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(54) **Diamond type cutting tool, with low noise emission, for sawing stone materials, and machine using said tool**

(57) The invention relates to a cutting tool, in particular a diamond-tipped cutting tool for cutting stone materials, formed by a sheet steel support core (1) with a plurality of cutting elements (2), such as highly abrasive diamond segments which are fixed at intervals along its cutting edge. In order to achieve sound-damping of said tool, a series of substantially parallel incisions (3), arranged inclined with respect to the cutting edge at an angle of 20° to 40° is formed in a central zone of said sheet metal support core, the ends of each incision, which are formed in the manner of a curl (3a), being located above the ends of the incisions adjacent thereto. Moreover, filling segments (5) are arranged

between the diamond segments, said filling segments being fixed to the bottom edge of the blades in a manner similar to the said diamond segments, with the function of increasing the bearing contact area of the blades inside the cutting groove. The invention also relates to a frame-type cutting machine, the blade-carrying group of which has, associated with it, damping means suitable for preventing the generation and/or the propagation of acoustic vibrations, such as calibrated spacer strips and/or damping blocks which are made of resilient sound-absorbing material and arranged between each pair of blades and/or between the latter and the frame.

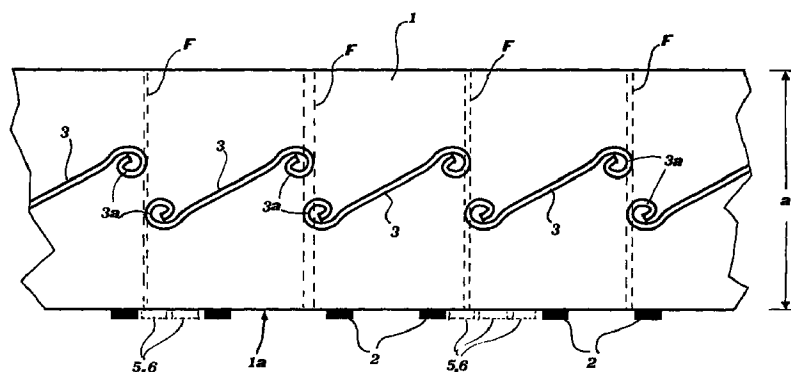


FIG. 1

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Description

As has been known for some years now, the sawing of blocks of marble or stone is generally performed by means of special tools, known as diamond-tipped tools, which may be constructed in the form of "diamond blades" or "diamond disks".

These tools are used on special machines consisting, in the first case, of an "oscillating frame" formed by a blade-carrying group which performs an alternating movement and contains, for example, 10 to 80 diamond blades which are positioned perfectly parallel to one another and suitably arranged at predefined distances from one another and, in the second case, of a rotating shaft on which one or more diamond disks are mounted.

Diamond blades consist of a band of tempered steel which normally has a cross-section of 180 x 3 mm and a length of about 4,000 mm. On their bottom edge, forming the cutting edge, they are provided with small abrasive inserts known as "diamond segments" fixed at a suitable distance from one another; these segments - there being, for example, 35 to 40 segments for each blade - have plan dimensions of 20 x 5 mm and a height of 7-8 mm. Diamond segments of this type - such as those described for example in EP-A-0,090,274 - have the function of cutting the marble owing to the high abrasive effect of the diamond granules incorporated on them, under the pressure exerted by the blade-carrying group on the blades themselves during their alternating movement.

Diamond disks have a substantially equivalent structure: they consist of sheet-steel disks which have a thickness of 2.5 to 5 mm and a diameter for example of 30 mm to 3500 mm and which also have fixed on their external edge diamond segments equivalent - except for their dimensions - to those used for blades.

The structures of these two types of tools have in common the fact that they comprise a support core, consisting precisely of sheet steel with a thickness of a few millimetres, along the cutting edge of which the said diamond segments are fixed by means of a welding process.

In order to perform a cut which is perfectly flat it is essential that the cutting edge of the core should be kept tensioned: in the case of blades, the blades themselves are mounted on a blade-carrying group under longitudinal tension produced by special tensioning devices, while in the case of disks the tension of the edge is produced by the centrifugal force resulting from the high-speed rotation of the diamond disk.

