

[54] SOUND-PROOFING WALL-FORMING
STRUCTURAL ELEMENT

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

[22] Filed: **Sept. 22, 1972**

[21] Appl. No.: **291,158**

[52] U.S. Cl. **181/33 G, 181/33 GA**

[51] Int. Cl. **E04b**

[58] Field of Search **181/33 G, 33 GA,**
181/33 Q, 33 K, 33 A, 33 C, 33 F, 40, 55,
71; 161/46, 116, 127, 165, 105, 119, 131

[56] **References Cited**
UNITED STATES PATENTS
2,087,248 7/1937 Fischer 181/33 G

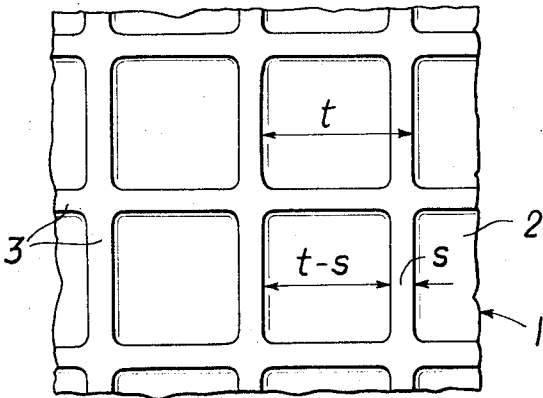
3,232,371 2/1966 Reichert et al. 181/33 K

Primary Examiner—Richard B. Wilkinson
Assistant Examiner—Pat Salce
Attorney—Watson, Cole, Grindle & Watson

[57] **ABSTRACT**

A sound-proofing structural element for the formation of a wall, in particular of a housing wall of an engine or machine, comprising a number of intersecting webs on at least one of its outer surfaces, the predetermined ratio between the wall thickness of the structural element, the dimensions of the webs and the clearances between them being such as to reduce the sound generation of the structural element.

