The invention concerns a method for the improvement of the sound insulation quality of a hollow-core slab and a building element slab combination with a high sound insulation quality. According to the method, at a distance from the surface of a first hollow-core building element slab (1, 2) is adapted at least one planar layer (3) of material and between said material layer (3) and the intermediate space (5) remaining between said building element slab (1, 2) are adapted spacer members (4) of a substantially resilient material which separate said material layer and said building element slab from each other. The air contained in said intermediate space (5), together with the resilient spacer members (4), forms a spring combination capable of attenuating sounds transmitted through said building element slab. According to the invention, the sound insulation quality of said spring combination is improved by connecting said intermediate space (5) to the cavities (6) of said hollow-core building element slab. Such an embodiment makes it possible to produce hollow-core slabs with a high sound insulation quality from high-strength material.
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Method for improving the sound insulation quality of a hollow-core slab and a combination hollow-core slab with high sound insulation quality

5 The present invention is related to building technology based on modular elements and to concrete intermediate floors and partitioning walls. In particular the invention concerns a method according to the preamble of claim 1 for improving the sound insulation quality of slab-like structural elements.

10 According to such a method, a planar layer of material is adapted spaced a distance from a hollow-core slab-like structural element, and the space remaining between said material layer and the hollow-core structural element is adapted to contain spacer members made of a resilient material that isolate the material layer and the structural element from each other.

15 The invention also concerns a combination structural element according to the preamble of claim 5 having a high sound insulation quality. Such a combination comprises a first hollow-core slab, at least one second hollow-core slab adapted at a distance from the first slab element and spacer members which are adapted between the first and the second slab and are made from a resilient material.

Building technology based on modular concrete elements has brought the provision of mass production to the building element industry. Building erection from elements, as well as on-site construction, involves certain sound insulation problems. So, when a building is erected from prefabricated elements, the adjoining structures are mated via multiple seams with concomitant sound leak paths. Moreover, the trend toward lightweight structures poses new challenges to sound insulation. Even if prefabricated slab elements are used, some erection steps can be performed only at the construction site, resulting in varying work tolerance depending on local conditions. Furthermore, some long-term dimensional deformations in concrete must be accounted for already in the design of the structures.
Theoretical computational models can be used to a reasonable accuracy for evaluation of sound insulation in buildings. For new constructions, such evaluations can be verified with the help of experimental tests.

Factors affecting the attenuation of mechanical vibrations in an intermediate floor slab are:
1. Mass of the structure
2. Resonances
3. Effect of coincidence of openings
4. Flooring
5. Bypass path transmission

Prior-art patent publications disclose solutions for improvement of sound insulation that aim at controlling some of these factors.

The DE patent publication 714,339 issued in 1941 describes a structure in which resilient rubber members are employed between two adjacent slabs or panels to separate said boards from each other and to provide air space between the boards.

A similar solution is disclosed in the FI patent publication 48,115, however, based on the use of resin-impregnated rope as the separating members between panels.

An insulation method for attenuating impact noise transmitted through intermediate floors is disclosed in the FI patent publication 29,753 based on separation of particle board panels from each other by means of point-shaped members that simultaneously act as spacing and fixing members between the panels.

The FI patent 29,859 is an extension of the invention disclosed in the above patent based on introducing the resilient compound in between the concrete slabs with the help of a paper substrate or similar layer onto which the resilient compound is applied point-wise or line-wise spaced at constant distance. According to the patent, the distance between the resilient connecting points is dependent on the desired frequency to be attenuated according to a certain formula.
The FI patent application 9167/73 describes a solution similar to that described above based on employing mineral wool as the sound-insulating members separating the panels.

In prefabricated intermediate floor slabs the standard solution to sound insulation problems has been formed by a so-called floating floor described in the above-cited patent publications that provides a satisfactory degree of sound insulation. According to conventional techniques the floor is formed onto the load-bearing structure by first laying a layer of resilient material and then casting a floating raft of concrete or similar layer of material on it.

For control of sound insulation the essential factor is constituted by the space remaining between the floating structure, the floor raft, and the supporting structure. Air confined in this space acts as a pneumatic spring which attenuates the movements of the floating floor, and simultaneously sound propagation, by way of forming a spring combination together with the resilient intermediate material or springs. As the air gap formed by said space is increased, also the sound insulation quality of the structure is improved.

The above-described techniques, however, involve major drawbacks and deficiencies.