To ensure perfect tensioning of the cutting edge zone of the tool it is also known for the central zone of the sheet-metal core to undergo a pre-tensioning machining process, for example by means of rolling. In this way, when the tool is subjected to a tensile force in the blade-carrying group, or is subjected to the centrifugal force produced by the rotating machine, these forces are applied mainly to the cutting edge zone, while

the pre-tensioned central zone is simply relieved of tension.

As an alternative to this operation of pre-tensioning of the central zone of the core of the tool, it has also been proposed to form, in this zone, openings, for example in the form of holes; in this way, the zone provided with the openings offers less resistance to the tensile force, the effect of which is transmitted mainly onto the cutting edge zone of the tool. This arrangement is known in particular in diamond disks.

Although these tools, which have been tested for many years now, allow sawing of blocks of marble or stone to be performed fairly easily and with very good qualitative results, they suffer, however, from the drawback of a high noise level which is such that it is clearly harmful for the operators concerned.

In fact, it has already been established that diamond disks which have a central zone provided with openings are less noisy than those with a solid core; the Applicant considers that this noisiness depends on the transmission of the vibrations of the cutting edge - produced inevitably by the friction of the diamond segments against the surface to be cut, at a frequency of the same order as sound waves - towards the support and the frame of the operating machine, which forms a kind of resonance chamber. In the case of diamond disks which have a central zone with holes or incisions, this transmission of vibrations would be partially prevented, being produced only in the zones which do not have holes or incisions.

On the basis of these observations it has already been proposed to provide also diamond blades with a series of bore holes in the central zone, if necessary closing off these bore holes with plastic stopper plugs. The practical results, however, have been unsatisfactory, mainly because said bore holes must be made fairly small and at a distance from one another so as not to weaken the structure of the blade and in particular so as not to affect its tensile strength. Furthermore, the stopper plugs are normally not able to perform any sound-damping function and moreover have the tendency to come out of their respective seats following ovalisation of the circular bore holes under the tensioning force of the blade. For these reasons these blades have not had the desired commercial success.

A first object of the present invention is to propose an improved diamond-tipped tool with low noise emission. This object is achieved by means of the characteristic features indicated in Claim 1.

The invention also relates to a machine for cutting marble and stone, in particular a "diamond cutting frame" of the type comprising a blade-carrying group containing a plurality of diamond blade tools arranged alongside and parallel to one another.

As is known, the blade-carrying group of a sawing frame, with the blades thus mounted, is made to perform, in addition to a longitudinal alternating movement, also a slow descending movement onto the block - or

alternately, in accordance with less well-known arrangements, the blade-carrying group is kept at a fixed height and the block is made to perform a rising movement - in such a way that the block is "sawn" and transformed into a plurality of slabs.

Although this technique, which has been tested for many years, allows the sawing of blocks into slabs to be performed fairly easily and with very good qualitative results, it has, as mentioned, the drawback of a high noise level. At present, a diamond cutting frame of this type produces, during sawing, a noise level of up to 90-100 decibels, such that it is clearly harmful for the operators involved and in any case does not comply with the current regulations governing noise levels.

In order to prevent the propagation of this noise and the disturbance also of the surrounding areas, it has already been thought to sound-proof these machines. For this purpose, the sole system which has been devised and effectively applied hitherto is that of surrounding these machines with screening enclosures made with panels of sound-proofing material. This solution, however, has not solved effectively the problem, both owing to the size and cost of these screens and because of the fact that such a high percentage of vapour mixed with dust is produced inside the sound-proofing enclosures that it prevents, on the one hand, the operators from entering into the enclosure during machining in order to carry out maintenance and/or adjusting operations, since it is impossible to breathe, and causes, on the other hand, a high degree of wear and corrosion of the materials in particular owing to the effect of the chemical additives which are used in the recycled water.

A further object of the present invention is therefore that of providing a structure for a cutting machine, in particular for a diamond cutting frame, which has a low noise level. This object is achieved by means of the characteristic features indicated in Claim 22.