3 Claims, 6 Drawing Figures



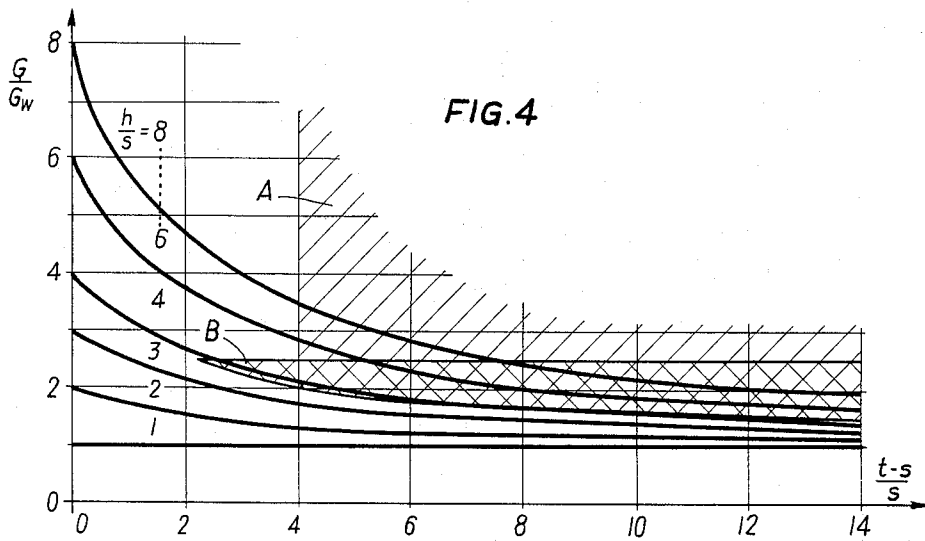
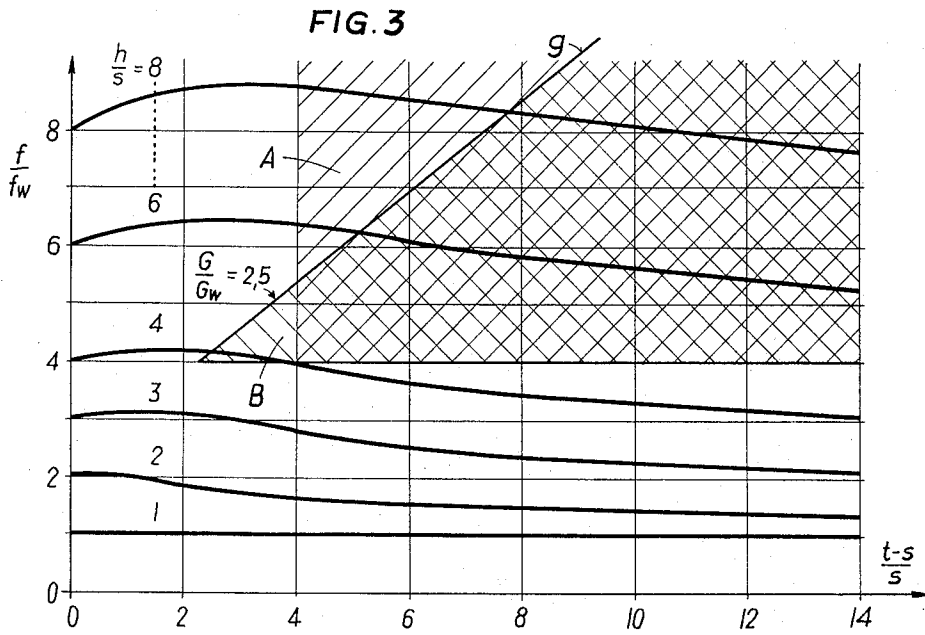
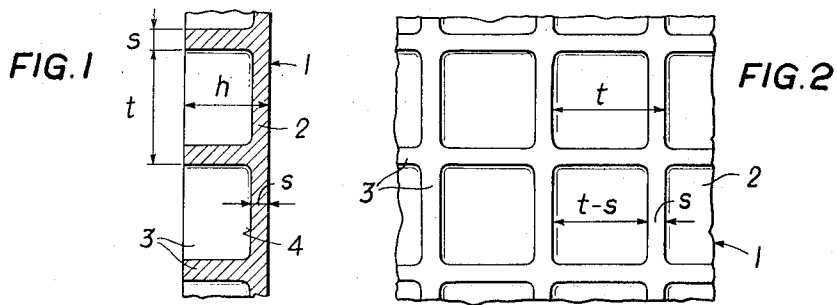


