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Dietzsch et al.

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[45] **Nov. 20, 1973**

[54] **METHOD FOR MANUFACTURING LOAD BEARING STRUCTURES, SUCH AS STRUCTURAL SLABS OR THE LIKE, AND APPARATUS FOR CARRYING OUT THE METHOD**

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[21] Appl. No.: **136,517**

[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **156/191,** 156/193, 156/195, 156/250, 156/264, 156/296, 156/512, 161/69, 161/139

[51] **Int. Cl.** **B65h 81/03**

[58] **Field of Search** 156/190, 191, 193, 156/195, 296, 264, 250, 512; 161/69, 139

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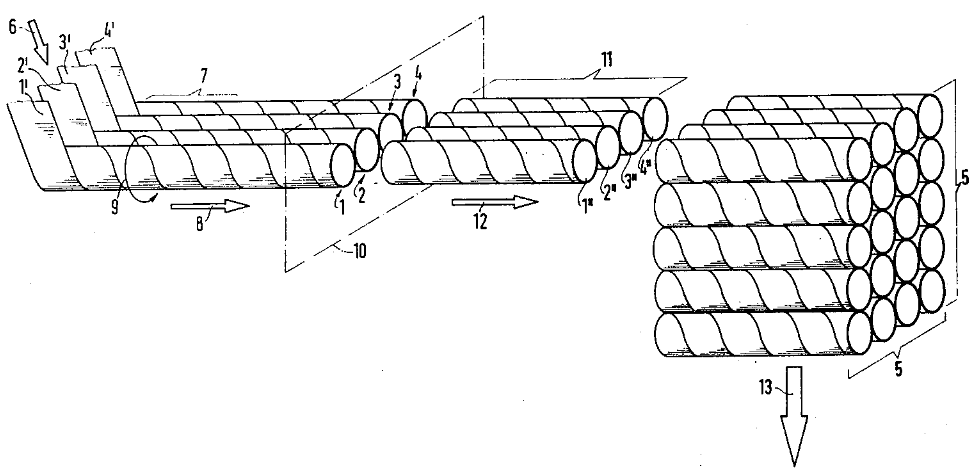
[57] **ABSTRACT**

A method for manufacturing load bearing structures, such as structural slabs or the like, from panels formed by tube sections extending parallel to each other and being connected together, each of which panels can be connected to at least one ply which may be provided with apertures, said ply covering completely or partially the front faces of all the tube sections lying in one plane.

18 Claims, 14 Drawing Figures



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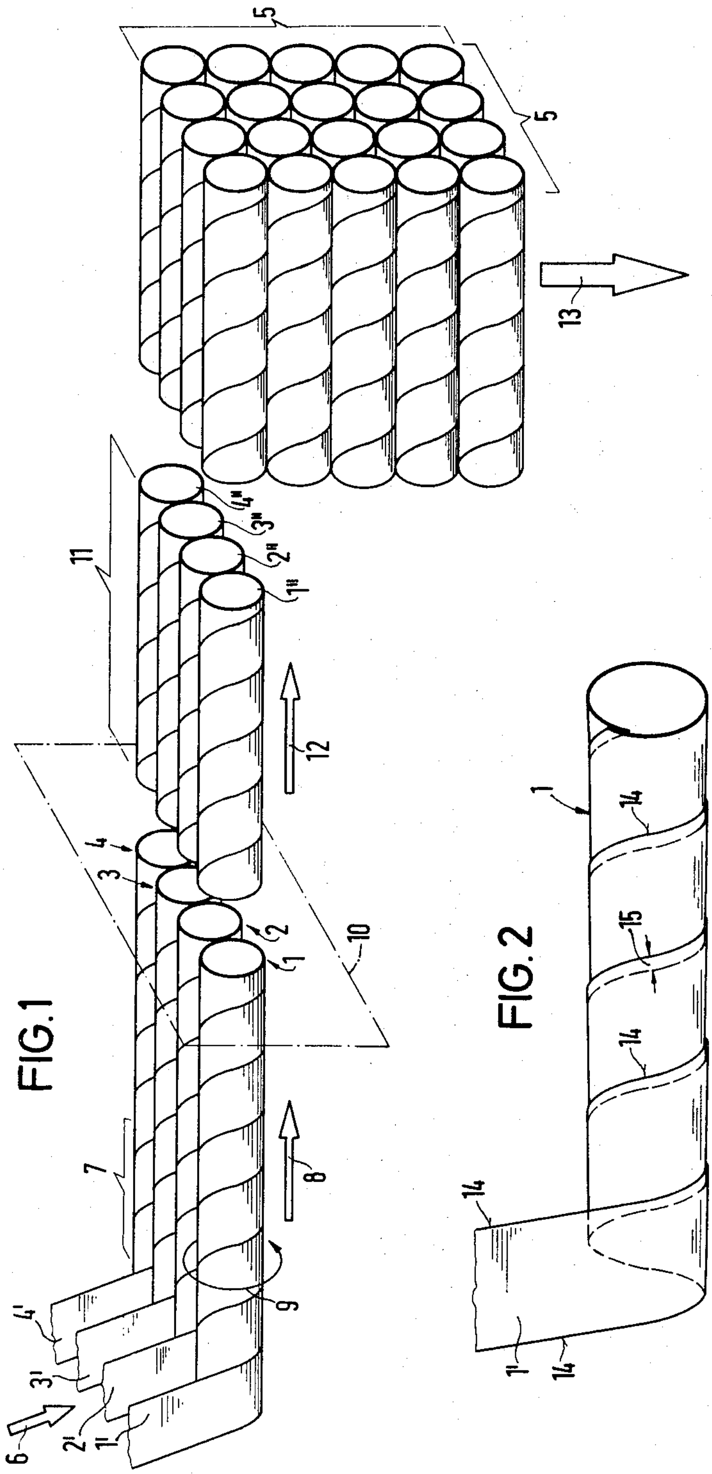