As can be understood, the idea underlying the present invention is that of obtaining a low noise emission not so much through the use of structures which prevent the noise from propagating outside the plant, but through the use of means which limit or dampen the noise-generating vibrations or which prevent the propagation of these vibrations, both to the tool and to the various moving parts of the machine.

As regards specifically the tool, this idea is realized by creating, as mentioned, a barrier between the cutting edge zone of the tool and the remaining part thereof, said barrier not only preventing the noise-generating vibrations from being transmitted, but also resulting in a substantial damping thereof.

Further characteristic features and advantages of the invention will emerge more clearly, however, from the detailed description which follows, of some preferred embodiments provided by way of example and illustrated in the accompanying drawings, in which:

Fig. 1 shows a schematic elevation view of a small section of a diamond blade according to the invention;

Figs. 2 and 3 show two types of filling segments, each being shown in three views: elevation view, plan view and side view;

Fig. 4 shows a partial view of assembly of the sawing blades on a blade-carrying group according to the known art;

Fig. 5 shows a view similar to that of Fig. 4, with assembly of the blades according to the invention;

Fig. 6 shows a partially exploded schematic view of a sound-absorbing spacer strip.

As shown in Fig. 1, a series of slots 3 covering the central zone of the blade is formed in a blade 1 which, in a known manner, is formed by a band of drawn sheet steel with a height a of about 180 mm and thickness of between 2.5 mm and 3.5 mm having fixed, on its cutting edge 1a, a plurality of diamond segments 2 which are arranged at a suitable distance from one another.

As can be clearly seen from the drawing, the slots 3 are inclined, parallel and arranged so that the ends of each of them are located above the ends of the immediately adjacent slots, for at least a short distance, corresponding to a zone running transversely with respect to the blade and defined by the pairs of broken lines F.

Said incisions 3 form, with respect to the cutting edge, an angle of the order of 20° to 40° and preferably 30°.

Preferably, moreover, the incisions 3 are thin, for example have a width of between 2.5 and 3.5 mm, i.e. of the same order of magnitude as the thickness of the blade through which they pass. Moreover, the ends of said incisions 3 are formed in the manner of a spiral or curl 3a so that the incision may be prevented from propagating as a result of the tensile force in the longitudinal direction, to which the blade is subject during machining.

According to an important characteristic feature of the invention, the incisions 3 and the spirals 3a are moreover filled with an elastomer material, for example a polyurethane, a synthetic rubber and in particular a rubber provided with sound-absorbing properties. This material is introduced and preferably vulcanized in situ where, also owing to the perfectly square cross-section of the incision 3, it adheres in a perfect and resistant manner.

As a result of the arrangement described above, blades with exceptional and entirely unexpected sound-damping characteristics are obtained; compared to the solid blades according to the known art, in which sound levels of the order of 97 dB have been measured, and also compared to the said blades with bore holes (where sound levels of up to 93 dB have been measured), the blades according to the invention have reduced the sound emission level to below 85 dB.

Furthermore, unlike the blades with circular bore

holes in the central zone, the shape and the arrangement of the incisions 3 according to the invention allow the following to be achieved:

- keep substantially unchanged the tensile strength characteristics of the diamond blade;
- ensure retention of the elastomer material owing, on the one hand, to the elasticity of the material and, on the other hand, to the more or less square cross-section of the incision, also in the case of a high degree of deformation of the blade;
- ensure the sound-absorbing characteristics of the blade owing to the continuous barrier effect provided by the sequence of superimposed slots, an effect which remains unvaried over time owing to the secure and stable anchoring of the elastomer material inside the incision.

A further sound-damping effect may be obtained on the cutting tool by means of another characteristic feature of the invention, namely by increasing the bearing contact area of the blades inside the cutting groove. It was stated above that a diamond blade of about 4000 mm length is normally provided with 35 to 40 diamond segments, each of which has a length of about 20 mm; this means that the blade section comprised between one diamond segment and the next one has a length of the order of 80 to 90 mm. Along each of these sections, the edge of the blade is free: it is in fact separated from the bottom of the cutting groove by about 7-8 mm, i.e. by a distance corresponding to the height of the diamond segment, and is moreover separated from the walls of the cutting groove by a distance corresponding to the difference between the thickness of the diamond segment, equivalent to about 5 mm, and the thickness of the blade, equivalent to about 3 mm. The edge of the blade is therefore able to vibrate.

