United States Patent

Fachbach et al.

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[54] **INTERNAL COMBUSTION ENGINE WITH SOUND-ABSORBING CASING**

[72] Inventors: **Heinz Fachbach; Gerhard Thien,** both of Graz, Austria

[73] Assignee: **Hans List,** Graz, Austria

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[52] **U.S. Cl.** .....**181/33 K,** 123/198 E

[51] **Int. Cl.**.....**F02b 77/00**

[58] **Field of Search**.....181/33 K; 123/195 S, 195 C, 123/198 E, 41.70

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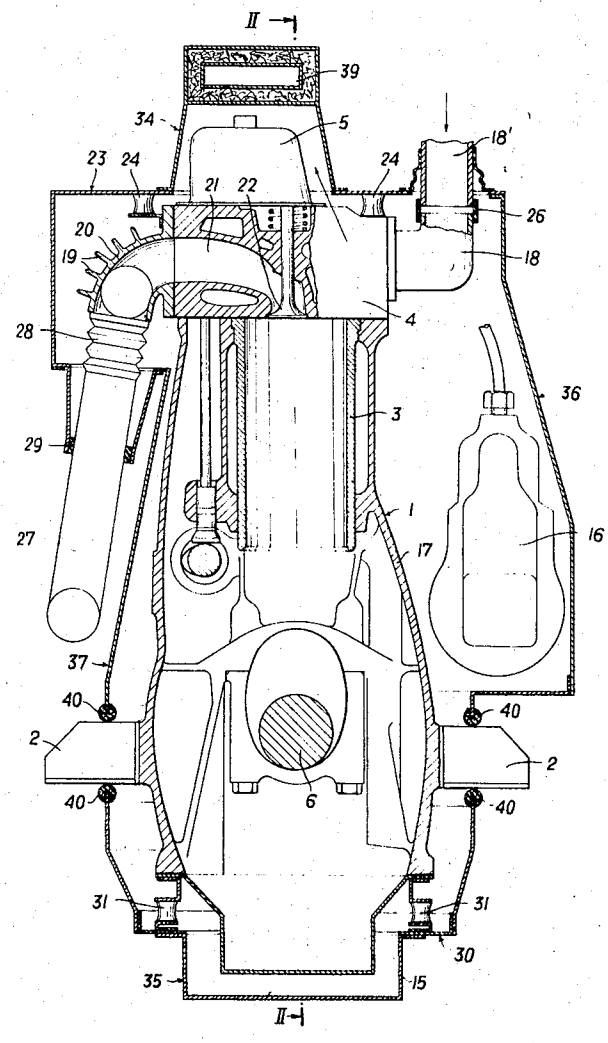
Primary Examiner—Stephen J. Tomsky
Assistant Examiner—John F. Gonzales
Attorney—Watson, Cole, Grindle & Watson

[57] **ABSTRACT**

A sound absorbing casing for internal combustion engines in which a first group of casing members are arranged in spaced relation to the engine and directly attached thereto to produce a sound-attenuating effect and a second group of casing members arranged in spaced relation to the engine and removably attached to the casing members of the first group.

