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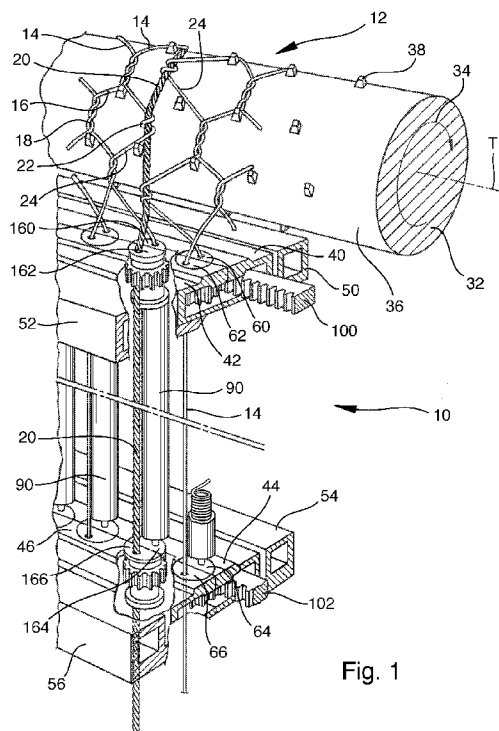


Fig. 1

(57) Abstract: A high-strength protection grid is produced with a plurality of metal wires which are intercalated with metal ropes. The metal wires are interlaced with each other in interlacing portions, or are twisted in twists around the ropes in twisting portions. The interlacings between the wires and the twists of the wires with the ropes define the mesh of the grid. The interlacings and the twists are each unidirectional. The ropes have an external diameter which is greater than the wires and greater than 8 mm, preferably between 9 and 12 mm, even more preferably approximately of 10 mm. The grid is produced with a machine which is provided for the passage of ropes with such an increased diameter with respect to the ropes of the protection grids of the prior art.



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HIGH-STRENGTH METAL GRID FOR CONTAINMENT AND PROTECTION AND MACHINE FOR THE PRODUCTION THEREOF

Field of the invention

The present invention relates to the field of high-strength civil works for the purpose of containment and protection, for example, for constructing protection barriers against rockfalls or avalanches, for bark-like coverings of rocky walls in order to contain detachments of rocks, for three-dimensional stabilization of earth, scarps, dams, embankments, tunnels and road constructions, for constructing containment walls for embankments, for protecting banks of bodies of water, for constructing weirs and other debris-protection barriers along rivers and streams and water works in general, for constructing gabions and other products made of metal grids, and any other use of the generally known civil and geo-technical type.

The present invention has been developed with particular regard for a metal protection and containment grid which is reinforced with metal ropes.

Technological background

There are known a large number of types of metal grids for containment and protection, such as, for example, grids with loose mesh, electro-welded grids, grids with hexagonal mesh with single, double or triple twists. Each type of grid usually has a specific application in accordance with the formation and the technical features of the metal components thereof. Thus, for example, an electro-welded grid is usually composed of a plurality of rectilinear bars with a large diameter, for example, 12 mm, having a great mechanical resistance to traction. The bars are arranged longitudinally and transversely and are welded to each other at the points

of intersection so as to form a woven arrangement with square and/or rectangular mesh. These grids, although they are very resistant, are very heavy and rigid so that they are not suitable for civil works in which there is required a specific flexibility of the grid, for example, for coverings on walls or other geo-technical works in which the grid has to adapt to the formation of the ground.

Another example of a protection grid, which is often used in civil works for protection from rockfalls, is the grid constituted by a plurality of crosswise steel wires or ropes which are arranged at an angle relative to each other and preferably perpendicularly. An example of this type of grid is illustrated and described in the European Patent No. WO 2008/132654 by the same Applicant. The ropes used in this type of grid may have a diameter of from 10 to 12 mm and, at the intersection points, are blocked on each other by means of connection devices of various types, the most common of which comprise clamping studs or plates or a pair of steel bars which wind with highly tightened coils around the intersection points of the ropes. These grids have a great resistance to traction and, at the same time, sufficient flexibility to absorb the energy of the bodies which hit them and which are supported thereon, such as, for example, stones, rocks or the like. One disadvantage of these grids is that the time necessary for producing them is relatively high. Furthermore, the dimensions of these grids are generally modest to such an extent that they are used for civil works with contained dimensions, for example, for so-called snow-catching umbrella-like systems or rockfall barriers.

As mentioned, each of the grids of the known type is particularly suitable for being used in specific conditions;

in some cases, however, the use of a correct type of grid may in any case be inconvenient, not very advantageous and very expensive. For example, a grid for protection from rockfalls with characteristics of great resistance to traction, though completely suitable for the purpose for which it is designed and intended, may be complex to transport as a result of the weight thereof, the dimensions and the difficulty of making it compact and folding it. It may further be expensive as a result of the material which constitutes it and the production process and difficult to install as a result of the rigidity thereof.

Another disadvantage of the high-strength grids of the known type mentioned above is that, while ensuring adequate resistance to impacts and the occurrences of thrust applied, for example, by a rocky mass, they do not ensure complete safety if the mesh thereof have such dimensions as not to succeed in retaining fragments of rock or other fine material. For this reason, it is also necessary to combine with all the types of grid described above panels of metal grids with a double twist with hexagonal mesh which have dimensions less than the mesh of the main grids, they are electro-welded or produced with intersecting ropes so as to generate a type of filter which retains the finer debris. However, this makes the installation of the containment structure more complex and expensive, comprising both the electro-welded grid or crossed-rope grid and the double-twist grid.