If, however, filling segments are applied along said free edge and between the diamond segments - for example as schematically represented by the elements 5, 6 shown in broken lines in Figure 1 and as is moreover described in European Patent Application 97119360 (EP-A-0,839,620) in the name of the same inventor - the blade is no longer so free inside the cutting groove and vibration thereof is at least partially prevented.

The filling segments 5, 6 may be made of bronze or of any other relatively soft metallic material which is easily subject to wear, as well as a synthetic material suitable for stable fixing on the metal edge of the blade, for example hard rubber which can be fixed by means of vulcanization.

Two possible embodiments of filling segments 5 and 6 are shown in Figures 2 and 3. In the variant according to Fig. 3, the filling segment 5 is in the form of a parallelepiped, which has a length for example of 20 to 30 mm, height of 7-8 mm and thickness of 3 to 5 mm; this segment has, on one of the larger vertical surfaces, inclined grooves 5a which are suitable for facilitating dis-

charging of the washing water. In this case it is preferable to fix the filling segments 5 on the blades with the grooves arranged alternately on either side.

In the variant according to Fig. 3, the filling segment 6 is similar to that shown in Fig. 2, but has inclined grooves 6a and 6b on both the opposite vertical surfaces; in particular these grooves 6a and 6b are oriented in opposite directions and intersect briefly in a central position where they form a window 6c which passes through the segment and is able to improve discharging of the washing water.

The number of filling segments may be chosen on the basis of their physical characteristics, in the sense that the vibration may be prevented by suitably choosing the number of filling segments, and in particular:

- with many segments, so as to fill almost all the space between the diamond segments, when the filling segments vibrate at the same frequency as the diamond segments and/or the blade; or
- with few segments, when these vibrate at an intrinsic frequency which is different from that of the diamond segments and/or the blade.

Obviously, although reference has always been made above to a cutting tool in the form of a diamond-tipped blade which is intended for a blade-carrying group of a sawing frame, the same identical teaching is applicable to diamond-tipped disks for rotary tool cutters.

Since the noisiness of the sawing machines depends mainly, but not exclusively, on the structure of the tool, the present invention proposes obtaining the maximum sound-damping effect by modifying not only the tool, but also the machine. In order to understand fully this modification, reference must be made to the assembly diagrams shown in Figures 4 and 5 which schematically show a blade-carrying group 11 containing a plurality of parallel blades 12 which are arranged alongside one another and suitably spaced and which are fixed, highly tensioned, onto the blade-carrying group, for example each subject to a load of the order of 9 tonnes.

It must also be remembered, as already mentioned, that the diamond blades are inevitably subject to vibrations during the cutting operation - resulting from the movement of the diamond segments along the cutting groove with a high frictional force - and that the vibrations of the steel of each blade accumulate, owing to the mutual contact via the calibrated spacer strips 13 which are also made of metal and against which lateral metal plates 14 are kept pressed (the purpose of this arrangement is to ensure that the set of blades is kept compact and immobile so as to ensure a uniform cutting thickness).

Owing to the fact that they are directly attached to the blade-carrying group and owing to clamping of said plates which are rigidly fixed to the blade-carrying

group, the diamond blades therefore transmit their vibrations to the blade-carrying group, which acts as a resonance chamber.