6 Claims, 5 Drawing Figures



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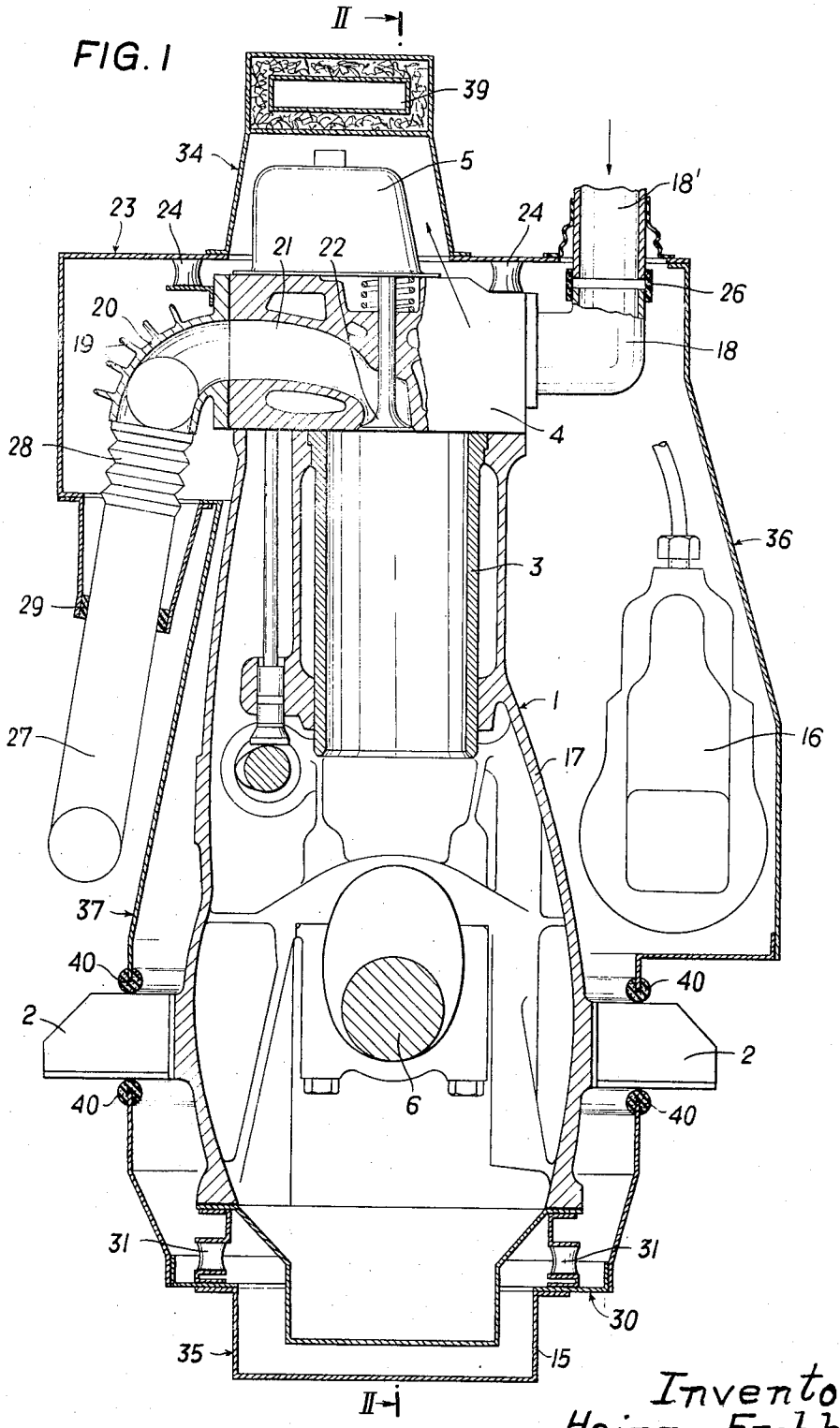
SHEET 1 OF 4

