fuel injection pump comprising the shielding members which includes: a first shielding member arranged between the cylinder block and the fuel injection pump; and a second shielding member covering the surface of the fuel injection pump left uncovered with the first shielding member, the first and second shielding members being separable on the surface of the fuel injection pump.

The first and second shielding members are made so easily dividable at the central portion of the surface of the fuel injection pump as to cover the back portion and the front portion of the fuel injection pump individually. In this case, the forming, inspecting and adjusting works can be improved if the shielding members can be divided to facilitate the exposure of the whole faces necessary for the adjustment, inspection and repair.

Moreover, if the cover members are so positioned near the dividable portion as to contact directly with the engine component such as the fuel injection pump, no cut is required in the sound absorbing members and it is possible to eliminate the member for and the step of closing the cut portion required for filling the foaming material.

There are second to fourth present inventions relating to the method of assembling the low-noise engine.

The second invention is a method of assembling an engine having sound absorbing members by covering a noise generating engine components such as the fuel injection pump with cover members through sound absorbing members, comprising the steps of: applying an unfoamed foaming material to one or both of the inner face of the cover members and the component; covering the component with the cover members; heating the component to foam the foaming material thereby to expand the sound absorbing members; and assembling the integrated component with the engine body.

Alternatively, there is provided a method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of: applying an unfoamed foaming material to one or both of the inner face of the cover members and the component; assembling the component covered with the cover members, with the engine body; and heating the component to foam the foaming material thereby to expand the sound absorbing members.

Further there is provided a method of assembling an engine having sound absorbing members comprising the steps of: applying an unfoamed foaming material to at least one portion of the face defining a space between a noise generating portion of the engine and an engine component confronting the noise generating portion; assembling the engine component; and foaming the foaming material by heating the noise generating portion to expand and foam sound absorbing members between the engine body and the engine component.

The third invention is a method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of: applying an unfoamed foaming material to one or both of the inner face of the cover members and the component; pre-foaming the foaming material by

heating it for a short time; covering the component with the cover members; and then heating the component to foam the foaming material thereby to expand the sound absorbing members.

Alternatively, there is provided a method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of: applying an unfoamed foaming material to one or both of the inner face of the cover members and the component; pre-foaming the foaming material by heating it for a short time; assembling the component in the state that it is covered with the cover members, with the engine body; and heating the component to foam the foaming material thereby to expand the sound absorbing members.

Thus, after the unfoamed foaming material has been applied, it is heated at its foaming temperature for a short time to perform the preheating, by which the foaming is effected substantially halfway, thereby to solidify the unfoamed gel foaming material so that the liquid run of the foaming material can be prevented to simplify the assembling work.

The fourth invention is a method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of: applying a foaming sheet formed into a sheet shape from an unfoamed foaming material to one or both of the inner face of the cover members and the component; covering the component with the cover members; and heating the component to foam the foaming material thereby to expand the sound absorbing members, before and after the component is assembled with the engine body.

Further there is provided a method of assembling an engine having sound absorbing members comprising the steps of: applying a foaming sheet formed into a sheet shape from an unfoamed foaming material to at least one portion of the face defining a space between a noise generating portion of the engine and an engine component confronting the noise generating portion; assembling the engine component; and foaming the foaming material by heating the noise generating portion to expand and form sound absorbing members between the engine body and the engine component.

Thus, if the foaming sheet formed into the sheet shape from the foaming material before the foaming, is applied in place of the unfoamed foaming material, the foaming material can be easily distributed in a proper amount by overlapping the foaming sheets in accordance with the thickness of the sound absorbing members to be formed.

In any of these second to fourth present inventions, the heating operation for the foaming after the engine assembly may be effected by heating the component and the noise generating portion from the outside of the cover members with the hot air or steam. However, the heat source and the heating work can be eliminated if the heating operation is performed by the heat of the engine itself generated at the bench test of the engine.

BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 is a sectional top plan view showing a structure of an embodiment of a first invention;

Fig. 2 is a sectional side elevation showing the structure of the embodiment of the first invention;

Fig. 3 is a sectional top plan view showing a structure of another embodiment of the first invention;

Fig. 4 is a sectional side elevation showing the structure of another embodiment of the first invention;

Fig. 5 is a graph illustrating a noise reducing effect of the first invention;

Figs. 6(a) and 6(b) are schematic views, showing the structure of an engine according to a second embodiment of the invention, in which Fig. 6(a) shows a state before foaming and Fig. 6(b) shows a state after foaming;

Figs. 7(a) and 7(b) are schematic views, showing the structure of an engine according to a third embodiment of the invention, in which Fig. 7(a) shows a state before the foaming and Fig. 7(b) shows a state after the foaming;

Fig. 8 is a perspective view showing an injection pump mounting position;

Fig. 9 is a perspective view showing a shielded portion of the injection pump;

Fig. 10 is a sectional side elevation showing the soundproof structure of the prior art; and

Fig. 11 is a sectional side elevation showing the soundproof structure of the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[Embodiment 1]

A first embodiment of the present invention will be described with reference to the accompanying drawings.

As shown in Fig. 8, a fuel injection pump 2A is so fixed on the cylinder block 1A side of an engine 10 that the fuel is sucked from a lower piping 13a and is pressurized until it is injected into the cylinder through an upper piping 13b and a fuel injection nozzle.