In order to avoid the occurrence of these vibrations and/or prevent them from propagating, the invention therefore proposes modifications in several areas, namely:

- a) making the calibrated spacer strips 13', which are arranged between the blades, out of synthetic - for example thermoplastic - material having sound-absorbing characteristics;
- b) mounting sound-absorbing spacers 13" also between the outermost blades of the set of blades and the said metal clamping plates 14;
- c) coating the surface of the blades, at least in the areas where they rest on the spacer strips and/or on the end spacers, with a coating film of sound-absorbing plastic material; this feature, in combination with the features according to points a) and b), tends to dampen the transmission of vibrations from the blades to the blade-carrying group;
- d) arranging, between each pair of blades, close to the base of the latter in the vicinity of the spacer strips, blocks of resilient sound-absorbing material. An example of a sound-absorbing block 7 is schematically shown in Fig. 6, from which it can be seen that it is composed of a plurality of superimposed layers: for example main layers 7a of open-cell elastomer material arranged alternately with layers of fabric-reinforced rubber 7b and/or sheets of lead 7c which are tightly packed together.

The experiments conducted on a frame structure modified in this manner have made it possible to establish that the noise level is reduced drastically, down to values of the order of 70 to 75 dB, which are entirely acceptable for such a plant.

It is understood, however, that the invention is not limited to the particular configurations illustrated, which constitute only non-limiting examples of the application of the invention, but that numerous variations are possible, all within the grasp of a person skilled in the art, without thereby departing from the scope of the invention itself. In particular, the teaching of the present invention may certainly be transferred from the sector of diamond blades and disks (to which reference has been made by way of example in connection with the cutting of marble and stone) to other sectors using sawing tools without diamond segments, in which the cutting elements consist of other types of inserts made of hard material, such as VIDIA, or simply sharpened teeth which are formed directly in the sheet steel support core, as in the case of wood sawing machines.

Claims

1. Diamond-tipped cutting tool, of the type comprising

a sheet steel support core having a plurality of abrasive diamond segments which are fixed at intervals along its cutting edge, characterized in that damping means able to prevent the generation and/or propagation of acoustic vibrations are associated therewith.

2. Cutting tool according to Claim 1, in which said damping means comprise, in a central zone of said support core, a series of substantially parallel incisions which are arranged inclined with respect to the cutting edge, the ends of each incision being located above the ends of the incisions adjacent thereto, with respect to alignments perpendicular to the cutting edge.
3. Cutting tool according to Claim 2, in which said incisions have a width of the same order of magnitude as the dimension of the thickness of the support core through which they pass.
4. Cutting tool according to Claim 2, in which said incisions have preferably a width of 2.5 to 3.5 mm.
5. Cutting tool according to Claim 2, in which the ends of said incisions are formed in the manner of a spiral or curl.
6. Cutting tool according to Claim 2 or Claim 5, in which said incisions and/or the spirals at their ends are filled with an elastomer material.
7. Cutting tool according to Claim 6, in which said elastomer material is a polyurethane or a synthetic rubber, in particular a rubber having sound-absorbing properties.
8. Cutting tool according to Claim 6, in which said elastomer material is stably fixed inside said incisions by means of bonding or vulcanization in situ.
9. Cutting tool according to Claim 2, in which said incisions form, with the cutting edge of the tool, an angle of 20° to 40°, preferably of the order of 30°.
10. Cutting tool according to Claim 1, in which said damping means comprise filling segments which are fixed to the cutting edge in the spaces between said diamond segments and are able to increase the bearing contact area of the tool inside the cutting groove.
11. Cutting tool according to Claim 10, in which said filling segments consist of parallelepiped-shaped elements made of material which is more easily subject to wear than the material of the diamond segments.