FIG. 1



Inventors
Heinz Fachbach
Gerhard Thien

By
Watson, Cole, Grindle & Watson
Attys

FIG. 2

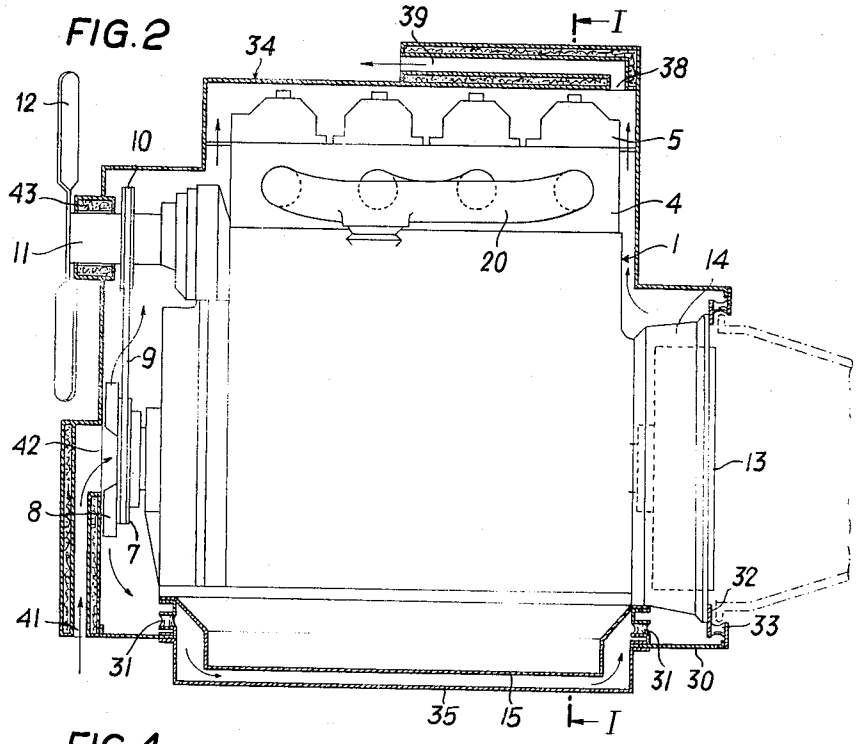
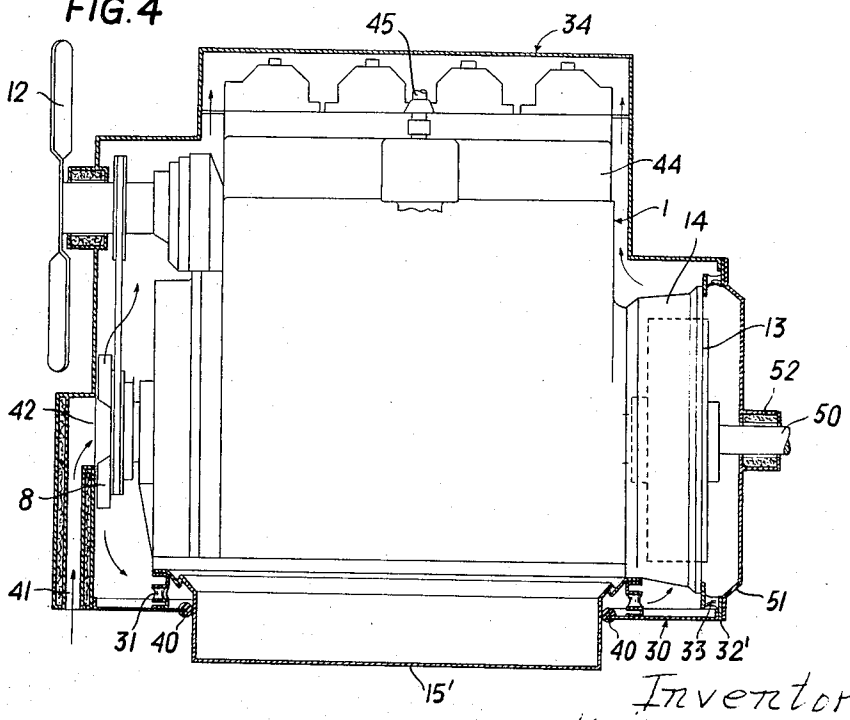
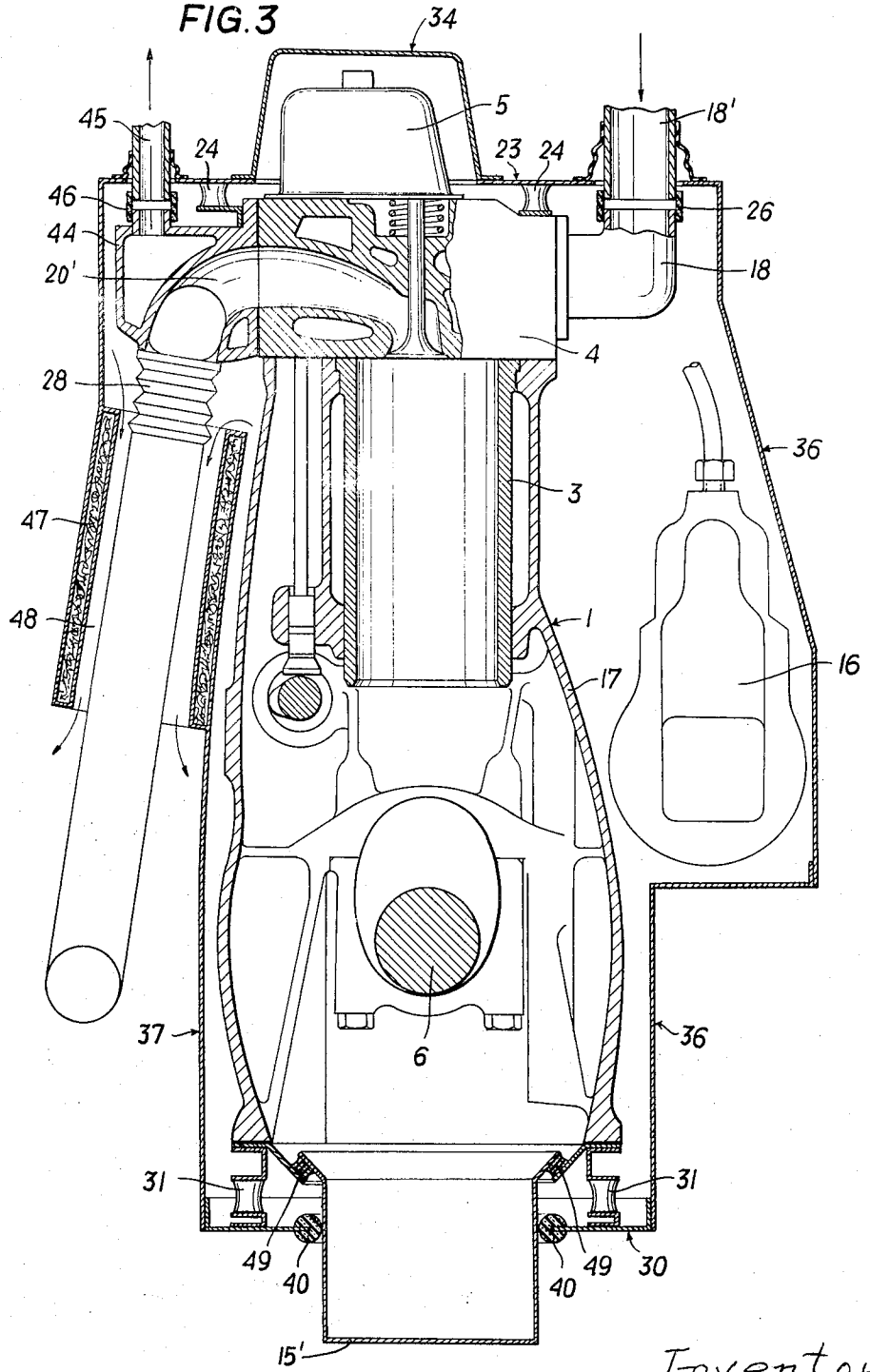