A major goal in the building industry is to perform as many work stages as possible in a factory. The casting of a floating floor concrete raft must, however, concurrently be performed at the construction site, which is contrary to this goal.

Floating floors can have a large area. Assuming that the floating concrete raft would be cast into a 4 cm thick concrete slab and the desired natural frequency be 10 Hz, the computational formula

\[ f = \frac{60}{\sqrt{md}} \]

where

- \( m \) = mass
- \( d = 4 \text{ cm} \)
- \( f = 10 \text{ Hz} \)

gives approx. 38 cm as the value for the required air gap.
As the spring actions of the resilient material and the air space cushion in practice work simultaneously, either the air gap or the floating concrete raft must be made even thicker to attain the desired natural frequency.

If the intermediate floor slabs shall be dimensioned for a total floor thickness of 30 cm maximum, yet maintaining a free choice of the flooring material, a compromise must be made between the structure mass, air gap width and acceptable natural frequency. Moreover, hollow-core slabs are preferred for several reasons, whereby a further reduction in structure mass is encountered.

The above discussion deals with the problems involved in prior-art technology as regards impact noise attenuation in intermediate floors. In wall structures the problems are not as complicated as in intermediate floors. However, modern audio equipment can produce sounds at such extremely high levels that are poorly attenuated by simple structures. This problem which is associated with so-called airborne sound emission could be solved by the use of completely mutually isolated double walls that, however, are far too expensive in the majority of practical applications.

It is an object of the present invention to overcome the drawbacks of the conventional technology and to achieve a novel embodiment for the improvement of sound insulation particularly in hollow-core slab structures.

The goal of the invention is to achieve sufficient sound insulation particularly in lightweight building elements. Especially such an embodiment is sought in which the attenuation of footstep-type tapping noise is combined with a free flooring material choice for the intermediate floor. Moreover, improved sound insulation for intermediate floors and partitioning walls is sought.

The invention is based on the concept of increasing the volume of the air space remaining between the floating concrete raft and the load-bearing structural element in a conventional floating floor combination by joining said air space via openings with the cavities of the load-bearing hollow-core slab. Such an arrangement reduces
the stiffness of said spring combination, whereby improved sound insulation is attained. The cross section of the openings to be formed is selected according to the invention so that the opening-free portion of the underlying hollow-core slab still can perform its function as a load-bearing structural element.

More specifically, the method according to the invention is principally characterized by what is stated in the characterizing part of claim 1.

Furthermore, the structural element combination according to the invention is characterized by what is stated in the characterizing part of claim 5.

In the context of this patent application, the term "hollow-core slab" refers to a structural element incorporating at least one cavity extending longitudinally or transversely across the slab. The cavity is advantageously void (free air space) or it can be filled to some degree with, e.g., a porous material. The essential characteristic required from the material only is that it must not present any substantial resistance to air compression or expansion.

The planar layer of "material" to be arranged beside or above the hollow-core slab can be any type of material capable of bearing a load distributed over a large area. Thus, the choice of materials can be made from different types of concrete slabs and boards, gypsum slabs and boards, particle board, fiber board and similar building slabs and boards. The selected layer thickness can be varied according to the strength requirements at the application site.

The invention provides significant benefits. For instance, the possibility of increasing the volume of the air space and thereby the height the of the air gap between the floating floor and the load-bearing building element permits reduction of the resilient layer height. Simultaneously, only a partial coverage of the slab with the resilient layer becomes possible, which gives further choices in the spring properties of the resilient layer.
The degree of sound insulation attained by virtue of the concept is good. Where a prior-art structure known as the Nilcon slab seeks to maximize the volume of the air space by compromising the properties of the load-bearing portion and maximizing the mass of the load-bearing portion, the structure according to our invention achieves a degree of sound insulation corresponding to the maximal volume of the air space and simultaneously a greater height of the load-bearing portion than with the use of massive slab.

In wall structures a load-bearing wall or partitioning wall according to the present invention gives possibilities of achieving good insulation against propagation of airborne sound. Thus, a wall lighter than conventional wall structures, together with better silencing of airborne sound, is provided.

According to the invention, the upper surface of the intermediate floor element, that is, the compressive stress bearing surface, is designed to incorporate openings extending down to the hollow core of the slab. The area formed by these openings is advantageously 10...50 % of the total area of the upper surface. The surface area ratio of compressively stressed structural element portion to the area of said acoustic openings is determined by construction design rules and the strength of the concrete grade used. Typically, the openings comprise approx. 15...35 % of the compressively stressed area, whereby the opening-free portion of the structure can still completely fulfill its function as a compressive-load bearing surface according to building standards.