As hatched in Fig. 9, shielding members 11 and 12 of the present invention covers the fuel injection pump 2A substantially except for the portion in which a control lever 15 and the pipings 13a and 13b are arranged.

With reference to Figs. 1 and 2, here will be described a method of forming the shielding members 11 and 12 of the present invention comprising cover members 11a, 11c and 12a and sound absorbing members 11b and 12b.

At a first step, the fuel injection pump 2A is mounted on the cylinder block 1A. After this, the back cover member 11a made of heat resisting rubber at the lower side of the back of the fuel injection pump 2A is fixed to the block 1A with bolts 16 to substantially cover the lower side of the gap between the cylinder block 1A and the fuel injection pump 2A. Next, the portion substantially surrounded by the back cover member 11a, the cylinder block 1A and the fuel injection pump 2A is charged with a foaming material of a synthetic resin to form the back sound absorbing member 11b. This back sound absorbing member 11b is applied without any clearance.

Moreover, the back cover member 11c made of heat resisting rubber at the upper side of the back of the fuel injection pump 2A is fixed to the cylinder block 1A with the bolts 16 to substantially cover the upper side of the gap between the cylinder block 1A and the fuel injection pump 2A. At this first step, it is possible to form the first shielding member 11, comprising the back cover members 11a and 11c and the back sound absorbing member 11b.

This charge of the foaming material can be simplified by eliminating the member for and the step of closing the gap if the cover members 11a and 11c are partially constructed in contact directly with the surface of the fuel injection pump 2A.

At a second step, after the first shielding member has been formed, the front cover member 12a is so fixed by a method using clips 17 or a hook-and-loop fastener as to substantially cover the surface of the fuel injection pump 2A left uncovered with the first shielding member 11. Next, the space portion substantially surrounded by the first shielding member 11, the front cover member 12a and the fuel injection pump 2A is charged with a foaming material of a synthetic resin to form the front sound absorbing member 12b. At this step, it is possible to form the second shielding member 12 comprising the front sound absorbing member 12b and the front cover member 12a.

This second shielding member 12 is constructed to cover the surface of the fuel injection pump 2A substantially except for the control portion such as the lever 15 of the fuel injection pump 1A, the portions of the pipings 13a and 13b, and an excepted portion 18 which is opened, as necessary, for the heat dissipation or for injecting the foaming material. This excepted portion 18 can be formed, as necessary, on the shielding member 11 side.

By these steps, it is possible to form the shielding structure in which the surface of the fuel injection pump 2A is substantially covered with the shielding members 11 and 12 comprising of the sound absorbing members 11b and 12b and the cover members 11a, 11c and 12a.

Incidentally, this charging step of those sound absorbing members 11b and 12b need not always be conducted only at the working time of mounting the fuel injection pump 2A on the cylinder block of the engine. With a mold of the same shape, the sound absorbing members can be molded beforehand for convenience of the working step by using the mold and the cover members 11a, 11c and 12a.

These first and second shielding members 11 and 12 can be mounted on and demounted from the surface of the fuel injection pump 2A by the clips 17 and the not-shown hook-and-loop fastener.

If this demountable portion is constructed such that the cover member 12a is partially in contact directly with the surface of the fuel injection pump 2A, the member for and the step of closing the gap between the fuel injection pump 2A and the cover members 11a and 11c required at the time of filling the foaming material, can be eliminated, unlike the construction having the sound absorbing members arranged in the gap, to simplify the work of filling the foaming material.

In regard to this demountable construction, for example, the shielding members 11 and 12 are divided into the back portion and the front portion of the fuel injection pump 2A so that they can be separated at the surface portion near the longitudinal center portion of the fuel injection pump 2A to facilitate the formation, disassembly and assembly.

As to this division, the adjustment, inspection and repair can be simplified if the shielding member 12 is formed such that the surface of the fuel injection pump 2A at the portions necessary for the adjustment, inspection and repair is easily exposed as a whole.

These first and second shielding members 11 and 12 need not always be made unitary but can be separated, as necessary, to facilitate the formation, disassembly and assembly.

[Embodiment 2]

Figs. 3 and 4 show another embodiment of the first invention, the first shielding member 11 between the cylinder block 1A and the fuel injection pump 2A is constructed into a sandwich structure of the sound absorbing member 11b, the cover member 11a and the sound absorbing member 11b. Thanks to this sandwich structure, the effect of retaining the sound absorbing member 11b is enhanced by the highly rigid cover member 11a, and this cover member 11a can be arranged at the back of the fuel injection pump 2 to enhance the noise preventing effect. This sandwich structure can also be applied to the second shielding member 12.

Fig. 5 is a graph illustrating this noise preventing effect, and the abscissa shows the number of revolutions of the engine whereas the ordinate shows the noise level measured near the engine, in a relative difference of one graduation of 2 dB.

Curve A shows the noise level of a place near by the engine but without the shielding structure, and curve B shows the noise level with the shielding structure of the present invention. Moreover, a hatched region C between the curves A and B is the difference between the aforementioned two noise levels and indicates the

noise preventing effect according to the present invention. As seen from the region C of this graph, according to the present invention, a high noise preventing effect can be achieved although the reduction in the noise level is different for the engine number of revolutions.