12. Cutting tool according to Claim 10, in which said filling segments consist of bronze or brass parallelepiped-shaped elements.
13. Cutting tool according to Claim 10, in which said filling segments have, at least on one of the larger vertical surfaces, inclined grooves. 5
14. Cutting tool according to Claim 13, in which the filling segments provided with inclined grooves on one side only are fixed onto the tool alternately with the grooves on one side and on the other side. 10
15. Cutting tool according to Claim 13, in which said filling segments have inclined grooves on both the opposite vertical surfaces, said grooves being oriented on one side in the opposite direction to those on the other side and there being formed between them, at the point where they intersect, a through-window for discharging washing water. 15 20
16. Cutting tool according to Claim 10, in which said filling segments are made of sound-absorbing synthetic material.
17. Cutting tool according to Claim 10, in which said filling segments are made of synthetic rubber which is vulcanized onto the cutting edge of the tool. 25
18. Cutting tool according to Claim 10, comprising a number of segments sufficient for filling, along the cutting edge, almost the whole of the space between the diamond segments. 30
19. Cutting tool according to Claim 1, in which said damping means comprise a film of sound-absorbing plastic material which is applied as a coating on the surface of the tool at least in the zones where the tool makes contact with the respective support means. 35 40
20. Cutting tool according to any one of the preceding claims, made in the form of a straight diamond blade for a frame for sawing marble, stone or other material. 45
21. Cutting tool according to any one of Claims 1 to 19, made in the form of a diamond disk for a rotary cutter for marble, stone or other material. 50
22. Machine structure for sawing stone materials, in particular marble, of the type in the form of a rotary tool cutter and/or in the form of a frame comprising a blade-carrying group containing a plurality of tools in the form of diamond blades which are arranged alongside one another and parallel, characterized in that damping means able to prevent the generation and/or the propagation of acoustic vibrations 55
- are associated with the tools and/or the blade-carrying group.
23. Machine structure according to Claim 22, in the form of a diamond cutting frame, in which said damping means are incorporated in the diamond blades, each consisting of a cutting tool according to Claim 20.
24. Machine structure according to Claim 22 or Claim 23, in which said damping means comprise calibrated spacer strips arranged between the blades so as to keep them spaced from one another at a predetermined distance, said spacer strips being made of a synthetic material having sound-absorbing properties.
25. Machine structure according to Claim 22 or Claim 23, in which said damping means comprise end spacers arranged between the outermost blades of the blade set and the lateral metal clamping plates rigidly fixed to the blade-carrying group, said end spacers being made of sound-absorbing material.
26. Machine structure according to Claim 22 or Claim 23, in which said damping means comprise damping blocks made of resilient sound-absorbing material which are arranged between each pair of blades, close to the base of the latter in the vicinity of the spacer strips.
27. Machine structure according to Claim 24, Claim 25 or Claim 26, in which said calibrated spacer strips and/or said end spacers and/or said damping blocks are made of thermoplastic material.
28. Machine structure according to Claim 24, Claim 25 or Claim 26, in which said calibrated spacer strips and/or said end spacers and/or said damping blocks each consist of an assembled set of layers of open-cell elastomer material arranged alternately with layers of fabric-reinforced rubber and/or sheets of lead.
29. Machine structure according to Claim 22, in the form of a rotary tool cutter, in which said damping means are incorporated in the tool consisting of a cutting tool according to Claim 21.