New high-strength, concrete-type materials have brought new possibilities of industrially manufacturing building elements in highly automated factories. This provides cost-effective implementation of most complicated structures such as intermediate floors and partitioning walls comprised of multiple parts. High-strength materials can be availed in the hollow-core designs so that the structures can be made essentially lighter in weight than counterparts made from conventional concrete grades. Element portions thus lightened do not, however, provide as good sound insulation in areas governed by the mass action law of attenuation as that available
with the use of heavier structures; so an efficient utilization of the spring action of the air space is important particularly in respect to these portions.

According to the present invention it is advantageous, yet not mandatory, to cast at least the floating raft slab, or screed slab, from a concrete material having the coarser aggregate replaced by polystyrene beads or similar soft particles. This provides a lightweight and strong, yet above all workable concrete called lightweight aggregate concrete hereinafter.

Reduction of dimensional deformations in the structures is an additional benefit offered by high strength. Smaller dimensional deformations and the lightweight aggregate cellular composition permit dimensionally accurate production of building elements by way of, e.g., machining. If the sound-insulating raft is made onto, e.g., a typical hollow-core slab reinforced by pretensioned steels, the machining stage is particularly important for straightening combination element free from the warping deformations characteristic of a hollow-core slab. Elements machined for good sound insulation reduce the possibilities of sound leak paths and also other defects arising from works at the construction site.

According to an advantageous embodiment of the invention, a prefabricated building slab combination is thereby achieved comprised of a floating raft made of lightweight aggregate concrete or similar material resting supported by resilient spacers on a hollow-core intermediate floor slab. As both slab members are fabricated to a high dimensional accuracy, the building elements according to the invention offer an easy way of constructing contiguous intermediate floors practically free from installation gaps between the slabs.

An advantageous intermediate floor construction has been developed in conjunction with the invention, comprised of two slabs each of which having a cross section resembling a shallow U, said slabs being juxtaposed at the tips of the U’s, whereby a central cavity is formed between the U’s. To the shell forming the upper U are herein, either during casting or subsequently, provided openings which reach through
the shell and thus in the slab combination connect the air space remaining between
the floating concrete raft and the intermediate floor slab to said cavity.

It must be noted, however, that the invention can also be employed in conventional
manufacturing technology for improvement of sound insulation, improvement and
manufacture of levelled, machined floor surfaces by way of fabricating the floating
raft from lightweight aggregate concrete and joining the cavities of the hollow-core
slab via its upper surface openings to the elastic portion of the combination element.

The details and benefits of the invention will be evident from the following
description in which the invention is examined by reference to the annexed drawing
in which

Fig. 1 shows a combination building element slab structure in a partially sectioned
cross section.
Fig. 2 shows the combination building element slab structure in a side view.
Figs. 3 and 4 show two alternative combination building element slab structures in
partially sectioned top views.
Fig. 5 shows the cross section of the seam between two combination building
element slabs.
Fig. 6 shows the cross section of a combination building element slab implemented
using a conventional hollow-core slab.

The embodiment of the invention illustrated in Figs. 1 and 2 comprises an
intermediate floor slab 1, 2 on which a floating floor raft 3 is adapted on resilient
spacers 4 so that an air gap 5 is provided between the intermediate floor slab 1, 2
and the floating raft 3.

The intermediate floor slab 1, 2 is made of a conventional concrete grade and it
contains a cavity 6 oriented parallel to the longitudinal axis of the slab so as to
extend from end to end over the entire length of slab. The lower surface 2 of the
slab, or the tensile stress bearing surface, is provided with prestressed shell tendons
7, 8 extending longitudinally over the slab. The shell tendons are comprised of
pretensioned steels 7 which are enclosed by shell parts 8 made of high-strength concrete. The upper part of the slab, or the compressively stressed part 1, is provided at the cavity 6 with openings 9, which connect the air space 5 formed between the slab and floating raft to the cavity 6. Longitudinal dowel grooves 10 are provided at the side walls of the intermediate floor slab lower part. Further, the side walls of the intermediate floor slab are provided at suitable spacings (e.g., approx. 50...70 cm) with thinned areas 11. The side walls of the slab can be pierced at these areas for routing, e.g., the piping and sewers.