Thus, according to the above-specified embodiments of the present invention, a high effect of preventing the engine noise is exhibited, and the sound absorbing member can be easily formed by the charging. In addition, the shielding member can be separated into a plurality of front and back parts so that it can be easily disassembled. As a result, it is possible to provide a shielding structure of a fuel injection pump for preventing the engine noise, which facilitates the adjustment, inspection and repair of the fuel injection pump.

[Embodiment 3]

The fuel injection pump 2A according to an embodiment of a second invention, covered with the cover member (or pump cover) 11a, 11c and 12a, will be described with reference to Figs. 1 and 2.

As shown in Figs. 1 and 2, the fuel injection pump 2A is mounted on the side of the cylinder block 1A constituting the engine body and is constructed to suck the fuel from the fuel suction piping (13a in Fig. 8) at its lower portion and to pressurize and inject it into the cylinder through the fuel discharge piping (13b in Fig. 8) at its upper portion and the fuel injection nozzle.

In order to prevent the noise of the fuel injection pump 2A, the shielding members 11 and 12, in which the sound absorbing members 11b and 12b are covered with the pump covers 11a, 11c and 12a, cover the entirety of the fuel injection pump 2A substantially except for the excepted portion, in which the control lever 15 and the fuel discharge piping 13b, the part hatched in Fig. 9.

Next, with reference to Figs. 6(a) and 6(b), a pump cover 30 (11a, 11c and 12a in Figs. 1 and 2) is made of a material having a heat resistance and a sound insulating effect and capable of keeping the cover shape, such as a thin sheet of metallic material, e.g., a steel sheet or a damping steel sheet, or heat resisting rubber.

The sound absorbing member 31a (11b and 12b in Figs. 1 and 2) is formed, in the following manner, of a foaming material 31 of a synthetic resin, e.g., foaming urethane, which will foam at an atmosphere temperature of, say, 40 to 50°C.

First of all, an appropriate amount of foaming material 31 before the foaming is applied to one or both of the inner face of the pump cover 30 and the surface of the fuel injection pump 2A, while considering its volume after the foaming. This application of appropriate amount can be optimized by partially applying the foaming material 31 in conformity with the local volume of the spatial portion or by partially applying it several times.

According to a first method of the second invention, moreover, the pump cover 30 coated with the foaming material 31 before the foaming is attached to the single body of the fuel injection pump 2A before assembled with the engine body 10. This pump cover 30 is heated from the outside with hot air, steam or infrared rays to raise the temperature of the pump cover 30 or its ambient temperature to the foaming level so that the foaming material 31 is foamed to expand a sound absorbing member 31a. The fuel injection pump 2A, covered with the pump cover 30, is assembled through the sound absorbing member 31a with the engine body 10.

According to a second method, in another case, the fuel injection pump 2A, covered with the pump cover 30, is assembled with the engine body 1, as shown in Fig. 6(a), and after this assembly, the fuel injection pump 2A is partially heated to raise the temperature of the pump cover 30 or its ambient temperature to the foaming level so that the foaming material 31 is foamed to expand and form the sound absorbing member 31a, as shown in Fig. 7(b).

This heating may be conducted with hot air or steam from the outside of the engine but may preferably be effected by the heat of the engine itself generated when the engine is run under the bench test. If this heat of the engine itself is used, the foaming of the sound absorbing member 31a can be effected during the test run after the engine assembly without preparing any special heating source, so that the shaping work of the sound absorbing member 31a can be simplified.

The present invention has been described heretofore as related to the fuel injection pump 2A as an component of an engine but should not be limited thereto and can be applied to another engine component producing the engine noise.

[Embodiment 4]

Next, another embodiment of the second invention will be described when the sound absorbing member 31a is mounted in the gap of a V-bank of a V-type engine or a noise generating portion 20 of the engine.

In this case, as shown in Fig. 7(a), an appropriate amount of the foaming material 31 before foamed is applied beforehand to one or both of the surface of a V-bank portion 20b of the cylinder block forming part of the noise generating portion of the engine and the lower face of an intake manifold 20a of the engine component. After this, the intake manifold 20a is assembled with that V-bank portion 20b to construct the engine.

The face or faces coated may be selected from those which confront the spatial portion formed in a portion of the engine or the engine component and to be charged with the foaming material and which can be easily coated without any obstruction to the assembling work.

With hot air or steam or the heat of the engine, moreover, the noise generating portion is heated to foam the foaming material 31 to expand and form the sound absorbing member 31a between the V-bank por-

tion 20b and the engine component 20a, as shown in Fig. 7(b).

According to the engine assembling method thus far described, it is possible to dispersedly provided the foaming material 31 easily deep into the narrow portion of the spatial portion to form the sound absorbing member 31a, and to distribute an adjusted amount of foaming material 31 conforming to the local volume of the spatial portion 21 while preventing any cavity or uneven density in the foamed sound absorbing member 31a, thereby to optimize the sound absorbing effect of the foaming material.

Moreover, the cover member need not have such an opening for injecting the foaming liquid unnecessary for the sound insulation, nor need be closed the opening of the cover member for preventing the leakage of the foaming liquid other than the injection opening, so that the shaping of the sound absorbing member 31a can be simplified.