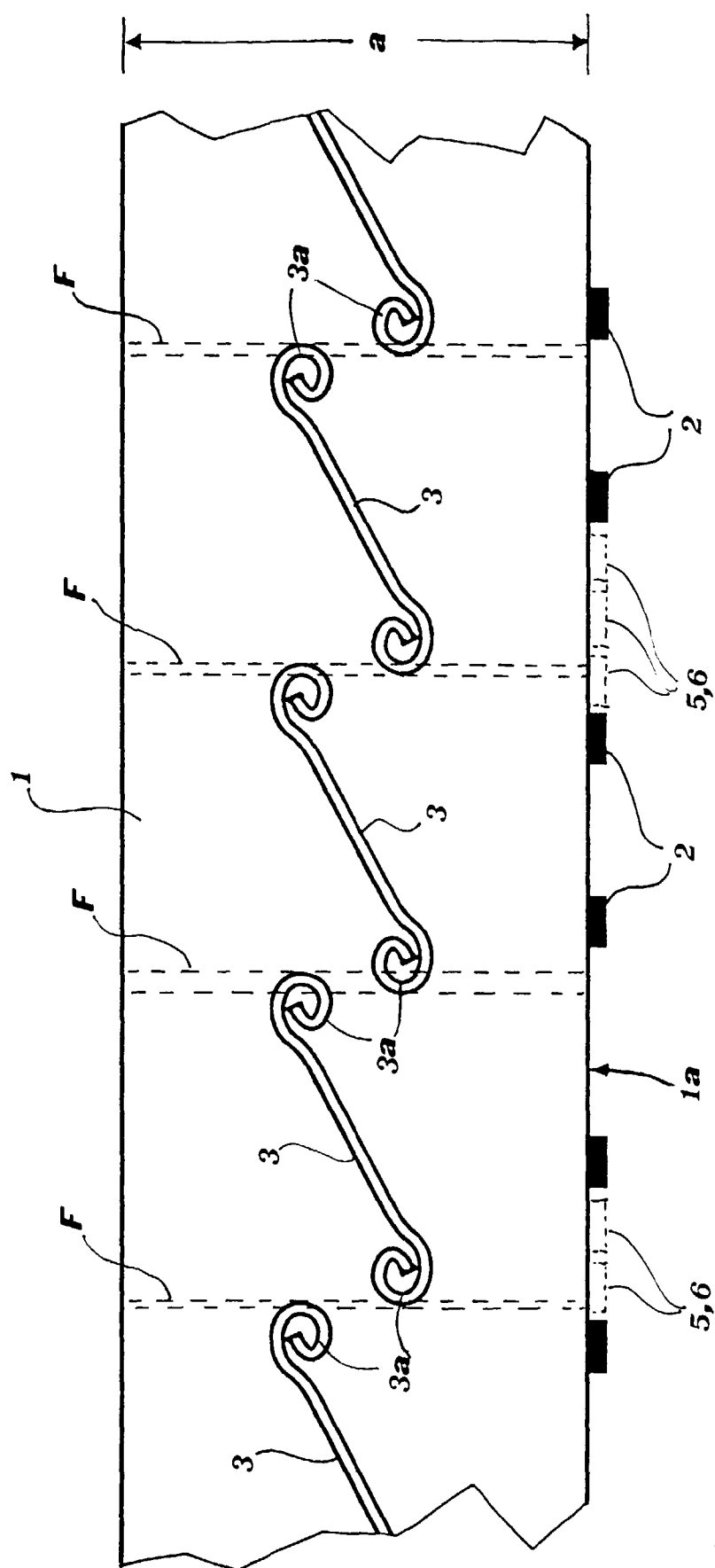
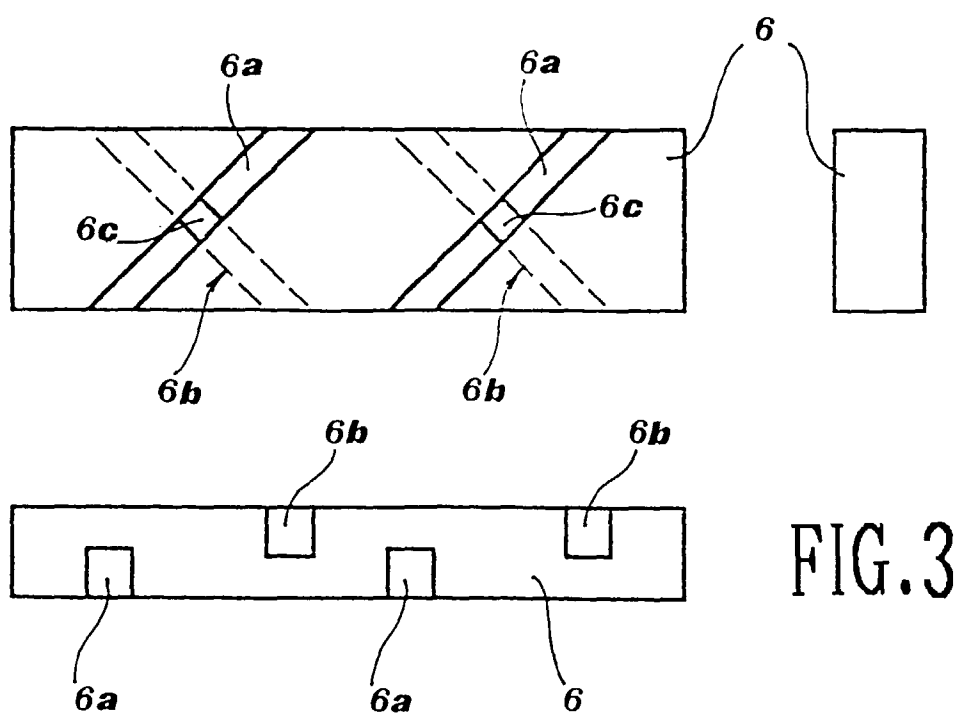
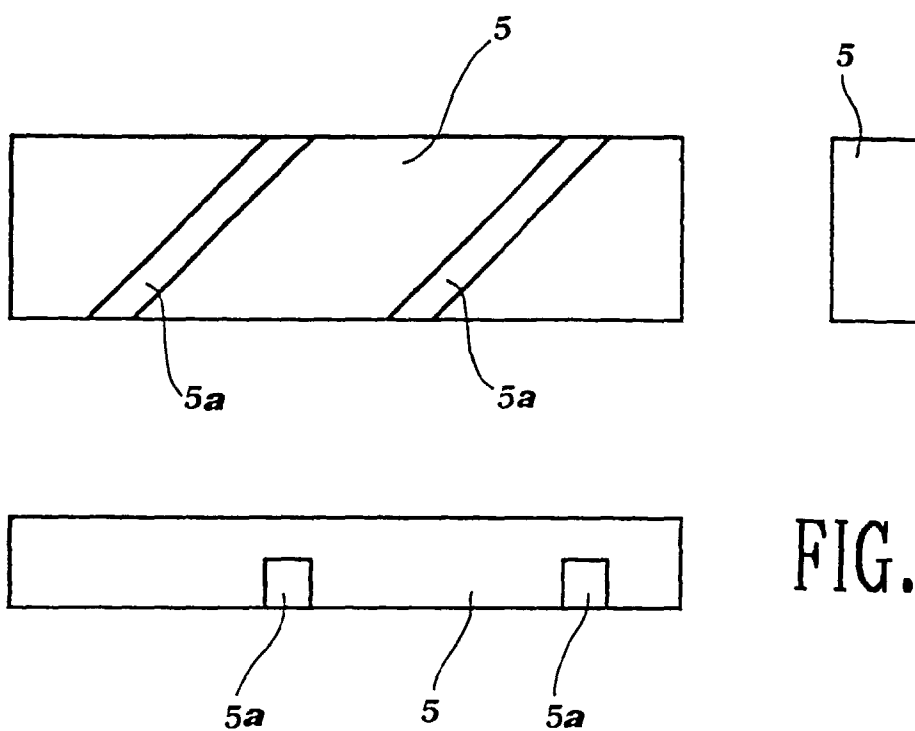