In the above-described structure, the air space remaining between the floating raft 3 and the intermediate floor slab 1, 2 is connected to the central cavity of the intermediate floor which lowers the acoustical stiffness of the air layer. Together with the resilient spacers, the extended air space thus forms a spring combination of high insulation quality to sound transmission.

The intermediate floor slab is fabricated with the help of, e.g., conventional mould techniques by first casting the lower part 2 with a cross section of a shallow U, then flipping the part upside down and connecting it to the upper part 1. The joining of the upper and lower halves of the intermediate floor slab can be implemented by, e.g., bolting. The mould for the slab’s lower part has contoured inward projections for providing the thinned areas 11 on the slab’s side walls.

According to another embodiment the upper part 1 is fabricated in the same mould as the lower part 2, whereby both halves of the slab are initially identical. After the joining of the halves into the intermediate floor slab, the upper part 1 of the slab is worked for openings 9 which penetrate the shell of the upper part 1 at the cavity 6 formed between halves of the intermediate floor slab. Such openings can be made by, e.g., drilling. This alternative embodiment is suited for use in cases where the sound insulation quality of intermediate floors or partitioning walls in a ready-made building are improved at the construction site (as a renovation operation).

According to another advantageous embodiment of the invention, the openings 9 are made already during the casting stage by casting the upper part 1 of the intermediate
floor slab in a mould having auxiliary mould projections for the openings.
Advantageously, the same mould is used as that made for casting the lower part by
complementing the mould with separate, detachable auxiliary mould projections.
However, also a mould with fixed projections for the openings can be used. As the
shell in the lower part 2 of the intermediate floor slab is thicker than the shell in the
upper part, also the lower part can be cast in latter mould without substantially
compromising the strength of the lower part.

The openings 9 can have a rectangular or round cross section, and they can be
arranged in one, two or multiple rows as shown in Figs. 3 and 4. The proportion of
their total area in the total area of the slab can be varied in wide range according to
the strength requirements of the intermediate floor. Typically, the total area of the
openings is, however, in the range 10...50 % of the slab’s total area.

Next, the upper surface of the intermediate floor 1, 2 is provided with spacers 4,
properly outdistanced from each other and made from a suitable resilient material.
The spacers can be made from natural polymers or synthetic polymers. Examples of
suitable spacer materials are natural rubber, polyisoprene, polyurethane, polystyrene
and different polyolefins. Advantageously, expanded rubber and polymer materials
(foamed plastics or rubbers) are used. The spacers can, however, also be comprised
of mechanical springs such as the undulated sheet steels described below. The mutual
outdistancing of the spacers is dependent on the slab dimensions and manufacturing
materials thereof. Typically, however, the spacers are outdistanced by approx.
40...70 cm.

To the upper surface of the intermediate floor slab, between the resilient spacers 4,
resting on the upper part 1 of the intermediate floor slab, are placed sheet steels
whose upper surfaces form a planar casting platform. For improved stiffness, the
sheet steels can be ribbed with undulations. Next, to produce the floating raft 3, a
few centimeter thick concrete layer is cast onto the sheet steels and spacers. Any
suitable concrete grade can be used for casting. As the floating raft has no function
as a load-bearing structure, it is advantageously always made from a most
lightweight material such as expanded concrete.
According to an advantageous embodiment of the invention in which the upper part 1 is cast in the same mould as the lower part after fitting the mould with separate auxiliary mould projections for the openings, the floating raft is also finally cast in the same mould subsequent to the casting of the upper part 1. This embodiment has the benefit that the mould projections can act as supports for the sheet steel during casting. Neither are separate mould walls required.

Alternatively, and particularly if the openings are separately worked to the upper surface of the intermediate floor slab as is the case with renovation improvement of sound insulation in existing constructions, the space between the sheet steels and the upper surface of the intermediate floor slab can be provided if necessary with specific support members such as, e.g., undulated sheet steels to support the casting platform sheet steels. Because such undulated sheet steel members are resilient, they can act as spacers in cooperation with the resilient spacers, or alternatively, replace them. The support members can be separate from the casting platform sheet steels or integrally fixed to them. Separate casting mould walls are in this embodiment placed against the sides of the intermediate floor slab upper part for the casting of the floating raft.