FIG. 5

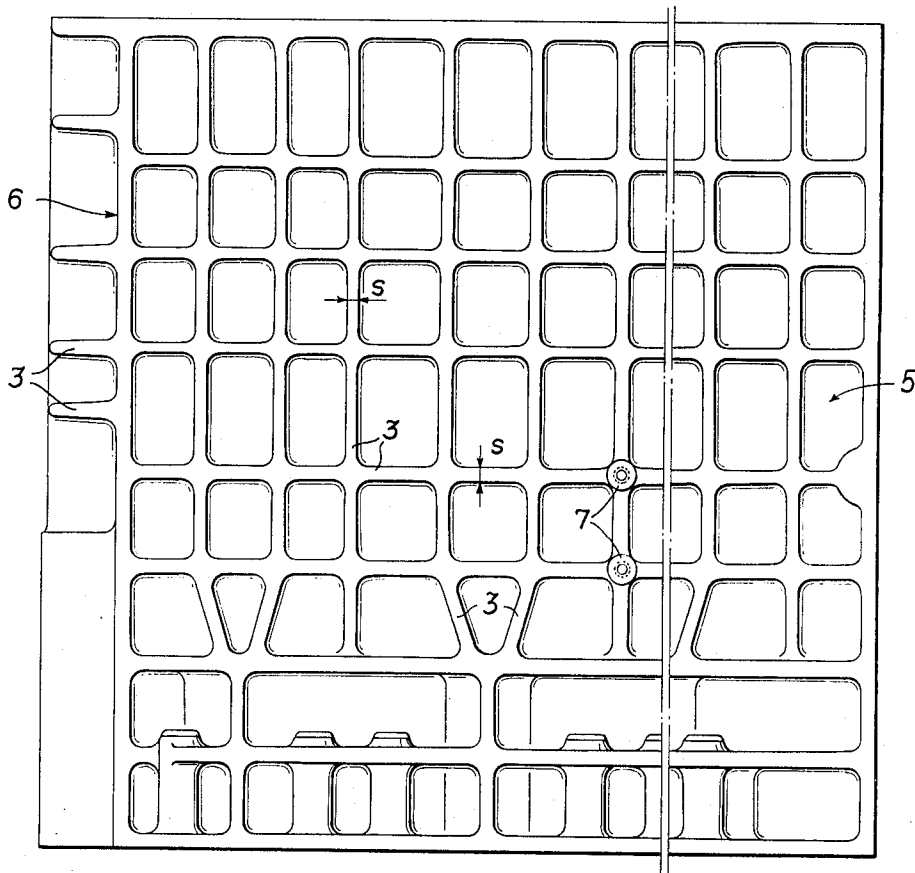
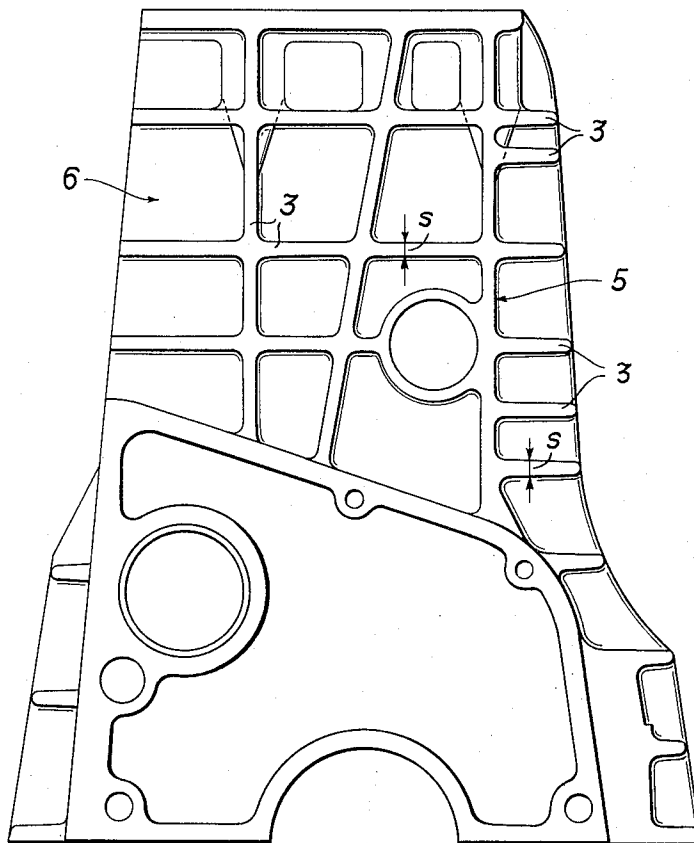


FIG. 6



SOUND-PROOFING WALL-FORMING STRUCTURAL ELEMENT

The invention relates to a sound-proofing wall-forming structural element, particularly to a housing or part of a housing of an engine or machine.

The frequency spectra of sound-generating processes are known either to decrease steadily as the frequency rises, as for example, the combustion chamber pressure of an internal combustion engine, or at least to decrease abruptly as in connection with mechanical thrusts, which means that the degree of sound generation diminishes either with increasing frequencies or at least as from a certain frequency level.

Every structural element has a multitude of natural frequencies excited by means of the sound introduced into same. By designing the structural element in such a manner as to raise the lowest natural frequencies to such a level as to reach the area of diminishing excitation one may safely anticipate a reduction of the noise produced by the structural element in question. The bending frequencies of wall elements are a function of the wall thickness, of the width between supports and the properties of the material. The basic interdependence of these values is expressed by the equation

$$f = \text{const.} \times (s/l^2) \sqrt{E/\rho}$$

wherein f signifies the frequency, s the wall thickness, l the width between supports, E the modulus of elasticity and ρ the density of the material. The constant is a function of the type and rigidity of the supporting means. It is predetermined by the construction features and therefore, liable to be influenced to a minor degree only.