FIG. 4



Inventors
Heinz Fachbach
Gerhard Thien
By
Watson, Cole, Grindle & Watson
Attys.

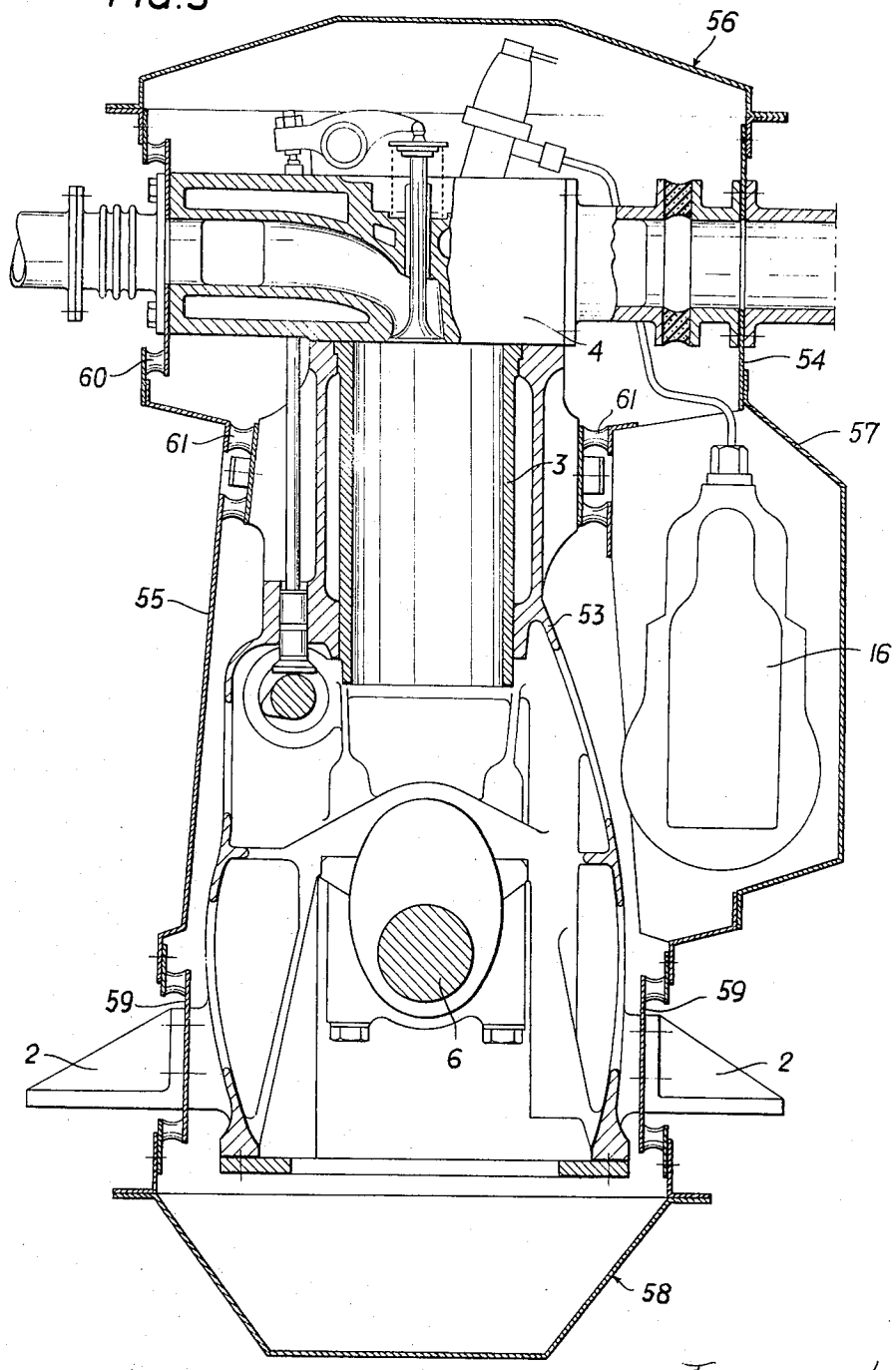
FIG. 3



Inventors
Heinz Fachbach
Gerhard Thien

By
Whittemore, Hulbert & Belknap
Attys.

FIG. 5



Inventors
Heinz Fachbach
Gerhard Thien
By
Watson, Cole, Grindle & Watson
Attys.

INTERNAL COMBUSTION ENGINE WITH SOUND-ABSORBING CASING

The invention relates to an internal combustion engine with a sound-absorbing casing comprising sound-proofing casing elements arranged in spaced relation to the engine.

A great number of different means have already been devised for the purpose of reducing the noise produced by internal combustion engines, some objectionable because of the considerable expense involved, others unsatisfactory in view of operational shortcomings resulting from the provision of sound-proofing means or on account of their relative ineffectiveness.

One known means consists in coating the outer walls of internal combustion engines with a vibration-damping material the effect of which is, however, relatively poor since the crankcases themselves are already vibration-absorbing to a comparatively high degree owing to the presence of various bolts and screws at their contact surfaces. Besides, the application of similar coatings is time-consuming, complicated and costly and the coating is bound to greatly impede heat irradiation from the crankcase.

Furthermore, internal combustion engines have occasionally been installed in housings lined with a sound-absorbing material. The main drawback of this design resides in the considerable space required and in the poor accessibility of the engines for maintenance operations. Moreover, similar housings are comparatively expensive and heavy, since in order to increase their effectiveness, they have to be provided with relatively thick walls. Likewise, partial sound-proofing of such areas of the engine surface as are particularly noise-radiating has already been resorted to but as is quite natural, similar measures produce only a limited effect.

Noises caused by internal combustion engines can also be reduced by combating objectionable sounds at their source, such as for example, by improving the course of combustion, by the reduction of backlash and play etc. However, such measures have their inherent limitations inasmuch as controlled combustion generally is objectionable from an economic viewpoint since a reduction of manufacturing allowances calls for more careful finishing with a consequent increase of production costs.

Occasionally, in an attempt at reducing noise radiation from internal combustion engines, the crankcase usually provided with solid walls has been replaced by a framework to which highly damped outer walls were attached.

It is the purpose of the present invention to provide an internal combustion engine comprising a highly effective and yet inexpensive casing advantageously adaptable both to engines featuring standard-type closed crankcases and to such models where a supporting framework for the crankshaft, cylinders, cylinder head, valve gear and the like has been substituted for the solid-wall crankcase. For that purpose the casing assembly comprises a first group of sound-proofing casing members through which the pipings and other connections of the engine extend, and a second group of detachable sound-proofing casing elements attached to the former to cover such parts of the engine and its auxiliary units as require regular maintenance. By keeping the distance between the engine and the casing members small enough and be far below the half-wave length of the frequencies chiefly responsible for noise radiation, sound-absorbing lining of the casing elements may be dispensed with. In addition, the space required for the accommodation of an encased internal combustion engine of this type is very small.

Another advantage of the design according to the invention resides in the particular facility with which assembling operations can be carried out. In fact, it is possible, owing to the provision of two distinct types of casing members, each serving different purposes, to leave the casing members of the first group during maintenance and overhaul operations in place, unfixing only such casing members of the second group as have to be removed in order to expose the parts of the engine and/or auxiliary units requiring maintenance, such as for example, the fuel-injection pump, injection pipes and nozzles, parts of the valve gear, oil fillers, oil-measuring sticks, oil-drain plugs, oil and fuel filters, belt transmission and dynamo.

With internal combustion engines comprising solid-wall crankcases it will not be necessary to provide for an oil-tight casing. This is particularly important for the easily detachable assembly of the casing members of the second group. It is even possible for these casing elements to be detachably fastened to the adjacent elements of the casing assembly by means of snap members, if required.

In order not to impede heat radiation from the outer surfaces of the engine it is advisable to provide a separate cooling-air blower inside the casing assembly in a manner known per se, for example at one extremity of the crankshaft, for the purpose of drawing in cooling air from a sound-proofed suction port of the casing assembly and of directing it alongside the outer surfaces of the engine to a sound-proofed outlet of the casing system.

According to a further feature of the invention the pipings and other engine connections extending through the casing members of the first group are both sound-absorbing inside the casing assembly and sound-proofed against the casing system. This refers not only to the pipings for the cooling water, air for combustion and fuel but also to connections for controls and monitoring devices etc. Practical experience goes to show that by these expedients the projection of sounds to the outside can be reduced to the lowest level practically attainable.

According to another embodiment of the invention as applied to engines comprising a solid-wall crankcase it is possible for individual elements of the engine, such as for example, the oil sump, to be mounted on the cylinder block in a sound-proof manner, the adjacent casing members being joined to these elements in a manner producing a sound-proofing effect. It is thus not necessary in all cases for the casing assembly to encompass the engine on all sides, but the casing system can be broken in the areas of the aforesaid engine elements without impairing the overall sound-damping effect.

Finally, according to a further embodiment of the invention it is possible for shafts extending through the casing assembly, such as for example, the driven shaft and/or the fan shaft, to be carried in sound-absorbing sleeves.

Further details of the invention will appear from the following description of several embodiments of the invention with reference to the accompanying drawings in which

FIG. 1 is a cross-sectional view of a sound-proofed internal combustion engine according to the invention taken on line I–I of FIG. 2,

FIG. 2 is a partially cross-sectional view of the same engine taken on line II—II of FIG. 1,

FIGS. 3 and 4 illustrate another variant of an internal combustion engine according to the invention as shown in FIGS. 1 and 2, respectively, and

FIG. 5 is a cross-sectional view of another embodiment of the invention as applied to an internal combustion engine.

The water-cooled internal combustion engine shown in FIGS. 1 and 2 comprises a solid-wall crankcase 1 with laterally spreading engine supports 2. The cylinder liners are designated by reference number 3, the cylinder head by 4, and the valve-rocker covers by 5.

The crankshaft 6 of the four-cylinder in-line internal combustion engine carries at one extremity a vee-belt pulley 7 with the adjacent blower impeller 8. A vee-belt 9 drives the shaft 11 carrying the fan 12 via a second vee-belt pulley 10.

The flywheel 13 located at the other extremity of the crankshaft 6 is covered by the flywheel housing 14 flanged to this end of the crankcase 1.

The crankcase 1 is closed by means of the oil sump 15 tightly attached to its lower connecting flange. The fuel-injection pump designated by reference number 16 whose mode of attachment is not shown in the drawings, is located at one of the sidewalls 17 of the crankcase. To the same side of the engine the upwardly bent suction pipe 18 is flanged to the cylinder head 4. To the other side of the cylinder head the exhaust manifold 20 provided with cooling ribs 19 is attached. The exhaust passage is designated by reference number 21 and the exhaust valve of the cylinder shown in FIG. 1 by reference number 22.

The internal combustion engine illustrated in the drawing is provided with a sound-proofing casing comprising a number of casing members arranged in paced relation to the outer surfaces of the engine in such a manner as to produce a sound-proofing effect. According to the invention, the individual members of the casing assembly are divided into two distinct groups. The first of these groups comprises casing members mounted directly on the engine in such a manner as to produce a sound-attenuating effect and serving as supports for the remaining members of the casing assembly. Through these casing members the pipings and other connections of the engine extend. This group also includes a frame-like upper casing member 23 mounted on the cylinder head 4 by means of elastic spacers 24, such as rubber elements for example, in such a way as to produce a sound-absorbing effect. The mode of attachment which is not the subject matter of the present invention, may vary as required, preferably by connecting the casing members concerned with the elastic spacers by vulcanization, gluing or the like. To the engine they are preferably attached by means of bolts or screws.

In order to impede the transmission of sounds via the pipings leading to the outside, sound-proofing connecting pieces are inserted in these pipings inside the casing system, serving at the same time as elastic sealing means. Such a connecting piece 26 connects the suction pipe 18 with a pipe section 18' extending through the casing member 23.

Likewise, the exhaust manifold 20 is connected with the outwards-leading exhaust pipe 27 by means of a sound-proofing connecting piece 28 designed, in the present instance, as a currugated tube. The through bore at the point where the exhaust pipe 27 emerges from the casing is lined with a sound-damping layer 29 serving to hold the transfer of heat from the hot exhaust pipe to the casing within admissible limits and at the same time, as a sealing member at this opening.

Another frame-like casing member 30 of the first group is mounted on the underside of the crankcase 1 by means of sound-absorbing supporting means 31. Further members of the casing assembly are supported by the flange of the flywheel housing with the interposition of an annular sound-proofing element 32, 33, part 32 of this element being located between the flange of the flywheel housing and the gearbox (indicated by dash-and-dot lines in the drawing) usually attached thereto. Thus the annular element serves both as a sound-absorbing support for the casing and as a sound-proofing insulation. Where the driven end of the shaft is mounted on the flywheel, the provision of an additional cover is required in which case sound-proofing individual elements may be substituted for the annular element, since sound-absorption is no longer required at this point.

The second group of casing members comprises casing elements attached to the first-mentioned casing elements 23 and 30 and/or to the annular element 33 in such a manner as to be readily detachable and to produce a sound-proofing effect, and serving as a cover for such areas of the engine and of its auxiliary machines and other accessories as require regular maintenance and must be easily accessible in the event of trouble. Such a casing member 34, comprising the valve-rocker covers 5 is detachably mounted on the upper frame-like casing member 23. The casing member 34 is provided with a cooling-air outlet 38 screend off by means of a muffler 39.

On the lower frame-like casing member 30 another casing member 35 of the second group is detachably mounted, upon removal of which the oil sump 15 becomes accessible. Connection between the casing members 23 and 30 and/or the annular member 33 is assured by two or more casing members 36 and 37 located on both sides of the engine and either directly interconnected at the front and rear ends of the engine or else joined by means of separate casing elements provided at the front and rear ends so as to produce a self-contained casing system. At the bores where the engine supporting members 2 extend through the lateral casing members 36 and 37 elastic sealing means 40 are provided. At the front end of the casing assembly another muffler 41 is provided which is associated with the cooling-air inlet 42 in front of the blower impeller 8. The two mufflers 41 and 39 serve to produce sufficient sound-attenuation for the two cooling-air openings so as to make sure that they will not impair the sound-proofing effect of the casing of the engine. Additional sound-proofing is ensured by the

provision of a sound-absorbing sleeve **43** at the point where the fan shaft **11** emerges from the casing.

Thus noise-radiation and sound-transmission from the engine are reduced to the minimum level while increasing external dimensions to a negligible degree only. At the same time, access to such parts of the engine as require regular care and maintenance is facilitated and simplified by the provision of easily detachable casing members.

The internal combustion engine illustrated in FIGS. **3** and **4** differs from the type hereabove described essentially in the following details only: Instead of an air-cooled exhaust manifold **20** of the former embodiment of the invention, provision has been made for an exhaust manifold **20'** located in a separate housing **44** traversed by cooling water, from where the cooling-water return pipe **45** emerges. The latter is attached to the housing **44** with the interposition of a sound-proofing connecting-piece **46** and extends through the upper casing member **23** mounted on the cylinder head **4**.

The exhaust pipe **27** attached to the housing **44** with the interposition of the corrugated tube **28** extends through a muffler **47** mounted on the easily detachable lateral casing member **37** and defining in conjunction with the exhaust pipe **27** an annular chamber **48** through which the cooling air delivered by the blower **8** is evacuated from the casing assembly as shown in the accompanying drawing. The heat radiating from the exhaust pipe **27** is transferred to the cooling air, as a result of which the adjacent areas of the casing assembly are protected from excessive heat.

In the internal combustion engine illustrated in FIGS. **3** and **4**, the oil sump **15'** is moreover, mounted directly on the lower fastening rim of the crankcase **1** in such a manner as to produce a sound-proofing effect. The sound-proofing member **49** of the oil sump **15'** is designed as a peripheral oiltight fillet. The lower casing member **30** adjoins the oil sump **15'** with the interposition of an elastic supporting member **40**, so as to make it part of the sound-proofing casing assembly of the engine.

As appears from FIG. **4**, the flywheel-end **50** of the crankshaft **6** protrudes from the flywheel casing **14** and extends through an easily removable cover **51** attached to the annular casing member **32'** in a sound-absorbing sleeve **52**. Thus the cover **51** also becomes part of the sound-proofing engine casing.

In the internal combustion engine shown in FIG. **5** an open-work supporting frame **53** for the crankshaft **6**, the cylinders **3**, the valve gear etc. is provided in the place of a solid-walled crankcase. As compared with the latter design, such wall members as can be readily dispensed with without impairing the required stability and rigidity have been omitted.

According to this embodiment of the invention the sound-proofing casing members additionally provide an oiltight housing, and both a separate valve chamber cover and a separate oil sump may be dispensed with.

According to the invention, the members of the casing assembly are divided into two distinct groups. The first group comprises the two casing members **54** and **55** mounted directly on the engine and supporting the readily removable casing members **56**, **57** and **58** of the second group. An elastic support is provided by annular elements **59** and **60** and additional supporting means **61**.

Inasmuch as in this case the elastically mounted casing members may be of ordinary sheet metal, the transfer of heat from the engine oil to the ambient air is fully assured.

We claim:

1. An internal combustion engine with a sound-absorbing casing, covering the entire surface of the engine in spaced relation to the surface thereof, said engine comprising pipings and other connection means extending through said sound-absorbing casing, the said casing including a first group of casing members directly attached to the engine in such a manner as to produce a sound-attenuating effect, a second group of casing members removably attached to the casing members of the first group in such a manner as to produce a sound-damping effect, said pipings and other engine connection means extending through said casing members of the first group, and said casing members of the second group covering such parts of the engine as have to be accessible for maintenance purposes.

2. An internal combustion engine according to claim **1**, comprising auxiliary units located within said sound-absorbing casing attached to the engine, said casing members of the second group covering also said auxiliary unit.

3. An internal combustion engine according to claim **1**, wherein the said pipings extending through openings of said casing members of the first group and said other engine connection means are connected to the engine in such manner as to provide isolation from sound conducted through solids, and the openings through which said pipings and connection means extend being closed by sound-insulating means.

4. An internal combustion engine according to claim **1**, comprising structural engine parts, such as for example, an oil sump attached to the cylinder block in such a manner as to provide isolation from sound conducted through solids, the casing members adjoining said structural engine parts being attached to the last-mentioned engine parts in such a manner as to produce a sound-proofing effect.

5. An internal combustion engine according to claim **1**, comprising a crankshaft extending through the said casing, a sound-absorbing sleeve encompassing the said crankshaft in the area of its passage through the casing.

6. An internal combustion engine according to claim **1**, comprising a fan shaft extending through the said casing, a sound-absorbing sleeve encompassing the said fan shaft in the area of its passage through the said casing.

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