In generally different sectors, for example, in order to enclose gardens or courtyards, in order to confine animals or to cover wall structures to be rendered, and other similar applications where there is no need for a grid with high resistance to impacts, there are known metal grids, the wires

of which are interlaced in a very simple manner. In addition to conventional enclosure grids, the single wires of which are folded in a helical manner and interlaced with each other, there are also known grids, the contiguous wires of which are wound with each other from a location in the middle of each mesh so that each interlacing is formed by a half-revolution in a clockwise direction and by another half-revolution in the clockwise direction. Examples of such grids are described in the patents US 1401557 and US 2053221. Some embodiments provided for a third wire to be introduced into these interlaced fabrications so as to run in a rectilinear manner in the middle of each mesh of the grid. These grids are not suitable for the civil uses in the geo-technical field, such as applications for containing earth or rocky slopes, or for protection from rockfalls, and cannot ensure any reasonable resistance and reliability following impacts, even modest impacts. In fact, by applying a traction which may even have only a small value to the interlacing of the wires of the grid, in a transverse direction with respect to the main direction in which the interlaced wires extend, the interlacing becomes loosened, and opens. In practice, the resistance of the interlacing of these grids is given by the resistance which the wire applies to the folding which is far less than the breaking load of the wire if it, in order to open the mesh of the grid, had to be torn, as in the high-strength grids which are mentioned above and which will be further discussed below.

Another type of high-strength metal grid for protection and containment is described in US 6279858. It involves a grid which is woven with wires which are resistant to corrosion and which is mounted on the surface of the ground or fixed in position in a state erected on a slope. The wires of this metal grid are made from a steel having a nominal resistance

between 1000 and 2200 MPa. The metal grid has rhomboidal mesh which are formed by the single wires which are folded helically and interlaced with each other. The main disadvantage of this grid is the cost because it is completely made with high-strength steel wires, at a cost which is high per se. Furthermore, the simple interlacing of the wires of the grid makes the grid vulnerable to breakages, even only of one of the wires, which may thereby become completely released from the adjacent wires with the result of a complete opening of the grid itself which irremediably compromises the functionality and safety thereof.

Another type of high-strength containment and protection grid is constituted by the structures comprising a combination of metal wires and metal ropes. An example of such grids is the structure commercially known as Steelgrid® HR which is produced by the present Applicant, Officine Maccaferri S.p.A. A number of variants of these grids are described in EP 1680552 and EP2475477 by the present Applicant. They involve a grid structure which has metal wires which are interlaced with a double twist in order to form hexagonal mesh which is reinforced by means of longitudinal metal ropes which replace a number of the metal wires in the weaving of the grid. The metal ropes of the grids Steelgrid® HR have a maximum diameter of 8 mm and an ultimate tensile strength of 1770 MPa and are interlaced with the metal wires at nominal distances of 300 mm, 500 mm and 1000 mm from each other, while the nominal transverse pitch of the mesh which are formed by the metal wires may be 80 mm. These grids can be produced by means of the usual machines which are used for manufacturing conventional double-twist metal grids.

These protection and containment grids which combine the versatility of a double-twist grid with the additional

resistance which is provided by the metal ropes are found to be particularly effective and appreciated by the market. However, these grids are not capable of complying with a number of particular requirements as a result of intrinsic limitations resulting from the constitution thereof.

A problem which is encountered in the production of these known grids in which the metal wires are interlaced with metal ropes is the fact that, in order to obtain a substantial linearity of the ropes which ensures better performance levels of resistance of the grid, it is necessary to tension the ropes downstream of the beam, that is to say, the cylinder which draws the woven grid, after the metal wires have been interlaced with the metal ropes. However, this tension which is applied to the ropes downstream of the beam brings about a transverse narrowing of the grid which brings about two main negative consequences. On the one hand, the width of the grid is less than the nominal dimensions, which involves a smaller transverse coverage of the grid with respect to the design data, and a higher weight per unit of surface-area, with resultant higher costs for transport and difficulty of installation as a result of the necessity for using a greater number of reels of grid to cover the same surface-area. Among other things, the narrowing value of the grid cannot be predicted with certainty and may vary from one production batch to another, with the result that specific grid supplies could be rejected by the client because they do not comply with the design specifications.

Another negative consequence which is caused by the narrowing of the grid downstream of the beam, after the wires and the ropes have been woven, is the impossibility of correctly inserting the transverse ropes in the grid in order to increase the transverse resistance thereof. During

production, the transverse ropes in fact have to be introduced into the grid immediately downstream of the weaving, before the tensioning of the grid by the beam. In this position, the grid has a nominal width corresponding to the intended width, but the longitudinal ropes are not yet tensioned and have undulations. By inserting a transverse rope in this condition of the grid, there would be provided a section of rope with a length equal to the nominal length. As a result of the narrowing of the grid downstream of the beam, however, the length of transverse rope exceeds the width of the grid which is subjected to the narrowing, with the result that the transverse rope forms undulations in order to compensate for the reduced width of the grid. These transverse undulations deform the grid, which is therefore coiled poorly and with difficulty for transport and which provides reduced performance levels, at least in a transverse direction, when it is put into operation.

Statement of invention

An object of the present invention is to overcome the disadvantages mentioned above of the metal grids for containment and protection of the known type, providing a metal grid which is reinforced by metal ropes and which substantially maintains the planarity and the nominal width which is predetermined following the weaving, and wherein the metal ropes are substantially rectilinear with minimal undulations already during the production when the metal wires are interlaced with each other and, at predetermined intervals, with the metal ropes.

Another object of the invention is to provide a metal grid, particularly of the type with double twists, which is reinforced by metal ropes which develop in a relatively rectilinear manner in the longitudinal direction with the

possibility of adding thereto, during production, transverse ropes which are, when the grid is complete, similarly relatively rectilinear, in the transverse direction of the grid, so that the grid, once manufactured, does not have individual relevant undulations either in the longitudinal direction or in the transverse direction, while being sufficiently flexible to adapt to the formation of pieces of ground, embankments, slopes, escarpments and generally various formations in the geo-technical sector.

Another object of the invention is to provide a metal grid, in particular of the type with double twists, which is reinforced by metal ropes which can withstand high traction forces and which at the same time is flexible, light and easy to handle.

Another object of the present invention is to provide a metal grid, in particular of the type with double twists, for protection in the geo-technical field, which is economical and rapid to manufacture, the manufacturing process of which can be mechanized and automated without using particularly complex or extremely expensive machinery with respect to the machinery known for producing known protection grids.

In order to achieve the objects indicated above, the invention relates to a metal protection grid according to claim 1. The invention also relates to a machine which is particularly suitable for manufacturing such a grid.

According to a first aspect, there is described a protection grid for civil works which is produced with a plurality of metal wires which are intercalated with metal ropes, the metal wires of which are interlaced with each other in wire interlacing portions, or are twisted around the ropes in

interlacing portions which, for convenience of description, are defined here as "rope interlacing portions" even if it is the wire to be twisted with twists thereof with the rope, while the rope remains extended as far as possible, substantially rectilinear or with a slightly undulating progression. The interlacings between the wires and the twists of the wires with the ropes define the mesh of the grid, wherein the interlacings and the twists are each unidirectional, wherein the ropes have an external diameter which is greater than the wires and greater than 8 mm. Preferably, the ropes have an external diameter between 9 and 12 mm except for the usual dimensional tolerances of such ropes. Even more preferably, the ropes have an external diameter which is approximately of 10 mm except for the usual dimensional tolerances of such ropes. The metal ropes may have a protective external covering of plastics material which contributes to forming the total external diameter of the rope.

From experiments carried out by the Applicant, it has surprisingly emerged that a rope having a diameter greater than 8 mm, preferably between 9 and 12 mm, and even more preferably approximately of 10 mm, leaves the interlacing and weaving zone with the metal wires in a substantially rectilinear state, already before the beam of a weaving machine for metal grids. This confirms that a greater diameter of the metal rope promotes the maintenance of the linearity thereof and therefore of the nominal width of the grid without it being subjected to a narrowing downstream of the beam which is caused by the straightening of the ropes, which is desirable in order to ensure high performance levels of resistance of the grid. In fact, it has been verified that, the more the ropes are extended, that is to say, rectilinear or virtually rectilinear, the greater is the

resistance to impacts or containment of debris by the protection grid.

According to a particular aspect, the protection grid may comprise ropes with an ultimate tensile strength greater than approximately 1000 MPa, preferably greater than 1500 MPa, even more preferably greater than or equal to approximately 1700 MPa. The ropes may be of various types and in some embodiments may be helical ropes.

According to another aspect, there is described a manufacturing machine for a protection grid of the type indicated above. The machine comprises a series of pairs of first guide devices, which are spaced apart from each other and coaxial, and which are arranged in rows parallel with the axis of a drum, and a series of pairs of second guide devices, which are spaced apart from each other and coaxial, and which are arranged at the other side of the plane of symmetry which is tangent to the drum. Each pair of second guide devices can be arranged specularly opposite, with respect to the plane of symmetry, one of the pairs of first guide devices. The pairs of first and second devices are simultaneously and alternately movable by half a step in opposite directions parallel with the axis of the drum. In the machine, the minimum distance between the guide devices of the same type in a passage zone of a rope is greater than 8 mm, preferably greater than or equal to approximately 10 mm, even more preferably greater than or equal to approximately 12 mm, for example, of 13 mm or more.

Brief description of the drawings

Additional features and advantages will be appreciated from the following detailed description of a preferred embodiment

with reference to the appended drawings which are given purely by way of non-limiting example and in which:

- Figure 1 is a perspective view, partially in section, of the portion of a machine for manufacturing a protection grid incorporating features of the present invention, in which portions of this grid can also be seen;
 - Figure 2 is a longitudinally sectioned view of a portion of the machine of Figure 1; and
- Figure 3 is a longitudinally sectioned view of a detail of the machine of Figure 1.

Detailed description

In the following embodiments, there are described features which allow the invention to be carried out. The features described can be combined with each other in various manners and are not necessarily limited to the precise embodiment to which the drawings and the relevant description refer. In other words, a person skilled in the art of the field who reads the following description will know how to obtain the information items which are advantageous for knowing the way to carry out one or more of the features described by combining it with one or more of the other features described without the particular formulation of the description, paragraphs, terms or drawings constituting a limitation on the possibility of isolating one or more of the features described and illustrated in order to combine them with one or more of any of the other features described and illustrated. In greater detail, in the present description there should be understood to be expressly described any combination of any two features which are expressly described, even in the case in which the features are individually extracted from the specific context in which they can be beside or combined with other, different features, taking into account the competences and knowledge

of a person skilled in the art in the field, who understands the possibility of functionally combining the features without it being necessary to functionally apply the other, different features. Unless otherwise specified, each and any element, member, means, system, component, object which is described and illustrated in the present description must be understood to be individually described and autonomously able to be modified and able to be separated from/combined with any and each other element, member, means, system, component, object which is described and illustrated. The materials, forms and functions described and illustrated do not limit the present invention but are only set out to allow a person skilled in the art to understand and carry out the invention according to preferred though non-exclusive embodiments.

Now with reference to Figure 1, there is illustrated as a perspective, partially sectioned view a portion of a machine 10 for manufacturing a protection grid 12, in particular a metal protection grid in the field of civil works, such as barriers against rockfalls or avalanches, anti-debris weirs for water courses, bark-like coverings and other works for the protection of rocky escarpments or terrain, and the like.

In greater detail, the protection grid 12 comprises an assembly of metal wires 14 which are interlaced with each other in order to form a series of mesh 16. In the embodiment illustrated in the Figures, the mesh 16 are of virtually hexagonal shape. The dimensions of the hexagonal mesh are generally known and standardized in the field of double-twist metal grids and are not in any case a limitation of the present invention which can be carried out with hexagonal mesh of any type and kind, and with a generally known proportion between width and height which in the field is generally around values between approximately 0.70 and

approximately 0.85, for example, - at least nominally - approximately 0.75 (for mesh of 60 x 80 mm), approximately 0.80 (mesh of 80 x 100 mm) and approximately 0.83 (mesh of 100 mm x 120 mm).

The metal wires 14 are generally arranged in the direction of the length thereof in a preferential longitudinal direction of the protection grid 12. The metal wires 14 are interlaced in wire interlacing portions 18. These wire interlacing portions 18 are defined by the sections of the respective metal wires 14 which are twisted around each other more than once, in a unidirectional twisting direction, that is to say, in a single direction, clockwise or counter-clockwise, for each wire interlacing portion 18. This type of interlacing which is defined as being "double-twist" is particularly resistant and stable and allows the production of protection grids with secure and resistant mesh.

There are intercalated between the assembly of metal wires 14, at predetermined intervals, metal ropes 20 with a greater resistance with respect to the metal wires 14. The metal ropes 20 have a generally less undulating progression than the metal wires 14 and particularly follow a direction which is as rectilinear as possible or slightly undulating so as to contribute predominantly to the resistance of the protection grid 12 following an impact on the grid itself, for example, by rocky material of a landslide. As can be seen in Figure 1, where for the sake of simplicity there is only illustrated a portion of the protection grid 12 with a metal rope 20, the metal rope 20 is preferably maintained as far as possible in a rectilinear state with respect to the preferential longitudinal direction of the protection grid 12. In the example of Figure 1, it can clearly be seen that the metal wires 14 adjacent to the metal rope 20 are wound around the

rope 20 in rope interlacing portions 22. These rope interlacing portions 22 are defined by the sections of metal wires 14 which are again twisted more than once around the rope in a unidirectional twisting direction, that is to say, in a single direction, clockwise or counter-clockwise, for each rope interlacing portion 22. The metal wires 14 become interlaced with the metal rope 20 which has transverse undulations with respect to the preferential longitudinal direction which are far less pronounced than those of the metal wires 14 and in particular is virtually rectilinear or with undulations as just mentioned. Therefore, the metal wires 14 form a so-called "half mesh" 24 which can take up, in the protection grid in which the metal wires which are interlaced with each other form hexagonal mesh, the characteristic form of a semi-hexagon.

The protection grid 12 which may be constituted by metal wires 14 constructed, for example, from common steel, for example, with a diameter of from 2 to 3 mm or greater, for example, also up to from 4 to 5 mm, is flexible and readily transportable. Naturally, the wires 14 can be completely or partially replaced by thin metal ropes having, for example, a diameter of approximately from 2 to 5 mm, which is far less than the diameter of the greatest metal ropes 20.

The metal wires 14 and the greatest metal ropes 20 can be covered by a protective covering, for example, a covering made of plastics material which prevents or at least reduces the corrosion of the wires and/or ropes.

According to a particularly advantageous feature, the metal ropes 20 with a greater diameter have a total diameter, including the potential protective covering, greater than 8 mm and preferably between 9 and 12 mm, even more preferably

approximately of 10 mm, naturally except for the typical dimensional tolerances in the field of manufacture of metal ropes. The resistance characteristics of such a grid are substantially greater than those of a grid of the known type with ropes having a diameter less than or equal to 8 mm for the same traction resistance per mm^2 of the ropes. A protection grid constructed with metal ropes 20 having a diameter greater than 8 mm, preferably between 9 and 12 mm, and even more preferably of approximately 10 mm, is in any case sufficiently flexible to be wound up and transported to the installation site, but sufficiently rigid, once stretched out, to construct protection structures having a relative dimensional stability thereof. This is particularly advantageous, for example, in bark-like coverings, in which the protection grid is arranged on a rocky wall in order to retain the rocky material which becomes detached therefrom.

Furthermore, it has been found by way of experiment that, by using a metal rope with a diameter greater than 8 mm, preferably between 9 and 12 mm, and even more preferably of approximately 10 mm, it is far simpler to maintain the rope 20 stretched out during the production of the grid as a result of the intrinsic rigidity of a metal rope with such an external diameter both with a protective covering and without. This is particularly advantageous for constructing protection grids 12 because the more rectilinear are the ropes 20 which are incorporated into the grid, the greater is the total resistance of the grid against impacts because the ropes 20 which are already substantially taut are urged virtually immediately with traction, long before the metal wires of the grid are urged. In other words, the impact force applied to the protection grid 12 is absorbed to a maximum extent virtually immediately by the ropes 20 while the residual force of the impact, which is reduced in intensity,

can be distributed more evenly over the surface of the grid which is formed by the interlaced metal wires.

Preferably, the metal ropes 20 have an ultimate tensile strength greater than approximately 1000 MPa, preferably greater than 1500 MPa, and even more preferably greater than or equal to approximately 1700 MPa. There have been found to be particularly effective ropes with an ultimate tensile strength of approximately 1770 MPa, even if they can also be successfully used for ropes with an ultimate tensile strength up to 2200 MPa and beyond. Naturally, the use of metal ropes 20 with a diameter greater than 8 mm, greater than the diameter of the ropes which are usually used in the similar protection grids of the prior art, allows the use of steels with a unitary ultimate tensile strength less than the known strength, in any case it being possible to at least match if not exceed the total resistance of the metal ropes used in the grids of the prior art.

A rope which is found to be particularly effective for constructing the grid of the present invention is a zinc-plated helical rope which has a nominal diameter of 10 mm and which is formed by a strand composed of 19 steel wires with an ultimate tensile strength of 1770 MPa which brings about a minimal ultimate tensile strength of the rope of 93.166 kN. The rope is included in the specifications relating to the standard EN12385-10. Naturally, ropes of different types can also be used, for example, with a plurality of strands, with a core, etc. In any case, a fundamental aspect which has been identified by the Applicant is that the more resistant the rope is, the less there occur undulations in the production of the grid. Therefore, the use of a rope with a diameter greater than the ones used in the known great structures promotes planarity. In this context, the use of a helical

rope or a high-grade rope, that is to say, with a high ultimate tensile strength, for example, as indicated above, ensures an adequate benefit in terms of planarity even with ropes having diameters slightly greater than 8 mm.

The protection grid 12 described above cannot be produced with the currently available machines which are not capable of receiving a rope having an external diameter greater than 8 mm. Therefore, an object of the present invention is also to provide a particular machine for manufacturing a protection grid 12 having the above-mentioned features. The machine which is intended for producing a grid with the above-described features is partially similar to a known machine for packing conventional double-twist grids. In the following description, although it relates to the entire machine, the focus will therefore be more extensively on the new and original elements which allow a grid to be produced with reinforcement ropes having a diameter greater than 8 mm.

As can be seen in Figure 1, the machine 10 comprises a drum or beam 32 which is mounted with means (not illustrated) in the fixed housing of the machine so as to be able to rotate in a manner synchronous with the speed of the wire interlacing means 14 at a constant speed in the direction of the arrow 34 about the axis T thereof. Radial projections or pins 38 project outwardly from the curved face 36 of the drum. These pins are ordered in rows which extend in a direction parallel with the axis T and are arranged at identical angular intervals. In each row, the pins 38 are arranged with constant spacing and two successive rows are staggered relative to each other by a half-pitch in an axial direction. These pins are used to form the grid with hexagonal mesh and to retain a portion of the grid which is

already formed in the direction of the discharge of the machine.

The interlacing and/or interconnection means of the metal wires and the ropes comprise a series of pairs of first guide devices, which are spaced part from each other and coaxial and which are arranged in parallel rows with respect to the axis of the drum 32 at one side of the plane of symmetry tangent to the cylindrical periphery of the beam 32. The pairs of guide members are arranged in radial planes with respect to the beam and the pitch thereof is identical to the pitch of the pins 38. The interlacing and/or interconnection means of metal wires and ropes further comprise a series of pairs of second guide devices which are spaced part from each other and coaxial and which are arranged at the other side of the plane of symmetry tangent to the drum 32. Each pair of second guide devices is arranged specularly opposite, with respect to the plane of symmetry, one of the pairs of first guide devices. The pairs of first and second devices are simultaneously movable in an alternating manner by half a step in opposite directions parallel with the axis of the drum 32. During use, the rotation about the axis thereof of the guide devices generates the interlacing of the wires while the movement in a manner parallel with the axis of the drum 32 of the pairs of first and second guide devices in the opposite direction generates the hexagonal mesh. The interlacing means are naturally coordinated in terms of the movements with the movement of the beam so as to carry out the weaving of the grid overall.

In greater detail, under the drum 32 there are provided two pairs of bars 40, 42 and 44, 46 which are parallel with the axis T and which act as a support for rotatable semi-cylindrical bodies 60, 62, 64 and 66; the function of the

semi-cylindrical bodies is to twist with each other the wires and the ropes in pairs in order to produce the grid 12.

The bars 40, 42 and 44, 46 have in cross-section a U-shaped profile rotated through 90° . The bars are positioned in pairs with the respective open edges of the U's facing each other and located in a vertical plane of symmetry tangent to the periphery of the drum 32; the bars 40 and 42 form an upper pair and the bars 44 and 46 form a lower pair. Naturally, the terms "upper" and "lower" indicate the position in which the bars are arranged in the embodiment of the Figures. In fact, however, it is not excluded that they may be arranged differently, for example, with the wires and the ropes which slide mainly in a horizontal direction and in a vertical direction, as illustrated in Figure 2. More generally, an "upper" bar is downstream in the working direction with respect to a corresponding "lower" bar, independently of the height at which it is located.

The pairs of bars 40, 42 and 44, 46 are supported by elements 50, 52, 54, 56 which form part of the fixed housing of the machine 10. Furthermore, they can move in a direction parallel with the direction of the axis T. The upper bars 40 and 42 are similar to the bars 44 and 46 of the lower pair of bars. At the edges of each of the bars 40, 42, 44, 46, there are formed semi-cylindrical seats with an axis perpendicular to the axis T, in each of which there is received a respective semi-cylindrical rotatable body 60, 62, 64, 66. The distance between each seat and the adjacent seat in the same bar is substantially equal to the distance between the pins 38.

The semi-cylindrical rotatable bodies 62 which are received in the upper bar 42 are aligned with the semi-cylindrical

rotatable bodies 66 of the lower bar 46 and each have a respective through-hole 72, 76 having an axis parallel with the axis of the corresponding semi-cylindrical rotatable body. The through-holes 72, 76 are also aligned. The holes 72, 76 are passed through by wires 14 to be supplied to the grid in a formation, as described in greater detail below.

In the region of the position in which it is desirable to insert a rope 20 into the grid 12, there are provided upper semi-cylindrical rotatable bodies 160, 162 and lower semi-cylindrical rotatable bodies 164, 166 which are of a different type from the ones used for the passage of the wires 14 and which are modified in order to allow the passage of ropes with a great diameter as indicated above, that is to say, greater than 8 mm and preferably though in a non-limiting manner up to 12 mm so as to be able to produce the above-described grid, as will become clearer below.

There can be mounted under each semi-cylindrical body 60 and 160 which is carried by the upper bar 40 a cylindrical container 90 which contains a predetermined length of wire 14 which is wound helically. The wires 14 leave the containers 90 at the top, pass through the through-holes 70 and supply the machine for forming the grid. During use, the cylindrical containers 90 rotate about the adjacent wires 14 or about the ropes 20.

The pairs of bars 40, 42 and 44, 46 are connected to movement mechanisms which allow at the same time the two bars 42, 46 one above the other and the two bars 40, 44 one above the other to move in translation in the same direction parallel with the axis T of the drum 32 but with opposite orientations, respectively. The movement mechanisms are configured so that each semi-cylindrical body which is

carried by the same bar can be moved in translation from a position in which it faces a first semi-cylindrical body of the bar facing towards it to a second position in which it faces a second semi-cylindrical body which is adjacent to the first semi-cylindrical body.

Furthermore, the semi-cylindrical rotatable bodies are connected by means of racks, such as the ones 100, 102 visible in Figure 1, to rotation mechanisms which rotate them in pairs in order to interlace two adjacent wires 14 with each other or to twist a wire 14 with a rope 20 and thereby to generate a portion which is twisted in order to gradually define the mesh of the protection grid 12.

As indicated above, the upper semi-cylindrical bodies 160, 162 and the lower rotatable semi-cylindrical bodies 164, 166 which are used in order to twist the wires 14 with the rope 20 are modified with respect to the ones used for the interlacing of the metal wires 14 alone. As can be seen in Figure 2, the lower rotatable semi-cylindrical bodies 166 in which the rope 20 passes have a through-hole 176 with an enlarged diameter, with a diameter greater than 8 mm, preferably greater than or equal to 10 mm, even more preferably greater than or equal to 12 mm, for example, of 13 mm or greater. This allows the passage of a rope 20 having an external diameter greater than 8 mm and preferably up to 12 mm. Naturally, the semi-cylindrical bodies 66 in which the wires 14 with a smaller diameter pass can also have holes with an enlarged diameter which is preferably identical to the diameter of the holes 166. In this manner, the machine 10 can be used to produce protection grids 12 having an arrangement of ropes 20 as desired.

The upper semi-cylindrical bodies 160, under which there are mounted the cylindrical containers 90, are produced in such a manner that between a cylindrical container 90 and the adjacent container there is available for the rope 20 a passage space greater than 8 mm, preferably greater than or equal to 10 mm and even more preferably greater than or equal to 12 mm, for example, of 13 mm, or greater. In this manner, during the rotational movement of the cylindrical containers 90 about the rope 20 during the twisting of a wire 14 around the rope 20 in order to produce a wire interlacing portion 22, it ensures the passage without any interference of the rope 20 between two adjacent cylindrical containers 90. The upper semi-cylindrical body 162 has a flared opening 163, in which the rope 20 is inserted with a slight inclination in order to move the rope 20 towards the wire 14 while carrying out the twisting thereof around the rope. The engagement of the various semi-cylindrical bodies in the racks 100, 102 is configured in such a manner that at least the semi-cylindrical body 162 has a sufficient diameter to be able to form a through-hole 172 with a diameter greater than 8 mm, preferably greater than or equal to 10 mm and even more preferably greater than or equal to 12 mm, for example, of 13 mm, or greater, in order to allow the passage of the rope 20 with an increased diameter, as set out above.

As can better be seen in Figure 3, the pairs of upper semi-cylindrical bodies 60, 160 are spaced apart from each other by an extent A which corresponds to the width of the mesh of the grid 12. This extent is given and does not change with respect to the double-twist grids, both single grids and grids reinforced by ropes, of known type. In order to allow the production of double-twist grids with ropes 20 with an increased diameter, as indicated above, the through-hole 172 in the upper semi-cylindrical body 162 is formed with a

diameter B greater than 8 mm up to 12 mm or slightly greater. The through-hole 170 in the upper semi-cylindrical body 160 may have a diameter C less than 8 mm and this is because there will always emerge from this hole only a single metal wire 14 which is received helically in the cylindrical container 90 under the lower semi-cylindrical body itself. As indicated above, the minimum distance D between two adjacent semi-cylindrical containers, particularly though non-exclusively where there is provision for the passage of a rope 20, is configured so as not to be less than 8 mm and preferably to be 12 mm or greater.

As a result of the above-described machine 10, it is possible to reinforce the protection grid 12 with ropes having an external diameter which is generally greater than 8 mm, both with and without a plastics protective covering, maintaining hexagonal mesh with dimensions which are conventionally known and preferable of 5x7, 6x8, 8x10, 10x12, 12x14 mm. The preferred distance between two adjacent ropes 20 may be between 25 cm and 100 cm and even more. The total lateral dimension of the grid is preferably between 2 and 5 m.

A particularly advantageous feature of the present invention is the fact that the machine 10 allows the production of a protection grid 12 in which the ropes 20, in addition to having a greater diameter and therefore a greater resistance than the ones which can be used in the known protection grids, are also more rectilinear, already upstream of the beam, thereby improving the performance levels of the protection grid following an impact, but particularly avoiding a narrowing of the grid downstream of the beam with respect to the nominal transverse dimension. In fact, as set out above, the ropes with a diameter greater than 8 mm of the grid described above, preferably between 9 mm and 12 mm, and

even more preferably approximately of 10 mm, maintain the linearity thereof, with no undulations or extremely small undulations already upstream of the beam, as a result of which the resulting grid is not subjected to the narrowing which occurs in the grids of the known type by straightening the ropes downstream of the beam. As a result of this feature, it is also possible to introduce into the protection grid 12 transverse ropes without this bringing about an undulation of the grid as a result of the narrowing of the grid. In particular, it is advantageous to insert the potential transverse ropes immediately downstream of the discharge of the wires or ropes from the semi-cylindrical rotatable bodies 60, 62, 160, 162, as indicated by the outline of the transverse rope Z indicated with a thin line in Figure 3, the diameter of which is less than the distance E between the axis of the discharge holes of the wires or ropes from the above-mentioned semi-cylindrical rotatable bodies 60, 62, 160, 162.

If the transverse ropes Z are used, there is the additional advantage that the impact force which is applied to the protection grid 12 is absorbed to the maximum extent virtually immediately both by the longitudinal ropes 20 and by the transverse ropes Z, with the immediate containing effect in both directions.

Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated, without thereby departing from the scope of the present invention.

Patent claims

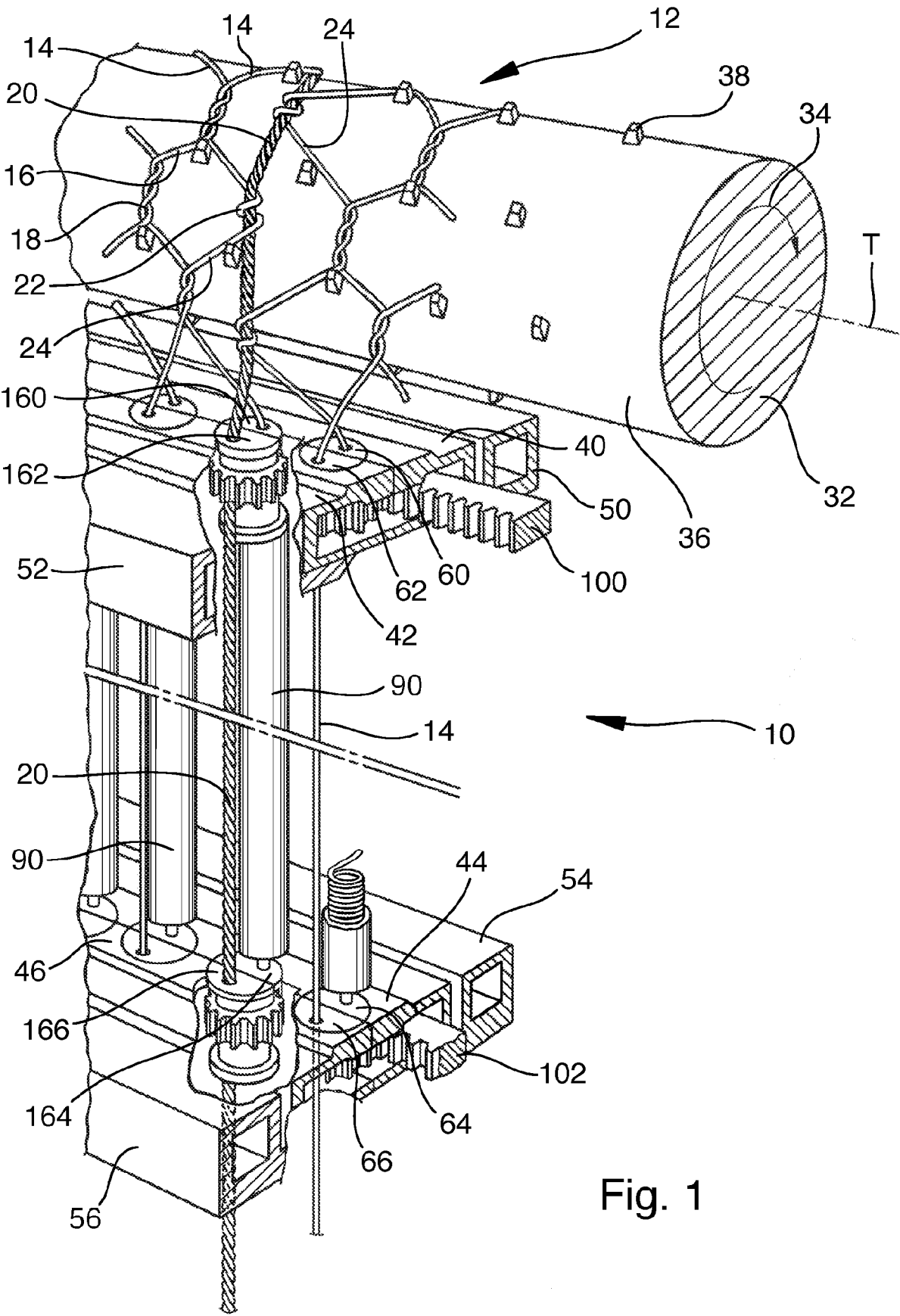
1. A high-strength protection grid for uses of the civil and geo-technical type which is produced with a plurality of metal wires (14) which are intercalated with metal ropes (20), the metal wires being interlaced with each other in interlacing portions (18), or which are twisted in twists around the ropes in twisting portions (22), the interlacings between the wires and the twists of the wires with the ropes defining the mesh of the grid, wherein the interlacings and the twists are each unidirectional and wherein the ropes have an external diameter which is greater than the wires and greater than 8 mm.
2. A protection grid according to claim 1, wherein the ropes (20) have an external diameter between 9 and 12 mm.
3. A protection grid according to claim 2, wherein the ropes (20) have an external diameter which is approximately of 10 mm.
4. A protection grid according to any one of claims 1 to 3, wherein the ropes (20) have a protective external covering of plastics material which contributes to the total external diameter of the rope.
5. A protection grid according to any one of claims 1 to 4, wherein the ropes (20) have an ultimate tensile strength greater than approximately 1000 MPa, preferably greater than 1500 MPa, even more preferably greater than or equal to approximately 1700 MPa.
6. A protection grid according to any one of the preceding claims, wherein the ropes (20) are helical ropes.

7. A protection grid according to any one of the preceding claims, the grid being substantially planar.

8. A protection grid according to any one of the preceding claims, comprising transverse ropes (Z) which are interlaced with the mesh of the grid.

9. A manufacturing machine for a protection grid according to any one of the preceding claims, comprising a series of pairs of first guide devices, which are spaced apart from each other and coaxial, and which are arranged in rows parallel with the axis of a drum, and a series of pairs of second guide devices, which are spaced apart from each other and coaxial, and which are arranged at the other side of the plane of symmetry which is tangent to the drum, each pair of second guide devices being arranged specularly opposite, with respect to the plane of symmetry, one of the pairs of first guide devices, wherein the pairs of first and second devices are simultaneously movable by half a step in opposite directions parallel with the axis of the drum, characterized in that the minimum distance (D) between the guide devices in a passage zone of a rope is greater than 8 mm.

10. A machine according to claim 9, wherein the minimum distance between the guide devices is greater than or equal to 10 mm, preferably greater than or equal to 12 mm, even more preferably of 13 mm or more.



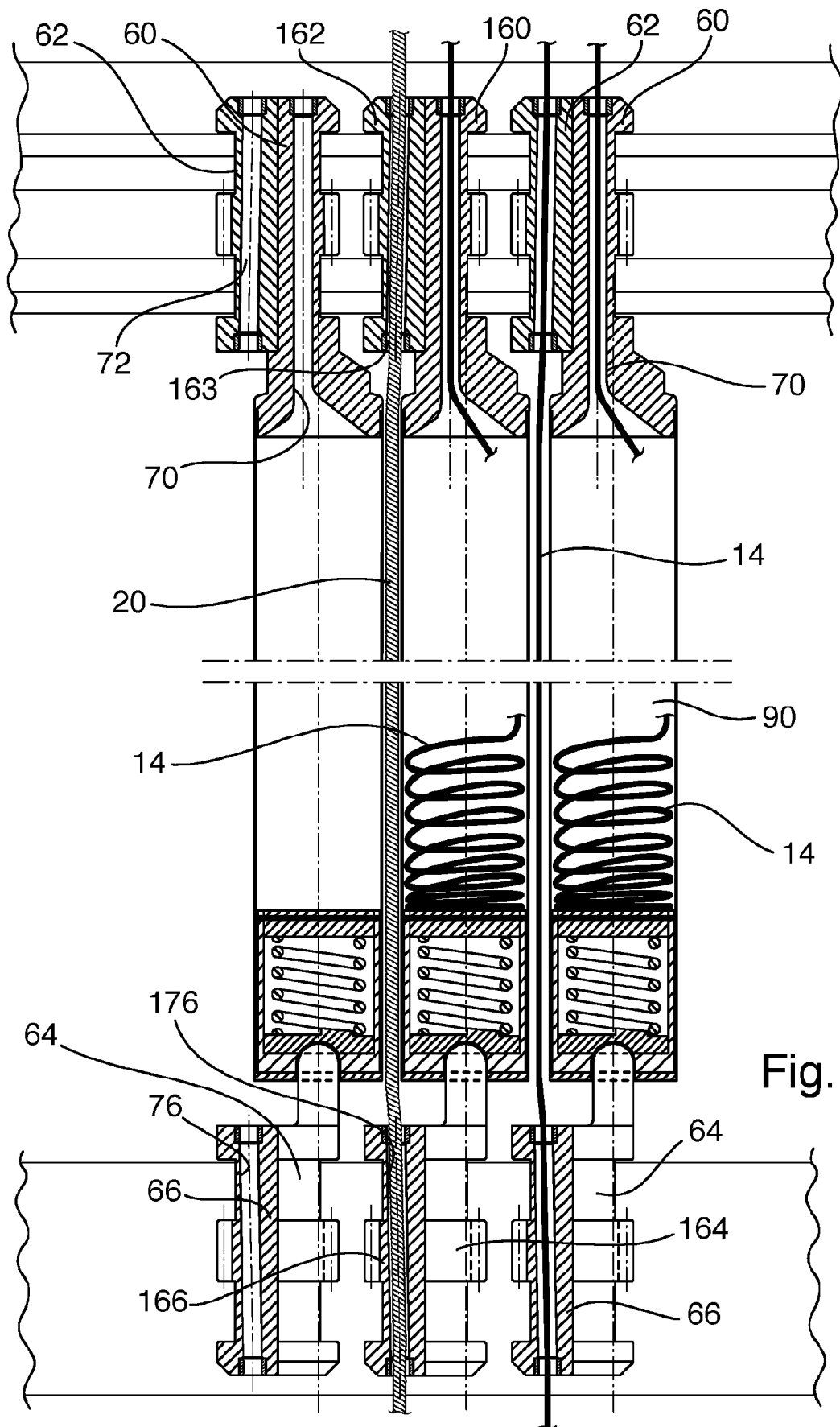


Fig. 2

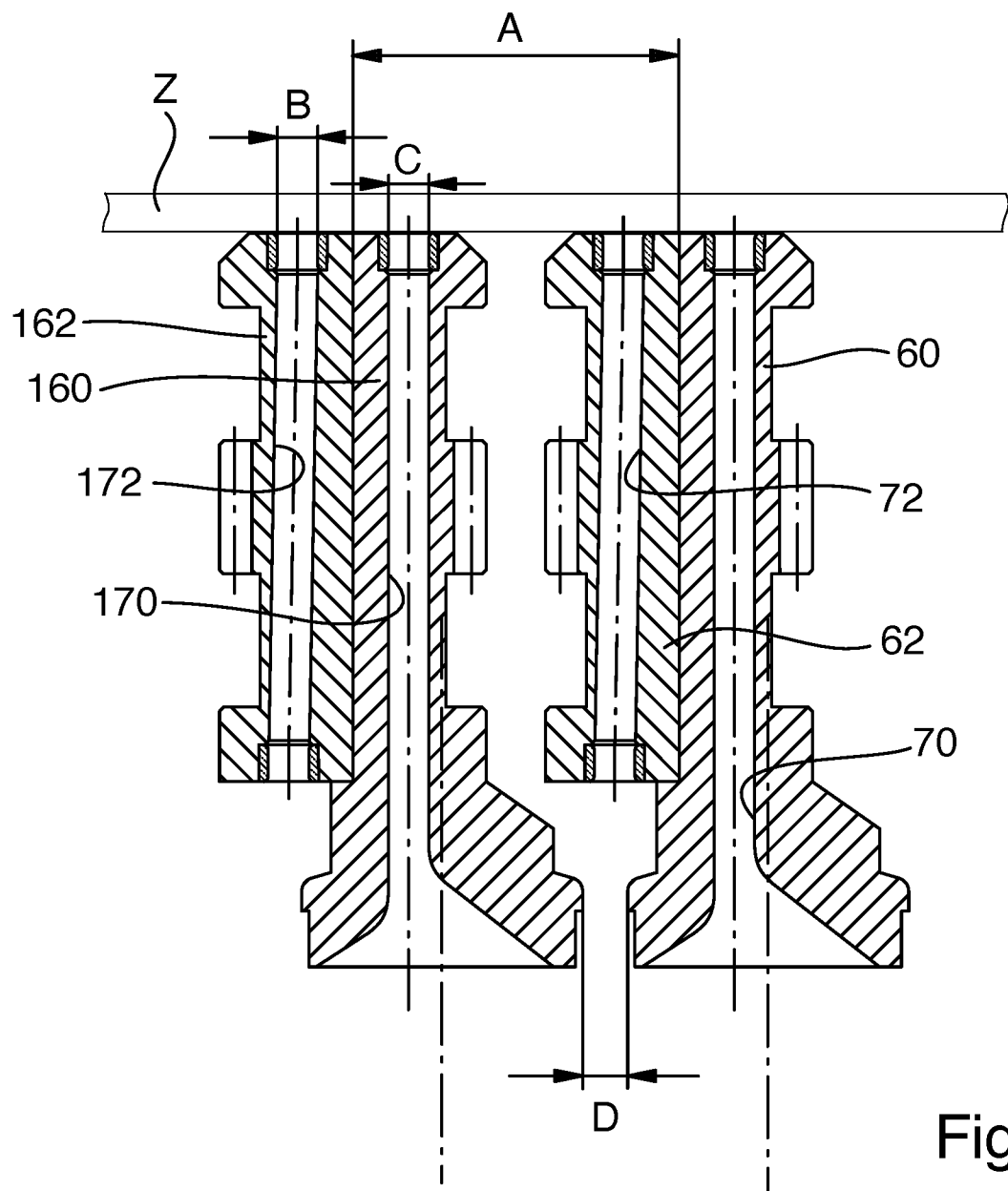


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/052056

A. CLASSIFICATION OF SUBJECT MATTER

INV. E01F7/04

ADD.

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)

E01F B21F

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

31 May 2024

Date of mailing of the international search report

02/07/2024

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Kremsler, Stefan

INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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