FIG.1

FIG.2

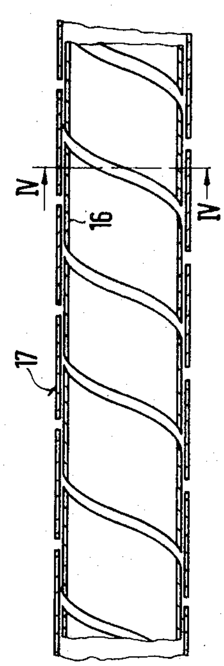

FIG.3

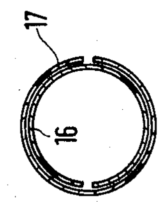

FIG.4

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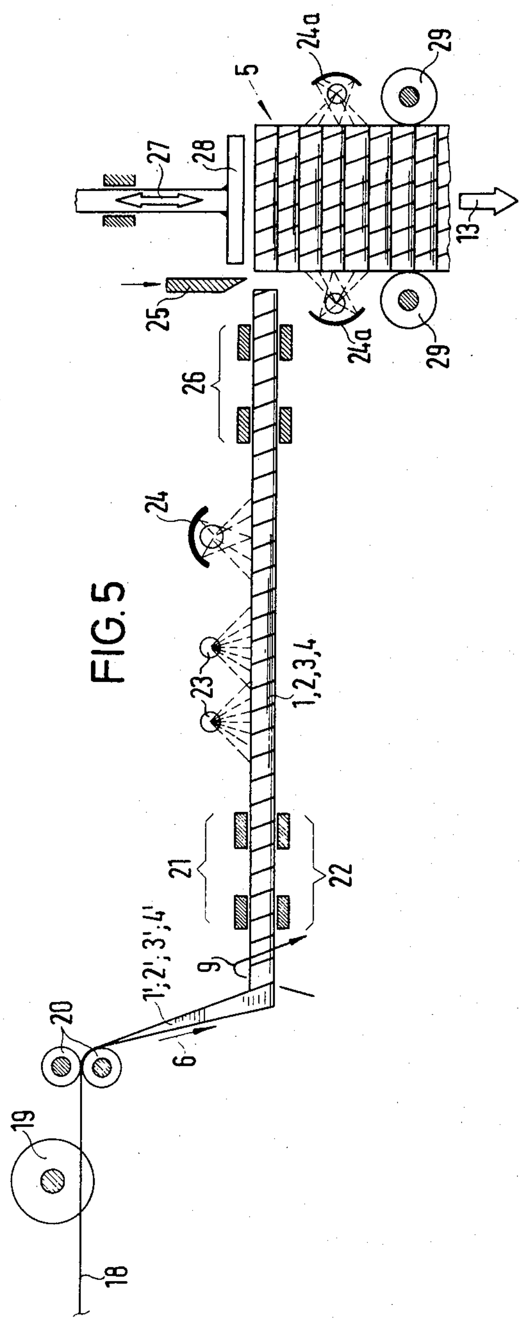

FIG. 5

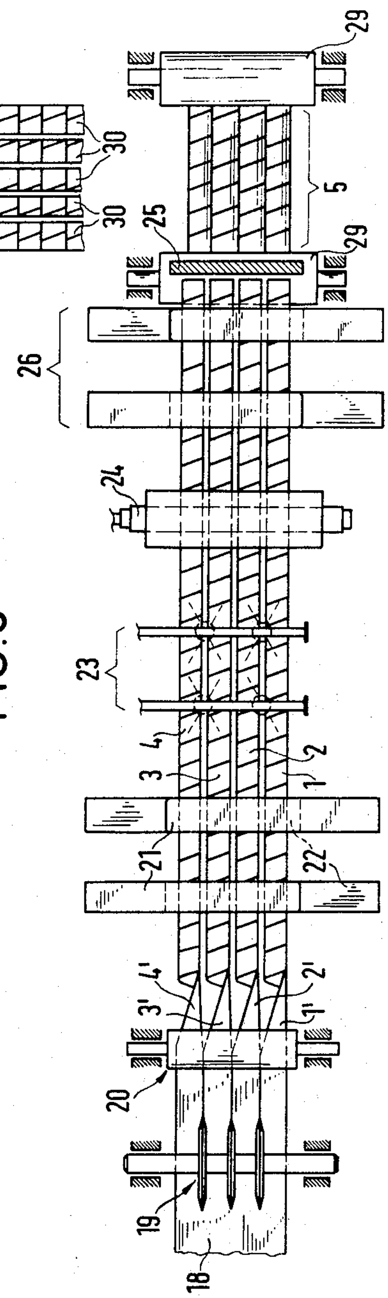

FIG. 6

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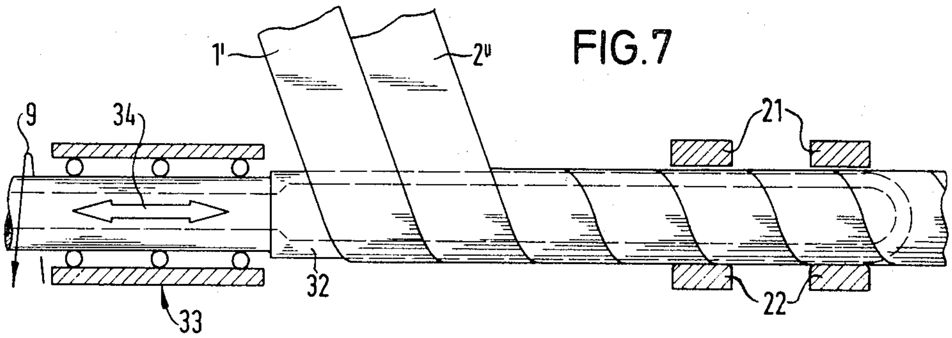