After the foaming material foamable by heating it has been applied, it is subjected to a preparatory foaming treatment in which it is heated at a foaming temperature for a short time so that it may be half foamed. As a result, the foaming material in an unfoamed gel state can be solidified and prevented from running thereby to simplify the assembling work.

In place of this method of applying the unfoamed foaming material, moreover, the unfoamed foaming material is shaped into a sheet, and this foaming sheet can be applied to the necessary portion. If this foaming sheet is used, the coating of the foaming material may be replaced by application of the foaming sheet which has been formed beforehand into a proper shape. Depending on the thickness of the sound absorbing member to be expanded, moreover, a suitable number of foaming sheets can be overlapped to distribute an appropriate amount of the foaming material easily thereby to improve the working efficiency.

In addition, if the heating is effected with the heat of the engine, generated at the test run of the engine, the foaming can be performed in the test run after the engine has been assembled. As a result, the foaming step can be eliminated, and the heat source for the foaming can be eliminated, so that the shaping work can be simplified to lower the cost.

According to the invention of claim 1, the surface of the fuel injection pump is covered substantially with the shielding members comprising the sound absorbing members and the cover members so that the noise produced by the fuel injection pump itself, and the noise due to the standing wave between the cylinder block and the fuel injection pump, can be prevented. Moreover, the surface of the cylinder block can be partially covered with the shielding members to prevent a portion of the noise produced by the cylinder block.

According to the invention of claim 2, the cover members are made of the heat resisting rubber so that the vibration transmitted from the engine block and the fuel injection pump can be attenuated by the attenuation characteristics of the rubber against the vibration thereby to prevent secondary noise generation.

The sound absorbing members are formed by filling the foaming material of a synthetic resin so that the noise can be prevented by the sound absorbing characteristics of the foaming material and so that the space where the standing wave may be generated, defined by the cylinder block, the fuel injection pump and the cover members, can be filled up with the foaming material without any cavity to prevent the noise due to the standing wave. Moreover, the shaping of the sound absorbing members is facilitated to improve the working efficiency at the time of making the shielding members.

According to the invention of claim 3, the shielding members can be separated into a plurality of parts to facilitate the shaping, and the disassembly and assembly for the adjustment, inspection and repair. Especially, if the shielding members are divided into such a shape that the portions necessary for the adjustment, inspection and repair may be easily exposed altogether, the number of shielding members necessary for the disassembly can be reduced to improve the workability of the disassembly and assembly.

According to the engine assembling methods of the inventions of claims 4 to 10, by the simple work of applying unfoamed foaming material or the foaming sheet to the face confronting the spatial portion where the sound absorbing members is to be formed, before the assembly, and assembling and heating it, the sound absorbing members for preventing the noise of the engine can be uniformly formed without any cavity either in the whole region of the spatial portion between the cover members and the engine component or in the whole region of the spatial portion between the poise generating portion of the engine and the engine component.

According to these engine assembling methods, therefore, it is possible to manufacture an engine which is equipped with the sound absorbing members capable of reducing the noise of the engine effectively.

Moreover, the foaming material can be foamed by making use of the heat of the engine at the running time so that it can eliminate the heat source and the heating work for foaming thereby to simplify the forming of the sound absorbing members.

Claims

1. A shielding structure for a fuel injection pump comprising: shielding members substantially covering the surface of the fuel injection pump which is fixed with a clearance to the side of the cylinder block of an engine, said shielding members including cover members covering the noise generating face of said fuel injection pump, and sound absorbing members filled between said fuel injection pump and said cover members.

2. A shielding structure for a fuel injection pump according to claim 1,

wherein the cover members of said shielding members are made of heat resisting rubber whereas the sound absorbing members of the same are made of a foaming material of a synthetic resin.

3. A shielding structure for a fuel injection pump according to claim 1 or 2,

wherein said shielding members include: a first shielding member arranged between the cylinder block and said fuel injection pump; and a second shielding member covering the surface of said fuel injection pump left uncovered with said first shielding member, said first and second shielding members being separable on the surface of said fuel injection pump.

4. A method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of:

applying an unfoamed foaming material to one or both of the inner face of said cover members and said component;
covering said component with said cover members;
heating said component to foam said foaming material thereby to expand said sound absorbing members; and
assembling the integrated component with the engine body.

5. A method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of:

applying an unfoamed foaming material to one or both of the inner face of said cover members and said component;
assembling said component, covered with said cover members, with the engine body; and
heating said component to foam said foaming material thereby to expand said sound absorbing members.

6. A method of assembling an engine having sound absorbing members comprising the steps of:

applying an unfoamed foaming material to at least one portion of the face defining a space between a noise generating portion of the engine and an engine component confronting said noise generating portion;
assembling said engine component; and
foaming said foaming material by heating said noise generating portion to expand and form sound absorbing members between the engine body and said engine component.

7. A method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of:

applying an unfoamed foaming material to one or both of the inner face of said cover members and said component;
pre-foaming said foaming material by heating it for a short time;
covering said component with said cover members; and
heating said component to foam said foaming material thereby to expand said sound absorbing members, before and after said component is assembled with the engine body.

8. A method of assembling an engine having sound absorbing members by covering a noise generating engine component with cover members through sound absorbing members, comprising the steps of:

applying a foaming sheet, formed into a sheet shape from an unfoamed foaming material to one or both of the inner face of said cover members and said component;
covering said component with said cover members; and
heating said component to foam said foaming material thereby to expand said sound absorbing members, before and after said component is assembled with the engine body.