FIG. 1



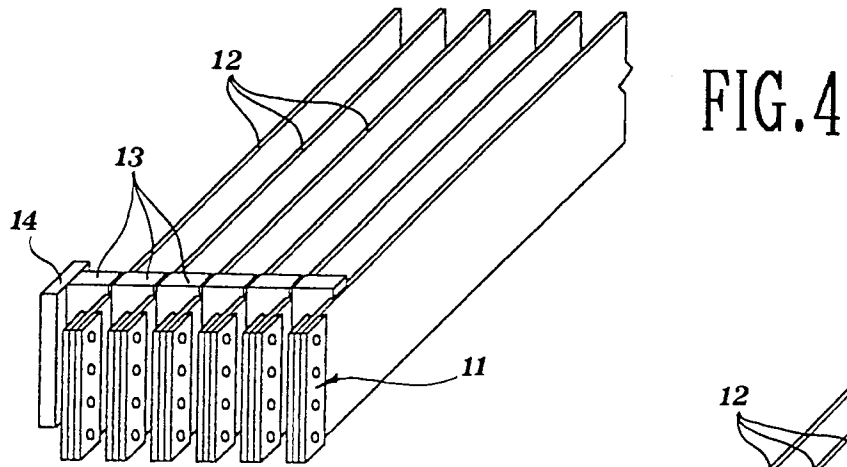


FIG. 5