FIG.7

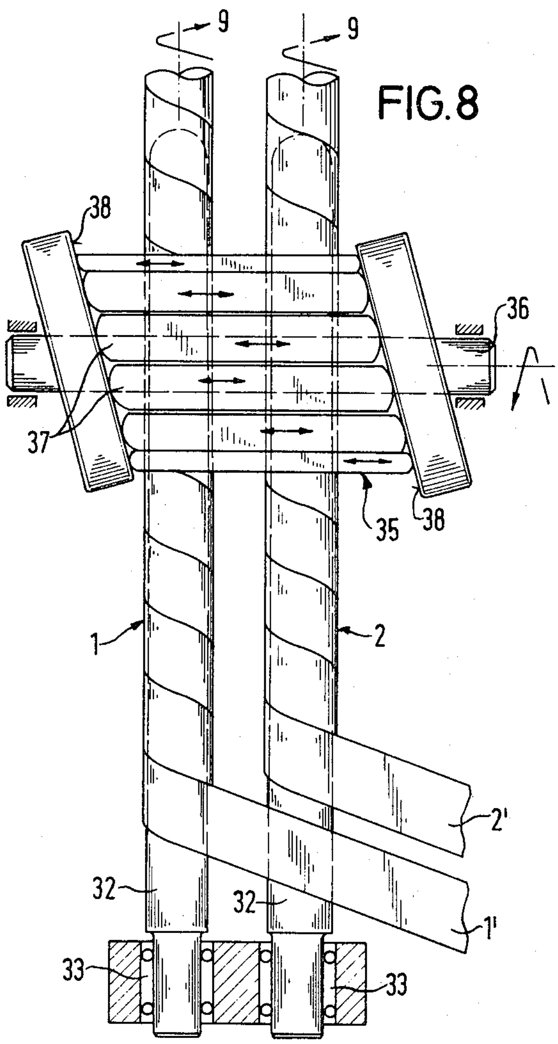

FIG.8

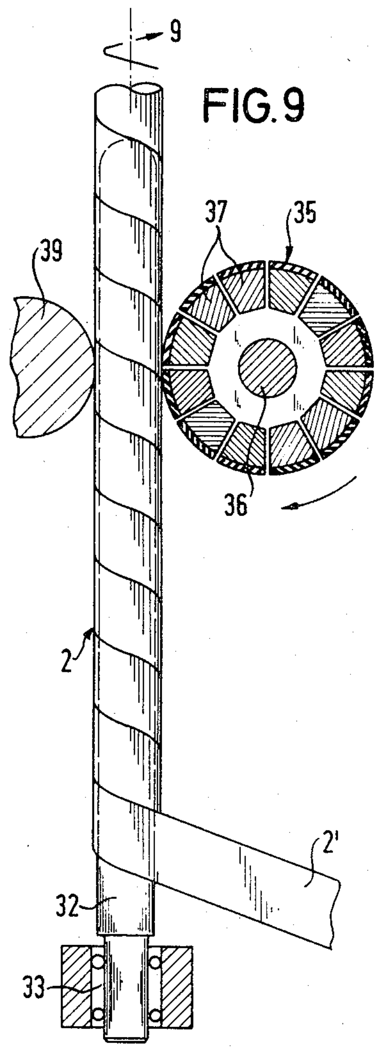

FIG.9

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FIG. 10

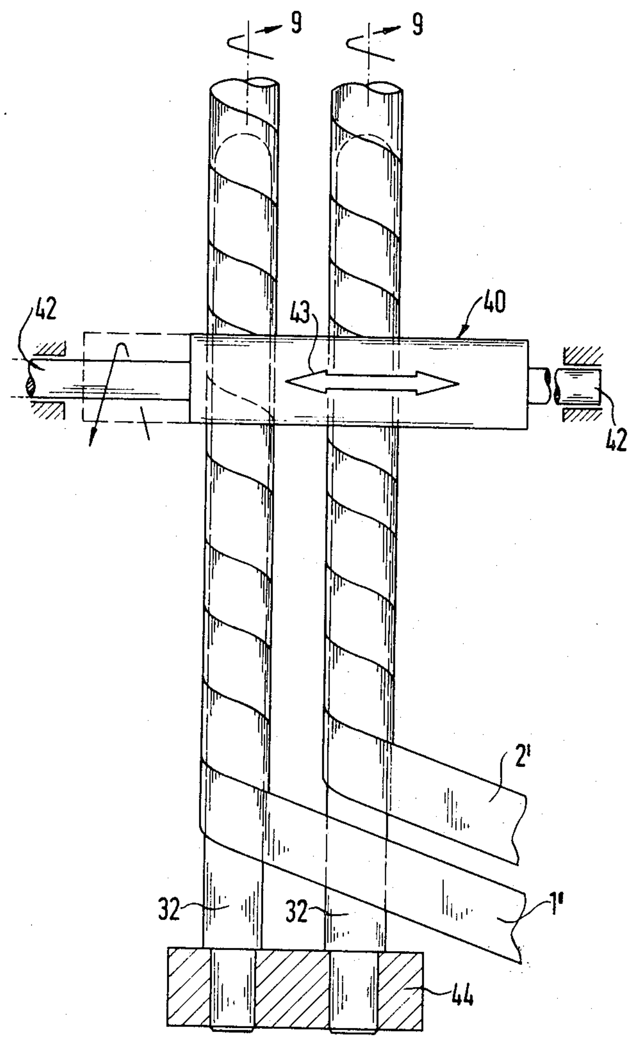

FIG. 11

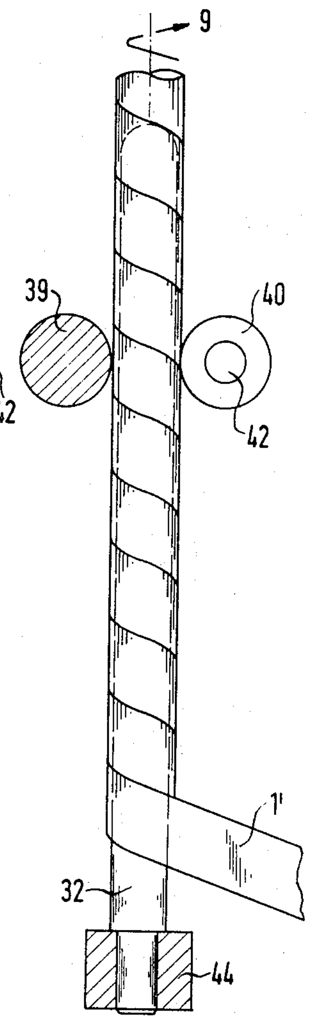

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FIG. 12

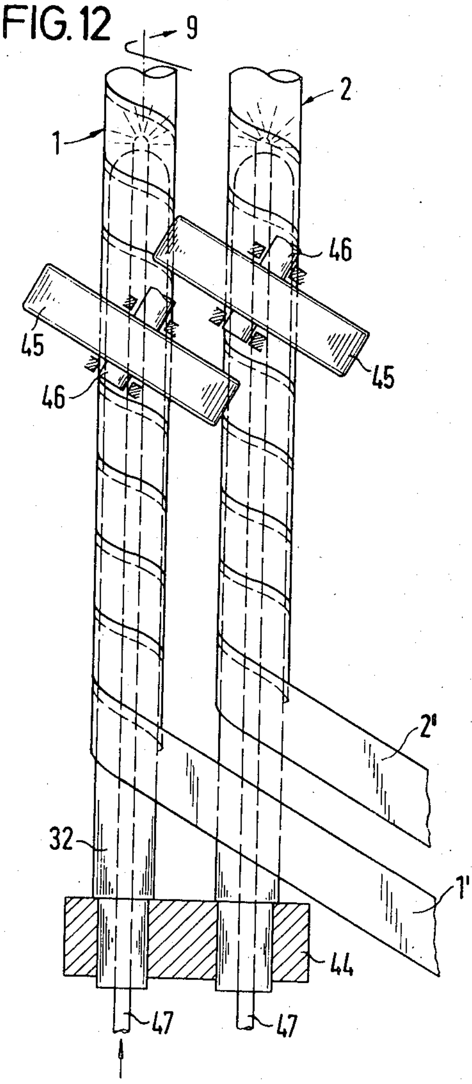


FIG. 13

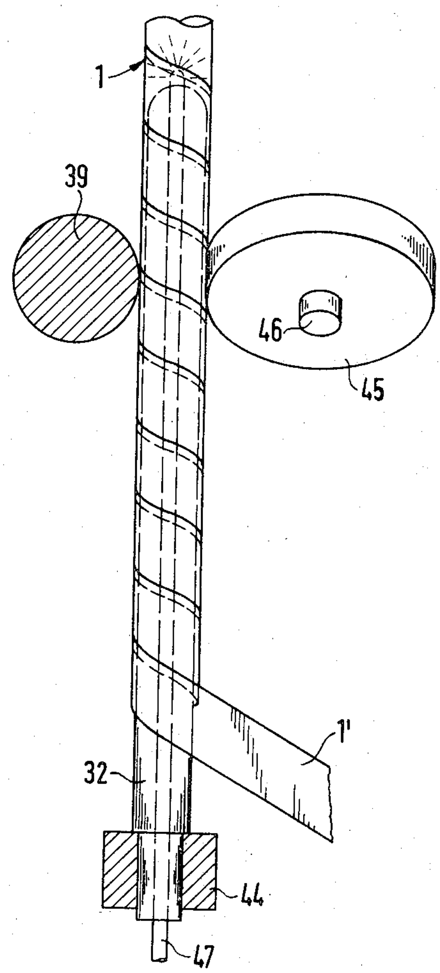
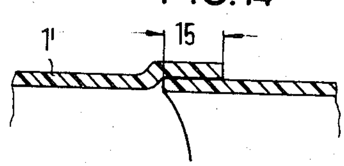


FIG. 14



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METHOD FOR MANUFACTURING LOAD BEARING STRUCTURES, SUCH AS STRUCTURAL SLABS OR THE LIKE, AND APPARATUS FOR CARRYING OUT THE METHOD

Load bearing structures of this kind are known (German Pat. No. 824,249, German Pat. No. 1,080,763, German Pat. No. 1,175,861). One load bearing structure of this kind consists of a light-permeable, heat-insulating slab, in particular for structural or insulating purposes, which comprises two boundary sheets of a transparent or translucent material, e.g., a plastics material, forming therebetween a hollow space, and tube portions or small rods for the same or a similar material as the sheets. In another load bearing structure which is intended as the hollow-celled middle ply for plywood boards, for the middle ply moulded bodies are arranged between two webs of paper and glued thereto. These moulded bodies consist of wood and either form hollow spaces by themselves or together with other moulded bodies. It is furthermore known to form middle plies for plywood boards from wood spirals closely pushed together, which are glued together at their contact points.