In both embodiments the mould is ripped off after casting and the floating raft 3 is machined to exactly match the dimensions of the intermediate floor slab.

Fig. 2 shows the cross section of the seam between two combination slabs according to the invention. As is evident from the diagram, exact matching of the combination slabs 1, 2, 3 results by virtue of the machining of the slabs. To align the slabs vertically in place, plastic or wood dowels 12 can be inserted during installation into the dowel grooves described above. The seams between the lower parts 2 of the intermediate floor slabs can be covered with a self-adhesive glass-fiber fabric 13 and a levelling compound.

After the installation of the intermediate floor, the floating raft can be covered with a desired flooring material such as parquet or plastic flooring mat.
For tests, a hollow-core combination slab with the above-described structure was made having a total thickness of 30 cm and span of 6 m. The upper surface of the load-bearing hollow-core slab (thickness 26 cm) was provided with vertically aligned openings extending down to the cavities of the slab. The total area of the openings was 30% of the upper surface area of the slab. Resilient spacer members were adapted about the openings at constant distances (outdistanced from each other by approx. 50 cm), after which a 3 cm thick floating raft made from expanded concrete was placed over the spacer members. The spacer members were made from expanded plastic with a thickness of 1 cm. Finally, a 1 cm thick parquet was laid on the floating raft.

Subsequent measurements indicated a value of footstep impact noise attenuation $L_{n,w} < 55 \text{ dB}$ for said portion of sound attenuation openings. The load-bearing capability of the slab fulfilled the applicable building standard requirements.

Fig. 6 shows a combination slab 21, 22 according to the invention implemented as a conventional hollow-core structure. In this case the intermediate floor slab comprises a single part 21 which is fabricated by, e.g., continuous slip-form casting so as to incorporate a plurality of parallel elongated cavities 23 with a circular or substantially circular cross section. The upper surface of the hollow-core slab is worked to have openings 24 extending down to said cavities 23 as is illustrated in Fig. 7. The openings 24 can have a circular or polygonal cross section. The hollow-core slab is reinforced by steels 26.

Analogously to the embodiment described last above, the resilient spacer members 25 are adapted onto the hollow-core slab 21 so as to support a floating raft slab 22. An air space 27 is formed between the floating raft 22 and the hollow-core slab 21.

Also this embodiment provides efficient sound insulation is a slab structure. In this conjunction it must be noted that the described embodiment is particularly suited for applications in buildings to be renovated. The sound insulation of the original intermediate floors comprised of hollow-core slabs can be improved in conjunction with floor renovations by piercing the slabs through drilling openings that extend
down to the cavities. Next, resilient spacer members are placed over the slabs, then covering the members with planar steel sheets and finally casting the floating raft from concrete over the sheets.

Embodyments different from those described above are feasible within the scope of the invention. Thus, as was already mentioned in the general part of the description, the invention can also be applied to the improvement of sound insulation in walls. Then, the wall structures are made from a slab similar, e.g., to that shown in Figs. 1...5, or an equivalent hollow-core slab. The slab is pierced by drilling openings extending down to the cavities of the core, after which the slab is covered from both sides with wall panels outdistanced by spacer members from the wall slab. In the case the load-bearing structure of the wall is formed by a beam, the slab forming the wall can also be made to have a shell structure with relatively thin edge walls.

When the combination slab according to the invention has the floating or wall panel boards on both sides of the hollow-core slab, the openings to be made in the hollow-core slab should preferably be made so as to avoid their coincidence in the transverse plane which might otherwise reduce the strength of the hollow-core slab.
Claims:

1. A method for improving the sound insulation quality of a hollow-core building element slab (1, 2; 21), according to which method

   - at least one planar layer (3; 22) of material is adapted at a distance from said hollow-core building element slab and
   - spacer members (4; 25) made from a material of substantially high resilience are adapted in the intermediate space (5; 27) formed between said material layer (3; 22) and said building element slab (1, 2; 21), said spacer members acting as separators between said material layer and said building element slab,

   whereby the air contained in the space (5; 27) formed between the material layer (3; 22) and the building element slab (1, 2; 21), together with the resilient spacer members (4; 25) forms a spring combination capable of attenuating sounds transmitted through said building element slab,

   characterized in that

   - said intermediate space (5; 27) is connected to the cavity space (6; 23) of the hollow-core building element slab in order to improve the sound insulation quality of said spring combination.