9. A method of assembling an engine having sound absorbing members comprising the steps of:

applying a foaming sheet, formed into a sheet shape from an unfoamed foaming material to at least one portion of the face defining a space between a noise generating portion of the engine and an engine component confronting said noise generating portion;
assembling said engine component; and
foaming said foaming material by heating said noise generating portion to expand and form sound absorbing members between the engine body and said engine component.

10. A method of assembling an engine having sound

absorbing members according to any of the claims 5 to 9,

wherein said heating is effected by the heat which is generated by running the engine.

Fig. 1

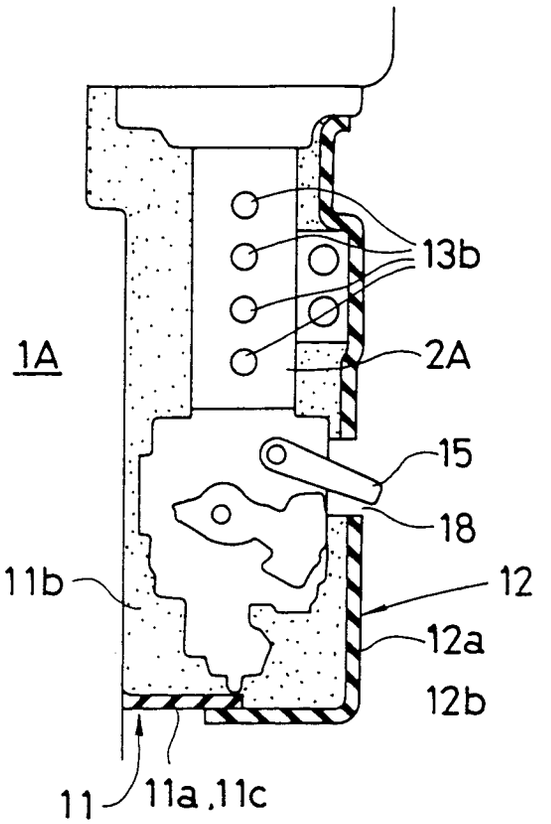

13b
1A
2A
15
18
11b
12
12a
12b
11
11a,11c

Fig. 2

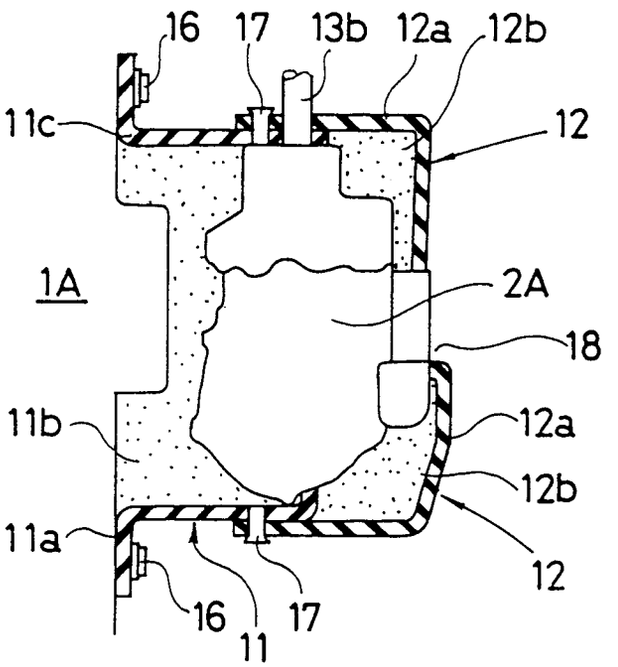

16
17
13b
12a
12b
11c
12
1A
2A
18
11b
12a
12b
11a
12
16
11
17

Fig. 3

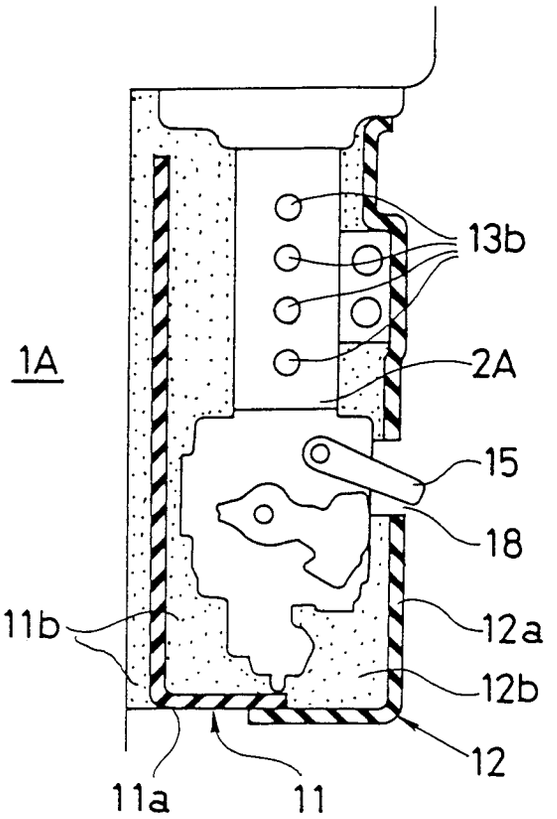

13b
1A
2A
15
18
11b
12a
12b
12
11a
11

Fig. 4

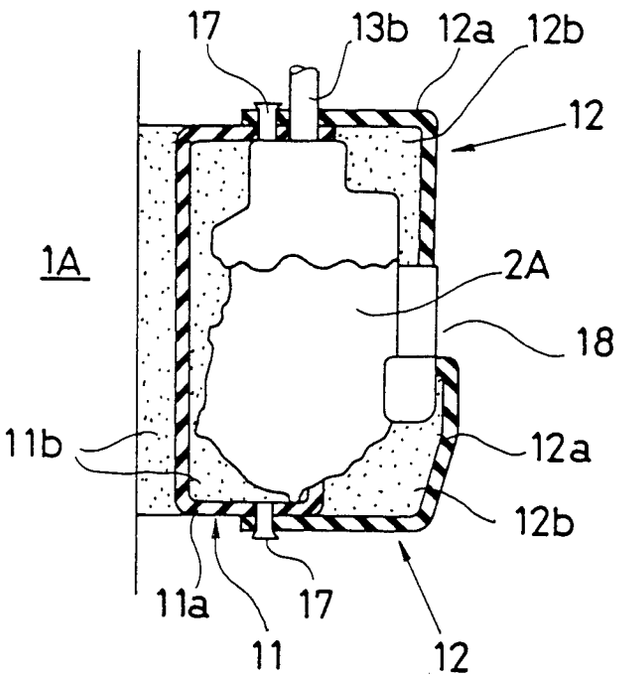

17
13b
12a
12b
12
1A
2A
18
11b
12a
12b
11a
17
11
12

Fig. 5

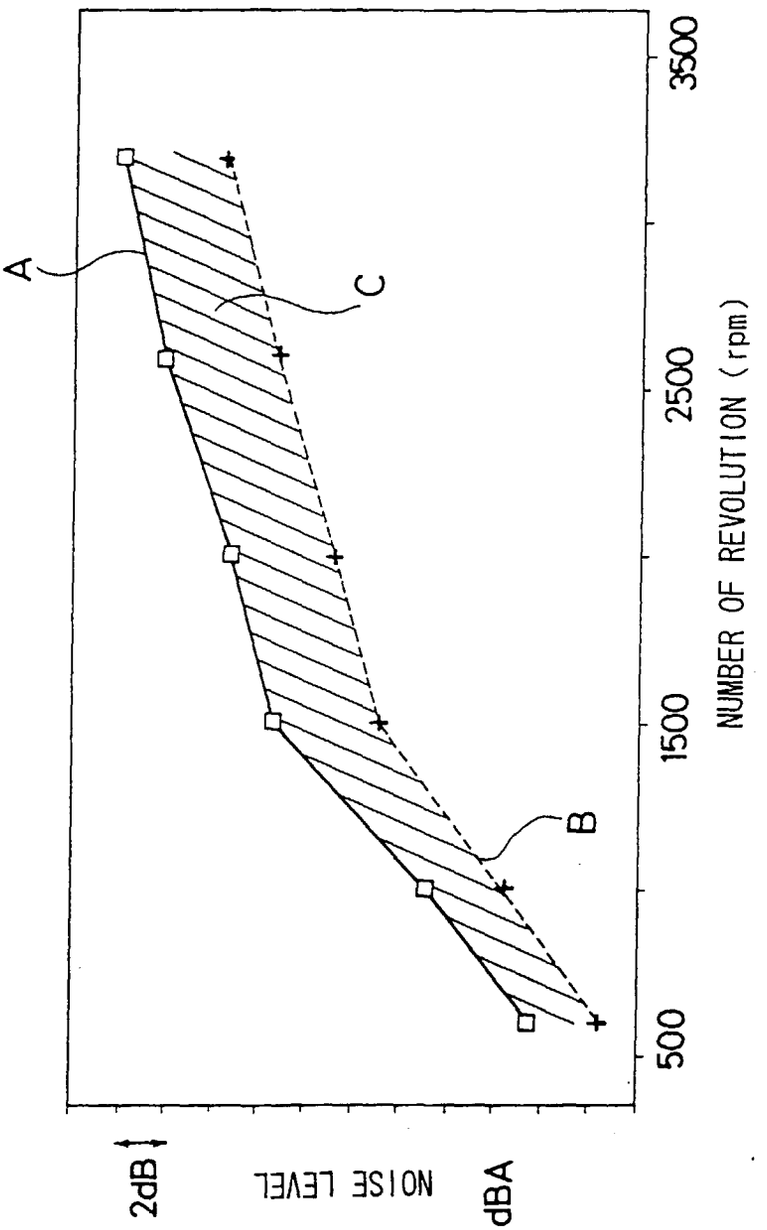

A
C
B
3500
2500
1500
500
NUMBER OF REVOLUTION (rpm)
NOISE LEVEL
dBA
2dB

Fig.6 (a)

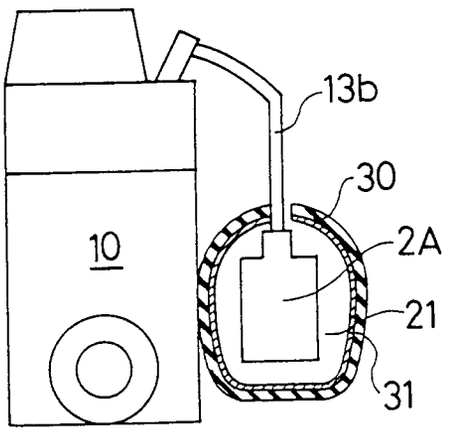


Fig.6(b)

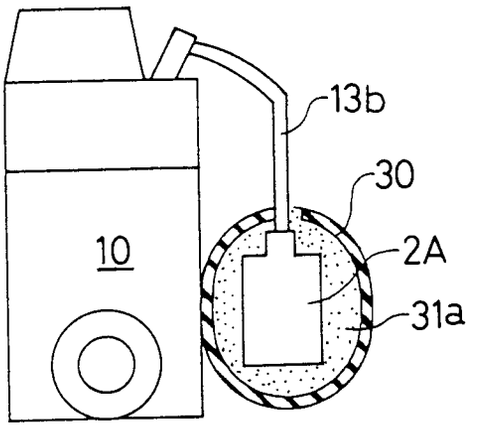


Fig.7 (a)

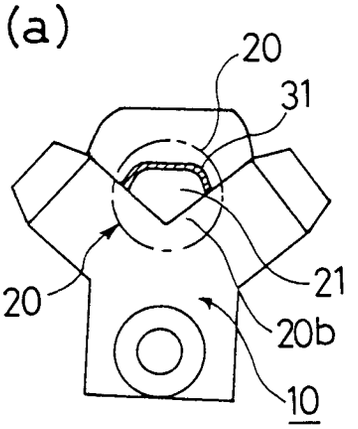


Fig.7 (b)