The known panels consisting of tube-like sections, which are provided on one or either side with a ply and which have proved themselves for the intended purpose, however, have the disadvantage that their parts serving to form the panel must have a certain inherent rigidity before being connected to other parts. It thus follows that load bearing structures of this kind have the disadvantage of being either heavy or of having a coarse internal structure. Finer internal structures of this kind are expensive and heavy.

The invention thus has the object of providing load bearing structures of the type mentioned above, which are intended to be stable structures and which in spite of a finer internal structure, can be manufactured considerably cheaper than the above-mentioned load bearing structures (known per se), although extremely thin materials which have thickness of e.g., 5 microns and are therefore difficult to work and to manipulate, have to be used for the manufacture of the panels.

According to the invention, it is proposed for achieving this object to produce at the same time several tube lengths each from at least one relatively thin, substantially plane strip and then to combine sections of equal length of these tube lengths into a block in such a way that the axes of all the tube sections extend parallel to one another, and that the block formed is then split up into panels by several cuts made at right angles to the axes of the tube sections. It is thus achieved that as compared with known load bearing structures, the manufacturing cost can be reduced to a fifth of its original cost. In addition, it becomes possible to reduce the internal cross-section of the hollow chambers formed by the tube sections practically as much as desired, e.g., to an order of magnitude of one square millimetre. As experiments have shown, the tube sections serving to form the panels can be produced not only from extremely thin starting materials, for example from plastics, metals or light alloys but also form such materials which in the intermediate working stages have an extremely low tensile strength, as is the case, by way of example, with paper wetted by bonding material. It is advantageous briefly to interrupt the manufacturing processes and during this time to secure the tube lengthsformed in position when the separation into sections of the equal length takes place.

It has proved to be particularly advantageous to produce each tube length by overlapping windings having the shape of helical seams. It thus becomes possible that each individual tube length receives a certain stiffness immediately after the winding, which is of great importance for the individual process steps.

A preferred feature of the method consists in that the winding of the tube lengths is carried out in at least one plane and the tube sections are removed layer-wise so as to form the block perpendicularly to the plane of motion of the tube lengths. Since the tube lengths are only wound in a single plane or in a single row, comparatively wide webs can be manufactured from a plurality of tube lengths, the separated part-lengths of which will then serve to form a compact block, whereby the cost of manufacture is considerably lowered. Separated part-lengths can also be so fed to the block so that one layer of tube length sections can be placed into the grooves of the uppermost, already deposited layer.

Since the method has to ensure easy and operationally safe working in spite of materials which are generally difficult to work and manipulate, it is recommended to use for winding the substantially plane strips winding mandrels which extend parallel to each other in the direction of motion of the tubes to be manufactured and are spaced from each other. A compressive force should be exerted on each wound strip, which does not only put the wound strip into rotation but also moves it in the direction of the mandrel axis relative to the mandrel. Winding will then take place without the necessity to drive the winding mandrels. The winding mandrels can be arranged stationary or they can be freely rotatably mounted. It is particularly recommendable to exert such a compressive force on the wound tubes that each time a permanent shaping of a strip takes place. Since winding is carried out with overlapping, the part of each strip wound onto a winding changes its form in the area of the edge of the underlying winding, as a result of which the rigidity of each wound tube is considerably increased due to the overlap and conical shaping of the individual layers of the windings.

The tube length sections removed from the plane of movement of the tube lengths, which already are connected together and form part of the block, can — in order to be connected to newly produced tube lengths sections — be moved back and forth transversely to the plane of movement of the end of the tube lengths and towards and away therefrom and thus be connected with the ends of the tube lengths produced, whereupon only then is a section of the tube length corresponding to the height of the block cut off. Obviously tube length sections can also be cut from the tube length end areas in a length corresponding to the height of the block, and then be removed transversely from the plane of movement of the tube length, for combining them with those tube length sections which already form part of the block.

The mutual connection of the tube length sections which lie side by side in the block and also the stiffening of the individual tubes themselves are effected by bonding materials which are preferably applied as hardenable precursors to the tube material and subsequently hardened. This additive can already be admixed to the substantially plane strips necessary for the formation of the tubes and/or to the tube lengths formed and/or to the tube length sections. This addition may be performed by spraying processes.

The invention also relates to apparatus for carrying out the method. According to the invention, such an apparatus comprises several winding devices each provided with a mandrel, to which winding devices at least one strip of material can be fed; these winding devices are arranged extending parallel to one another in at least one plane, the strips of material surrounding the mandrels being subject to the influence of one or more pressure means rotating and advancing the strips about the mandrel axes. In addition there are provided separating means for cutting finished tube lengths into equal lengths, as well as means which move tube length groups having equal lengths transversely to the plane of finishing and combine them into a block. Although due to separation of tube length sections from the tube lengths and their stacking into a block, the course of manufacture is preferably carried out discontinuously, the interruptions necessary for the separations are so short that the manufacturing process is nevertheless carried out practically like a continously performed process.

In order to be able to exert compressive forces on the tube windings, various means may be used. The pressure means can thus consist of at least one rail which is movably guided to and fro transversely and longitudinally to the direction of motion of the tube lengths and can only be brought into work in connection with the tube lengths during one of the to and fro movements. Guiding this rail involves no difficulties nor do disadvantages occur during the return movement of the rail since this return movement can be carried out relatively quickly. it is, however, more expedient to provide on the circumference of a cylinder extending transversely to the axes of the tube lengths, several rails guided parallel to the axis of rotation of the cylinder, which are controlledly movable to and fro. In this case at any time one of the rails provided on the circumference is in positive contact with the individual tube windings, moving them in the feed direction and putting them into rotation. The rails following thereon act in the same sense since, after they have become disengaged from the tube windings, they are always moved back again into their initial position by slide cams or the like.

It is also possible, however, to provide as a pressure means acting on all the tube lengths, a roller arranged transversely to the axes of the tube lengths, which can be driven about its axis, and is guided so as to be movable to and fro in the direction of its axis and can only be brought into working connection with the tube lengths during one of the two to and fro movements. The above statements on a to and fro movably guided rail likewise apply to this embodiment.

It is also possible, however, to provide for each individual tube length a pressure means consisting of a drivable wheel, a roll or the like, the plane of rotation of which extends in the direction of the pitch of the windings. Since the individual tube lengths have in any event a certain distance from each other, the mounting of such wheels, rolls or the like does not cause any difficulties.

It should be ensured in all these cases that each rail, each roller or each wheel should be provided on its face coming into working connection with the tube lengths, with a deformable coat, and that each mandrel should consist of a material having as low a frictional resistance as possible, as is the case with polytetrafluorethylene (trade name Teflon).

Particularly favourable results can be achieved if each pressure means is arranged at a spacing of at least two winding pitches from the input point of a strip, and that each strip being fed in can be put under tension by a braking means.

In order to simplify the process in certain cases, it is recommended to design each winding mandrel as a hollow mandrel and to provide therein a duct for conveying a bonding material to the inner surface of the tube length. It is furthermore possible to assign supply means to the tube lengths or tube length sections for the application of a bonding material to the outer surfaces of the tubes or tube sections.

A panel designed according to the invention consists of parts — arranged in layers — of preferably wound, layer-wise formed tube length sections which are mutually connected by means of bonding material, the layer preferably constituting parallel panes.

It is possible to use *inter alia* as raw materials for the strips of material which may be arranged in a single layer or in multiple layers combining different raw materials: *Paper*, *unwoven web*, *fabrics* (the latter with or without impregnation with additives). *foils* of cellulose derivatives, thermoplastics (such as polymethacrylate), thermosetting resins (such as epoxy resin), rubber (or other elastomers), organic fluorine containing polymers (such as Teflon, polyvinyl fluoride), molecularly oriented high polymers, such as two-dimensionally stretched polyamides or polyesters, *Metal foils* which are preferably electro-deposited but can also be e.g., rolled, in particular hard-rolled aluminum foils.

These materials may also include reinforcing substances, e.g., a thermosetting foil can be provided with glass fibre cuttings.

The webs serving to produce tubes consist e.g., of strips which contain incombustible fibres, or of hard-rolled light alloy strips or of foil strips produced by electro-deposited or of thin metal strips.

The incombustible fibres may consist of asbestos or melted silicates, to which preferably cement is added as an incombustible binder; also gypsum may be added. If for special purposes of use hard-rolled light metal foil strips are employed which are particularly recommendable, it is preferred to connect the wound tubes or tube sections together by means of thermosetting resins although also other bonding materials may be used. The webs can also consist of electro-deposit foil strips, e.g., hard nickel, or of thin metal strips, for example chromium nickel steel, in which case a solder can be used as a bonding material. It is also possible to wind thin metal strips which after their production are welded together by the action of heat, should preferably be carried out in an atmosphere of protective gas. Incombustible bonding materials can be added prior to winding or else only after the winding.

In the following, the invention will be explained, by way of example, with reference to several embodiments, shown diagrammatically in the drawings. There is shown:

FIG. 1 the manufacturing process in a perspective view,

FIG. 2 the manufacture of a tube,

FIG. 3 and 4 a tube of two strips, in side view and in section,

FIG. 5 a side view of a manufacturing arrangement,

FIG. 6 a plan view of FIG. 5,

FIG. 7 an embodiment of a winding device,

FIG. 8 a second embodiment of a winding device, in plan,

FIG. 9 the winding device according to FIG. 8 in section,

FIG. 10 a plan view of several just completed tubes with a roller as a pressure means,

FIG. 11 a side view of FIG. 10,

FIG. 12 a plan view of several just completed tubes, each being acted upon by a pressure means consisting of a wheel, a roll or the like,

FIG. 13 a side view of FIG. 12,

FIG. 14 a section through an overlapping wound strip.

For the sake of clarity, the drawings are shown with the scales distorted and they only illustrate a few of the tubes to be produced at the same time.

In FIG. 1, only four tubes 1,2,3 and 4 are shown, each of which is produced from a substantially plane strip 1', 2', 3' and 4' by winding, in order to be combined, after being severed into tube sections, with a plurality of others into a block 5. The strips are fed to the winding devices in the direction of arrow 6. In area 7 the strips are formed into winding which are fed in the direction of arrow 8. The windings rotate in the direction of arrow 9 at a constant rotational speed or intermittently, i.e., the finished winding stand still when, for example, they are severed together, as illustrated by the cutting plane 10, into tube sections I'', 2'', 3'' and 4'', the lengths of which are indicated by the extent 11. The tube sections forming a transverse band are fed in the direction of the arrow 12 and then moved downwardly in the direction of arrow 13 so as to form, together with already produced tube sections, the block 5. The block shown consists of five layers of tube sections. Obviously the tubes and tube sections can also be moved in directions other than shown in FIG. 1, e.g., the tubes can be moved in the vertical direction, and the tube sections moved in the horizontal direction for forming a block. Deposited layers can be so arranged that the individual windings of superimposed tube lengths are disposed in the same planes or are alternately offset with respect to each other.

FIG. 2 shows a perspective view of the winding of the tube with an overlap. The longitudinal edges of the strip 1' to be formed are designated as 14 and the overlap area as 15.

FIG. 3 illustrate the simultaneous winding of two strips 16 and 17 shown spaced apart for simplifying the drawing.

FIG. 4 shows a section on line IV—IV of FIG. 3. In this case the individual windings of each tube need not be wound with an overlap but can be butt-jointed. The strips 16 and 17 may be wound in opposite directions.

FIGS. 5 and 6 show an apparatus in side and in plan views respectively to illustrate schematically the manufacturing process. Of a plurality of strips or tubes, also here only four of them are shown. It is assumed that the starting material consists of a web 18 which is cut up into individual strips by a cutting device formed by severing discs 19. These strips are fed via pairs of conveyor rollers 20 to the winding devices which are arranged in the area 7. In order to put the wound tubes into rotation on the one hand, and to move them in the feed direction on the other hand, pairs of guide rails 21, 22 are provided in the case of the embodiment of FIGS. 5 and 6, which are controlledly moved to and fro, transversely and longitudinally of the direction of movement of the tubes.

As viewed in the direction of movement of the tubes, nozzles 23 are provided behing the pairs of rails 21, 22 which spray a drying lacquer or other bonding materials onto the circumferential surface of the tubes or the like. If the bonding material applied is to be prehardened or hardened, for example, infrared lamps 24 may be arranged behind the nozzles 23. If necessary additional pairs of guide rails 26 or the like can be provided at a short distance in front of a cutting-off device 25. In contrast to the diagram of FIG. 1, according to which tube sections 11 are cut off the tube lengths before being combined to form the block 5, it is here assumed that separation only takes place when the ends of the tube lengths have been pushed onto parts of the block to be produced and have been connected therewith. A ram 28 moving to and fro in the directions of the double arrow 27 helps in the stacking of the tube sections, roller 29 being provided to guide the already produced part of the block 5. How the connection is effected is immaterial *per se;* for connecting tube sections to the block 5, the block can be moved pilgrim stepwise.

After a block 5 has been completed, it can be split up into panels 30; when for example synthetic strips or unwoven web of synthetic fibers mutually secured in position by thermoplastic binders, were used as starting material, instead of cutting means, such as saw blades, also electrically heated wires 31 may be employed. In order to be able to interconnect tube sections satisfactorily, bonding materials applied can be activated by heat sources, such as lamps 24*a*.

FIG. 7 shows an embodiment of a winding method. In this case for producing a tube two strip 1' and 2' are simultaneously fed to a winding device which consists of a mandrel 32 which is mounted in a bearing 33 and is of such length that it serves as a support for pressure means, here a pair of rails 21. 22. Although it is assumed in this case that the mandrel is moved in the direction of the direction of the double arrow 34, synchronously with the winding movement, said mandrel can also be arranged only for rotation.

In order to show that also differently designed means can be provided as pressure means, reference is made to FIG. 8 and 9. A cylinder 35 is provided on its circumference with several rails 37 controlledly movable to and fro which are guided parallel to the axis of rotation 36 of the cylinder. The cylinder 35 rotates about an axis extending transversely to the direction of motion of the tube. During this rotational movement the rail which at that moment exerts a compressive force on the wound tubes, is additionally displaced transversly to the direction of motion of the individual tubes so that the resultant action is in the direction of the pitch of the winding. This control is effected by slide cams 38 which are in engagement with the front faces of the individual rails. As soon as a rail is no longer in communication with the tubes, it is moved back into its initial position during the rotation of the cylinder. The individual tubes are supported by a roller 39 mounted in parallel to the cylinder 36; instead of said roller 39 also other support means may be provided. The mandrels 32 are also here freely rotatably mounted in bearings 33. Obviously a plurality of mandrels is provided for producing a plurality of tubes although only two winding devices have here been shown.

The embodiment of FIG. 10 and 11 shows that in place of a cylinder provided with rails, also a roller 40 may be provided which can be put in rotation about its axis 42 in the direction of arrow 41 and is also guided movably to and fro in the direction of the axis 42; this is indicated by the arrow 43. This feature is particularly advantageous when the winding processes have to be interrupted for a short time for the severance of tube sections since the roller 40 can then be returned to its initial position during this short interruption. In the case shown it is assumed that the mandrels 32 are fixedly mounted at 44; the mandrels have a coat of polytetrafluorethylene (trade name Teflon): they can also be rotatably mounted.

Finally, the embodiment of FIGS. 12 and 13 shows a further possibility of how the individual tube windings can be acted upon in the sense of rotation and feed. As pressure means, drivable wheels, rolls or the like 45 are provided, the axes of rotation of which are designated as 46. The wheels or the like 45 extend obliquely to the direction of motion of the individual tube windings. Also here the mandrels 32 are fixedly mounted at 44 and they are of hollow construction for receiving ducts 47 which serve to feed bonding material or the like to the inner wall surfaces of the individual tube windings.

The compressive force exerted by the rails, roller or wheels should preferably not only be so great that each tube winding is rotated and advanced thereby; the compressive force should also enable a permanent deformation by a certain amount in each wound strip as shown in FIG. 14, as a result of which the rigidity of each individual tube length is considerably increased.

It is furthermore recommended to provide at least the surface of each pressure means, which comes into working contact with one or more tubes, with a deformable coating, for example of rubber so that the compressive force exerted by each one can be distributed over the surface on which it acts.

Obviously the manufacture of a block explained by way of example with reference to several embodiments can also be achieved with other means which are equivalent to those of the embodiment shown. Thus, the substantially plane strips can also consist of most dissimilar materials and they can also be wound into tubes using different means. As bonding materials for the reciprocal location of the individual windings and for connection tube sections to other sections, also differently composed bonding materials may be used, for example glue, lacquer, silicon rubber, hardened casting resin (thermosetting plastics), cement, gypsum, metal or the like. Similar considerations also apply to other connection means; tube sections can be connected to other such sections also by soldering, welding, sintering or the like, depending on the starting materials used.

The blocks produced and the load bearing structures manufactured therefrom have a relatively low specific weight since the wall thicknesses of the starting materials used can be extremely small; these thicknesses vary in magnitude between a few microns and 0.1mm (100 microns). Since no difficulties are caused by arranging winding devices closely side by side, a plurality of tubes, for example one thousand side by side, can be produced simultaneously in a single plane. It becomes thus possible to produce panels, the width of which cor-

responds to the height of a room, whilst its length has to be suited to requirements.

If as starting material incombustible fibres are used which are provided with incombustible bonding materials, for example fibres of fused silicates, such as a glass or slag, to which cement or gypsum-containing bonding materials are added before or during the manufacturing process of the blocks or panels, it will be possible to manufacture non-combustible building elements of high heat insulation which are not only relatively light in weight and stable but which can not even be deformed by an execssive action of heat. After being produced but before being bonded with their cover layers, the panels according to the invention can be provided with reinforcing means, preferably by impregnating them with substances which are castable and hardenable. For this purpose preferably panels are suitable, the tube portions of which are wound from strips of non-woven web, and to which bonding materials have been so added that the structure of the tube becomes porous and thus absorbent for the reinforcing means. Cement or gypsum mixtures are suitable as reinforcing means.

We claim:

1. A method for manufacturing load bearing structures, such as structural slabs or the like, from panels formed by tube sections extending parallel to each other and being characterised in that several tube lengths each of at least one relatively thin, substantially plane strip are produced at the same time and sections of equal length of these tube lengths are then combined into a block in such a way that the axes of all the tube length sections extend parallel to one another, and that the block formed is then split up into panels by several cuts made at right angles to the axes of the tube length sections.

2. A method according to claim 1, characterised in that the manufacturing processes are interrupted for a short time and at least the ends of the formed tube lengths are secured in position during this interruption.

3. A method according to claim 1, characterised in that each tube length is produced by overlapping windings having the shape of helical seams.

4. A method according to claim 1, characterised in that the winding of the tube lengths is carried out at least in one plane and that for forming the block the tube length sections are removed layer-wise, transversely to the plane of motion of the tube lengths.

5. A method according to claim 4, characterised in that already interconnected tube length sections removed from the plane of movement of the tube lengths are moved transversely to the plane of movement and towards and away therefrom, and thus are connected to the ends of the tube lengths produced, and that only then is a section corresponding to the height of the block separated from the tube lengths.

6. A method according to claim 1, including the use of winding mandrels which extend in the direction of motion of the tubes to be produced parallel to and with spacing from each other, characterised in that upon each wound strip a compressive force is exerted which not only puts the strip into rotation but moves it also in the direction of the mandrel axis, relative to the mandrel.

7. A method according to claim 6, characterised in that such a compressive force is exerted that a permenant shaping of the strip results.

8. A method according to claim 1, characterised in that a material constituting a precursor of a hardenable bonding material is applied to the tube lengths produced prior to their connection to already separated sections.

9. A method according to claim 1, further comprising the steps of connecting at least one ply to each of the formed panels, the play at least partially covering the front faces of all the tube sections lying in one plane.

10. A method according to claim 9, wherein the ply is provided with apertures.

11. A method according to claim 9, wherein the ply completely covers the front faces of all the tube sections lying in one plane.

12. A method according to claim 1, wherein the combining of the tube lengths into a block includes the step of bonding the tube length sections to one another.

13. A method for manufacturing load bearing structures, such as structural alabs or the like, from panels formed by individually bendable tube sections extending parallel to each other and being connected together, characterized by simultaneously producing in at least one plane a plurality of tube sections having a relatively small diameter by overlapping winding of at least one relatively thin substantially planar strip, combining tube sections of equal length into a block by extending the axes of all the tube sections in parallel to one another, and splitting the formed block into panels by cutting the block at right angles to the axes of the tube sections at several places along the length thereof.

14. A method according to claim 13, wherein the tube sections are provided with a diameter of approximately 1 mm and the planar strip has a thickness in the range of several microns to 100 microns.

15. A method according to claim 13, further comprising the step of joining at least one ply to a formed panel, the ply at least partially covering the front faces of all the tube sections of the panel lying in one plane.

16. A method according to claim 15, wherein the ply is provided with apertures.

17. A method according to claim 15, wherein the ply completely covers the front faces of all the tube sections lying in one plane.

18. A method according to claim 13, wherein the step of combining tube sections of equal length into a block includes the step of bonding the tube sections to one another.

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