In view of the quadratic functional relation it would be possible to decidedly influence frequency by altering the width between supports, if the latter were not to a considerable extent predetermined by the prescribed main measurements of the structural element involved. Another substantially influential value is the wall thickness. However, its increase involves a proportional, and therefore, unfeasible augmentation of weight if the same material is to be used.

In a known type of vehicle-borne diesel engine a considerable increase of the natural frequencies of wall members has been achieved by the provision of a housing featuring an extremely large wall thickness and by using a material where the relation between the modulus of elasticity and the density was particularly advantageous. The conventional cast-iron housing was replaced by one of magnesium of equal weight, that is, one having a wall thickness approximately six times larger, as a result of which the natural frequencies of the wall portions were increased tenfold. With other portions of the engine remaining unchanged, sound attenuation thus achieved was in the order of 10 dB (A). Considerable corrosion problems and high material costs involved in this attempt at solving noise problems have so far impeded its practical application on a large scale.

It is the purpose of the present invention to provide a sound-proofing wall-forming structural element of high rigidity involving only minor additional quantities of material for the purpose of greatly reducing sound radiation. This structural element should be particularly suitable for the manufacture of machine housings and their covers. These elements are so excited by the introduction of sound as to produce oscillation phe-

nomena and will therefore, radiate sound transmitted by air. According to the invention, webs or the like projecting from the wall surface are arranged in spaced relation to each other in a manner known per se at least on one wall surface of the structural element, the webs extending crosswise in two directions almost perpendicular to each other, the ratio between web height plus wall thickness and wall thickness amounting at least to 4, whereas the ratio between the inside width separating adjacent webs and the width of the webs ranges from 4 to 14.

The invention is based on the realization that if a solid wall is resolved into a number of webs supported by means of a partition whose thickness is only a fraction of the full wall thickness, the natural frequency is at first even increased as compared with a solid wall as the distance between the webs augments, and even with very wide intervals between the webs, the natural frequency diminishes only slightly as compared with the solid wall.

It is therefore, possible for example, to achieve with a structural element according to the invention, having only about 25 percent of the weight of a solid wall, the same natural bending frequencies, or else to multiply the natural bending frequencies of the original wall by no more than doubling the weight of the wall through the provision of webs, depending on the distance between individual webs.

Experience has shown that if the relationship between web and wall dimensions according to the invention is strictly observed, the frequency can easily be increased at least three or four-fold in conventional types of housings and covers with ordinary excitations. With known wall elements which for reasons of solidity are provided with webs in the shape of reinforcing ribs it is normally impossible to achieve an adequate shift of natural frequency levels, adequacy being understood here to mean that resonances reach the above-mentioned area of lesser excitation.

For practical purposes, the structural element according to the invention should have no more than 2.5 times the original weight of the non-ribbed wall.

According to another embodiment of the invention the webs extend at least approximately in parallel relation to the outer contours of the structural element. This design offers certain advantages for reasons of solidity and because it is easily and conveniently cast.

Finally, it is preferable according to another feature of the invention to provide nipples, through bores or the like at the intersections of the webs. The nipples or other wall members serving for the attachment of accessories or the like to the structural element are thus increasingly reinforced.

Further details of the invention will become apparent from the following description with reference to the accompanying drawings wherein

FIG. 1 is a cross-sectional view of a structural element according to the invention,

FIG. 2 is a top plan view of a structural element as shown in FIG. 1,

FIG. 3 is a diagram illustrating the relationship between the relative frequency and the distance between ribs,

FIG. 4 is another diagram describing the relationship between the relative weight and the relative distance between ribs,

FIG. 5 is a side elevation of the upper portion of a crankcase according to the invention, and

FIG. 6 is a front view of the crankcase shown in FIG. 5.