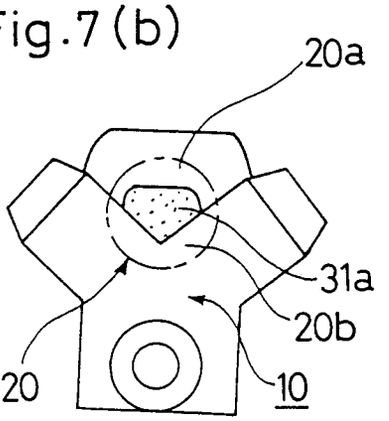


Fig. 8

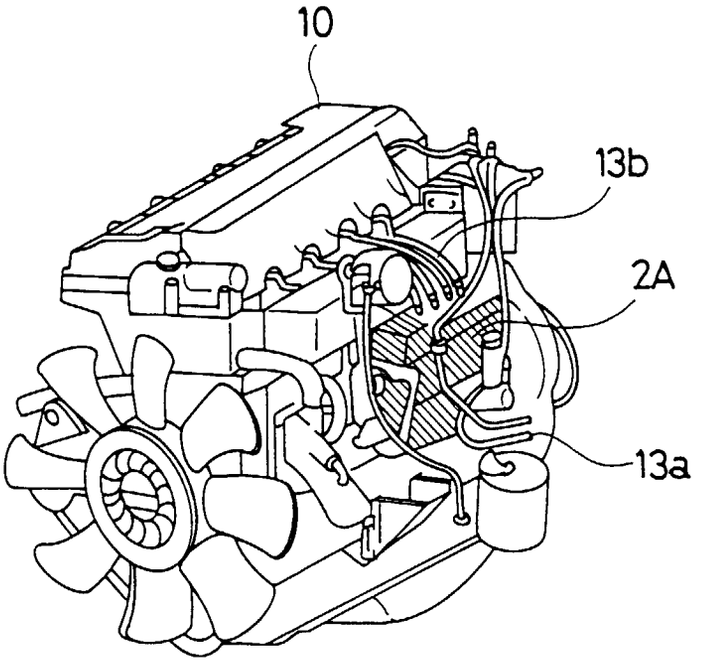


Fig. 9

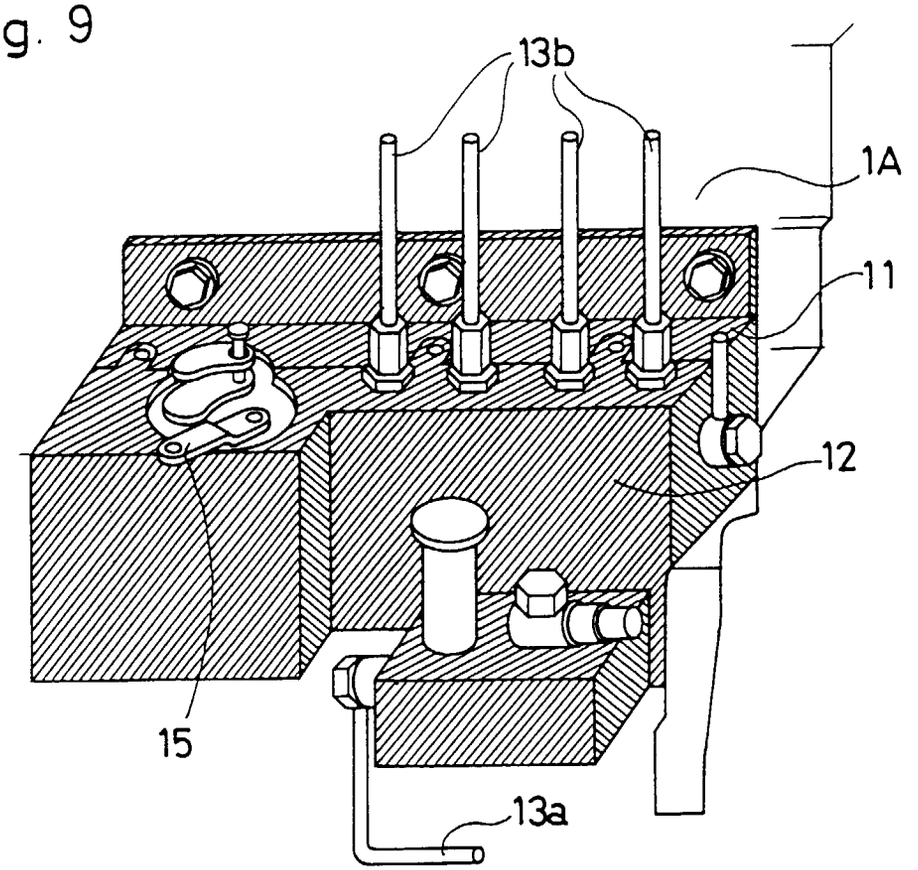


Fig. 10

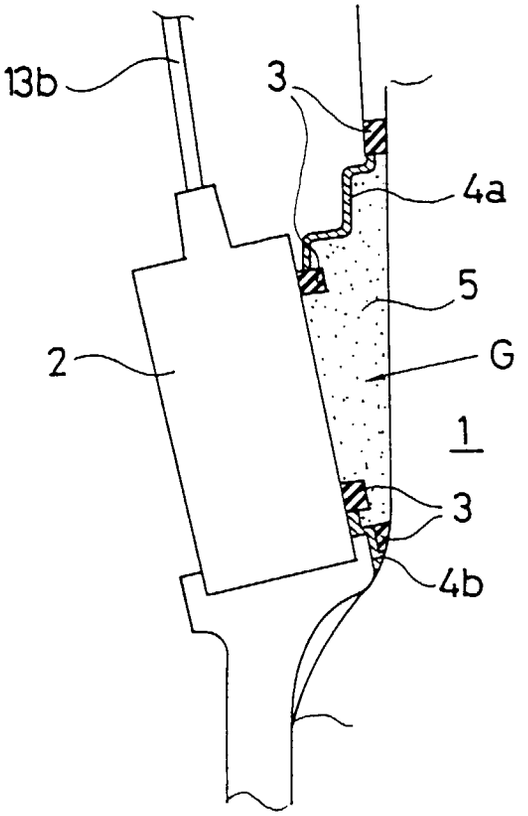
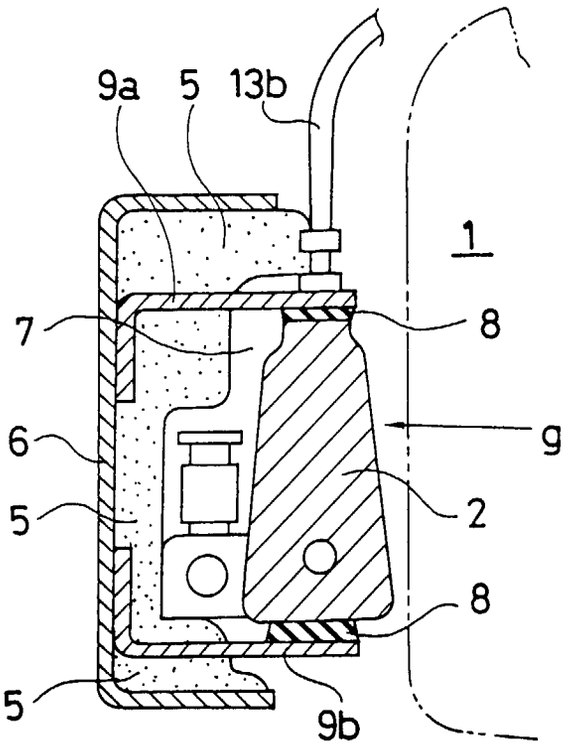


Fig.11



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 10 2947

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)
A	US 3 684 053 A (FACHBACH HEINZ ET AL) 15 August 1972 * column 2, line 7 - column 5, line 42; figures 1-5 *	1	F02M59/00 F02B77/13
A	EP 0 691 462 A (STEYR NUTZFAHRZEUGE) 10 January 1996 * column 3, line 11 - column 4, line 54; figure 4 *	1-4	
A	US 3 534 828 A (LEPAGE LEONARD STUART ET AL) 20 October 1970 * abstract; figure 1 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 454 (M-1031), 28 September 1990 & JP 02 181034 A (YANMAR DIESEL ENGINE CO LTD), 13 July 1990, * abstract *	1-3	
A	GB 2 094 948 A (MASSEY FERGUSON PERKINS LTD) 22 September 1982 * the whole document *	1,4,5	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F02M F02B
A	EP 0 341 330 A (ESSEX COMPOSITE SYSTEMS) 15 November 1989 * abstract *	1,4-9	
A	US 5 266 133 A (HANLEY JOHN L ET AL) 30 November 1993 * abstract *	1,4-9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 July 1997	Wassenaar, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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