2. A method as defined in claim 1, characterized in that said intermediate space (5; 27) is connected to said cavity space (6; 23) of the hollow-core building element slab via openings (9; 24) made to the shell of the building element slab so that the total area of said openings is approx. 10...50% of the total area of the building element slab (1, 2; 21) remaining on the side of the superimposed material layer, whereby the opening-free part of the building element slab retains its function as the structural strength part

3. A method as defined in claim 2, characterized in that said openings (9) are made to the building element slab (1, 2) during the casting stage.
4. A method as defined in claim 2, characterized in that said openings (9; 24) are made to a ready-hardened building element slab (1, 2; 21) by mechanical working.

5. A building element slab combination of high sound insulation quality, comprising
   - a first building element slab (1, 2; 21) incorporating at least one
     longitudinal cavity (6; 23),
   - at least one second building element slab (3; 22) adapted at a distance
     from said first building element slab in order to form an intermediate space
     (5; 27) between said building element slabs, and
   - spacer members (4; 25) placed between said first and said second slab,
     made from a resilient material and suited to retain said first and said
     second building element slab outdistanced from each other,
whereby the air contained in the space (5; 27) formed between the first building
element slab (1, 2; 21) and the second building element slab (3; 22), together with
the resilient spacer members (4; 25) forms a spring combination capable of
attenuating sounds transmitted through said building element slab,
characterized in that
   - the first building element slab (1, 2; 21) is provided with openings (9; 24)
     extending from the intermediate space formed between said first and said
     second building element slab to the cavity space (6; 23) of the first hollow-
     core building element slab in order to improve the sound insulation quality
     of said spring combination.

6. A building element slab combination as defined in claim 5, characterized in that the first building element slab (1, 2) is comprised of two slab halves each of which having a cross section resembling a shallow U, said slabs being juxtaposed at the tips of the U's so as to form a central cavity (6), and that at least that half (1) which remains on the side of the second building element slab (3) is provided with openings (9) extending through said half of the slab.

7. A building element slab combination as defined in claim 5, characterized in that the first building element slab (21) is comprised of a conventional
hollow core slab incorporating a plurality of parallel cavities (23) extending longitudinally from one end of the slab to the other and having at least one of their walls worked to have openings (24) extending into said cavities.

8. A building element slab combination as defined in any foregoing claim 5...7, characterized in that said slab is prefabricated by machining said second building element slab (3; 22) exactly to the dimensions of said first building element slab (1, 2; 21).

9. A building element slab combination as defined in any foregoing claim 5...8, characterized in that said second building element slab (3; 22) is made from expanded concrete.

10. A building element slab combination as defined in any foregoing claim 5...9, characterized in that said combination comprises two second building element slabs (3; 22), one on either side of said first building element slab (1, 2, 21), and that the surfaces on both sides of said first building element slab are provided with openings (9; 24) extending from said intermediate space into said cavities, said openings being positionally shifted so as to avoid mutual coincidence of openings located on opposite sides.

11. A building element slab combination as defined in any foregoing claim 5...10, characterized in that said spacer members (4; 25) are made from a natural polymer, synthetic polymer or a mechanically resilient material.

12. A building element slab combination as defined in any foregoing claim 5...11, in which combination said openings are made during the casting of the first building element slab, characterized in that said openings (9) have an essentially rectangular cross section.

13. A building element slab combination as defined in any foregoing claim 5...11, in which combination said openings are made during the casting of the first building
element slab, characterized in that said openings (9) have an essentially circular cross section.

14. A building element slab combination as defined in any foregoing claim 5...13, characterized in that said second building element slab (3; 22) is cast onto a steel sheet platform supported by said first building element slab.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: E04B 1/82 // E04B 5/02, E04F 15/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: E04B, E04C, E04F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>Y</td>
<td>GB, A, 1181931 (N.G. BOJRAHAG), 18 February 1970 (18.02.70), page 1, line 36 - line 39, figure 1, detail 8</td>
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<td>A</td>
<td>DE, C, 714399 (G. HOFBAUER), 28 November 1941 (28.11.41), claims 1-2, figure 1, detail 5</td>
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<td>DE, C, 821702 (K. MEHRINGS), 19 November 1951 (19.11.51), page 2, line 72 - line 76, figure 1</td>
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[X] Further documents are listed in the continuation of Box C.  [X] See patent family annex.

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Date of the actual completion of the international search 10 May 1993

Date of mailing of the international search report 11-05-1993

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