FIGS. 1 and 2 illustrate the fundamental design of a sound-proofing structural element 1 according to the invention. It comprises a plate-shaped portion 2, on the outer surface 4 of which webs 3 are arranged at regular intervals and intersecting at right angles, the dimensional relationship according to the invention being such that the overall cross-sectional height h (height of web plus wall thickness s) is at least four times as large as the wall thickness s and besides, the inside width $t - s$ (distance between ribs t less web width s) is more than four times as large as the web width s .

The graph as per FIG. 3 shows the interconnection between the relative frequency f/f_w , that is, the possible multiplication of the natural frequency of the structural element according to the invention as compared with the natural frequency f_w of a non-ribbed wall, on the one hand, and the relative rib distance $(t - s)/s$, or the relationship between the inter-web inside width and the web width, on the other hand. The relation h/s , that is, the relative rib height, is used as a parameter for the set of curves shown in the graph, the relation $h/s = 1$ being applicable to a non-ribbed wall, in which case the relative frequency is 1. The technically suitable limits for the various ratio values are highlighted in the graph by differences in shading. The right-hand-hatched area A is defined towards both sides of the graph by the actually feasible boundary values 4 and 14 of the relative rib distance. A relative web height $h/s = 4$ represents the bottom boundary of the area A.

The technically applicable area of the graph shown in FIG. 3 can, however, also be defined under a different angle as illustrated by the lefthand-hatched area B in FIG. 3, wherein a relative frequency 4 is assumed to be the actually suitable bottom boundary, whereas the upper boundary is defined by the straight line g representing the admissible upper boundary value for the relative weight G/G_w of 2.5, G signifying the weight of the ribbed wall and G_w the weight of the non-ribbed wall.

The graph of FIG. 4 shows the interdependence between the relative weight G/G_w and the relative rib distance $(t - s)/s$ for different relative web heights h/s . The technically applicable boundaries of the aforesaid ratios are, as in the graph of FIG. 3, defined by the right-hand-hatched area A' and the lefthand-hatched area

B'.

FIGS. 5 and 6 show a practical embodiment of the invention as applied to an internal combustion engine. The entire sidewall 5 and parts of the front wall 6 of the upper portion of the crankcase shown are designed as sound-proofing walls according to the invention and provided with webs 3 projecting from the outer wall surface and extending essentially in parallel relation to the outer contours of the associated wall portions. Thus with the sidewall 5 the webs 3 form an almost continuous orthogonal web system. The dimensions of, and clearances between, individual webs as well as the wall thickness relationships are determined by the ratios according to the invention.

As can be seen from FIG. 5, nipples for the attachment of accessories of the internal combustion engine are provided in the web system and located at the intersections of the webs 3.

The scope of the present invention is not restricted to the embodiment hereabove described by way of example and shown in the drawings. It can also be used for the design of housing or housing members of any other type of machine whose walls are excited by sound conducted through solids, provided the proportional values according to the invention are strictly observed so as to achieve the desired sound-proofing effect.

I claim:

1. A sound-proofing structural element for the formation of a wall, particularly the wall of a housing of an engine or machine, said wall having an outer and an inner surface, a number of webs projecting from at least one of said surfaces and extending in spaced relation to each other and intersecting in two directions approximately perpendicular to each other, the ratio between the height of the webs plus the wall thickness of the structural element and the wall thickness being at least 4 and the ratio between the inside width of inter-web clearances and the width of the webs being somewhere between 4 and 14.

2. A sound-proofing structural element according to claim 1, wherein said webs extend at least approximately in parallel relation to the outer contours of the structural element.

3. A structural element according to claim 1, comprising nipples on the surface supporting the said webs, the nipples being located at the intersections of the webs.

* * * * *

50

55

60

65

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,773,141 Dated November 20, 1973

Inventor(s) Gerhard Thien and Heinz Fachbach

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title page of the patent, the following information should be added:

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

Signed and sealed this 14th day of May 1974.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,773,141 Dated November 20, 1973

Inventor(s) Gerhard Thien and Heinz Fachbach

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title page of the patent, the following information should be added:

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

Signed and sealed this 14th day of May 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents