May 19, 1959 K. H. BROSENIUS 2,886,857

WOODEN BEAM CONSTRUCTIONS

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Fig. 1

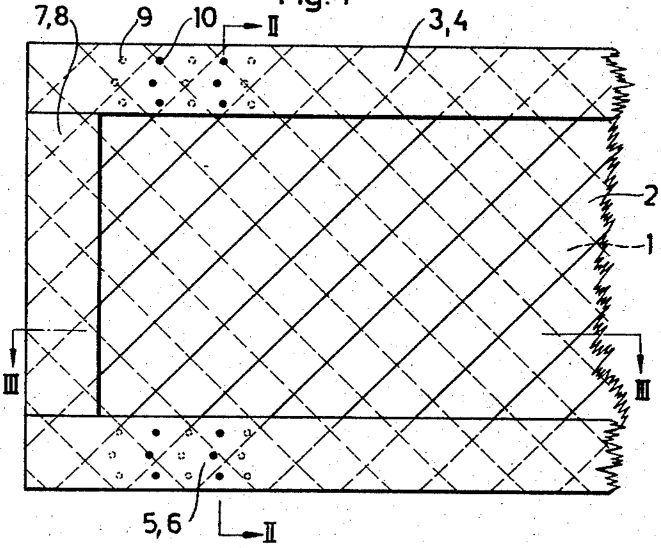


Fig. 2

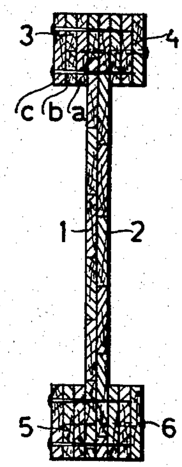


Fig. 3

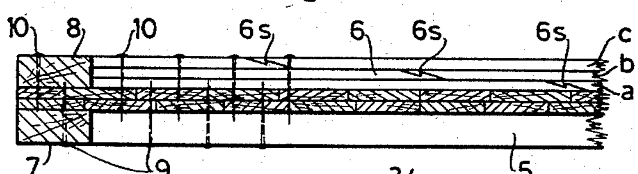


Fig. 4

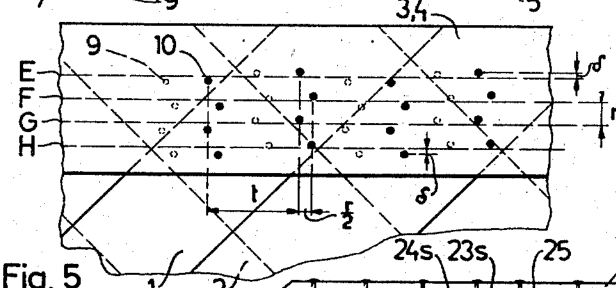
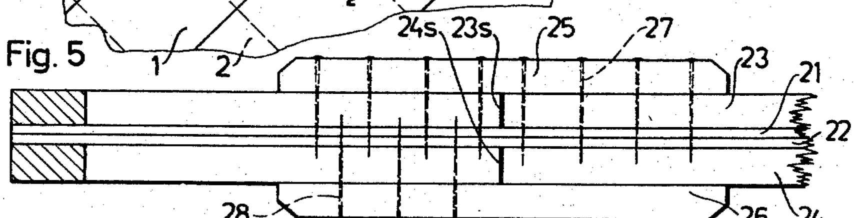


Fig. 5



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WOODEN BEAM CONSTRUCTIONS

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Fig. 6

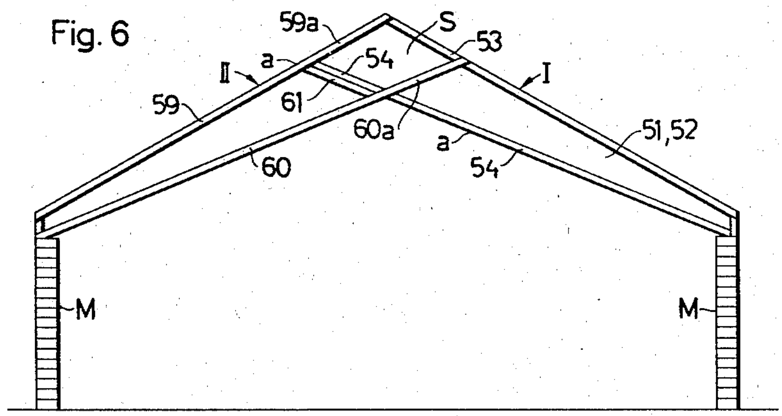


Fig. 7

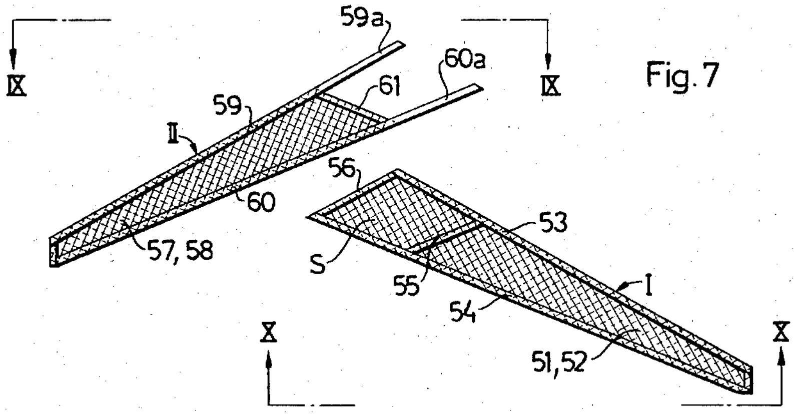
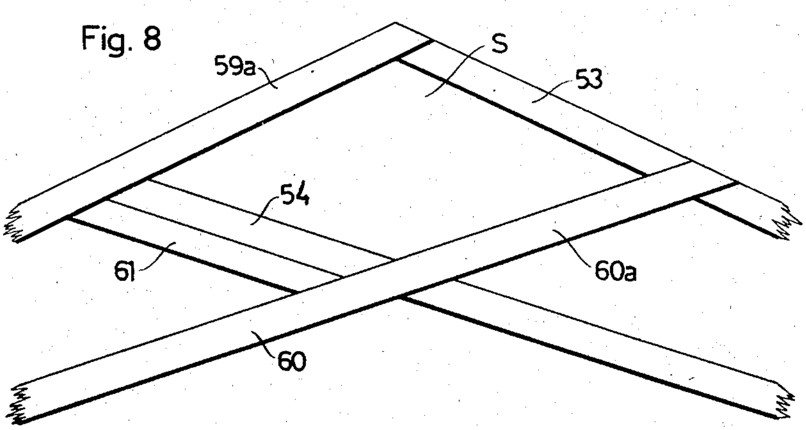


Fig. 8



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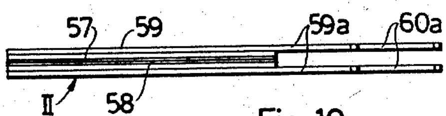

Fig. 9

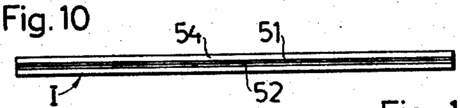

Fig. 10

Fig. 11

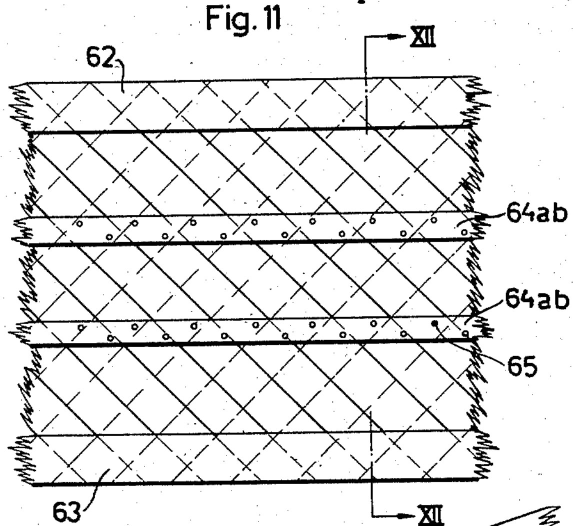

Fig. 12

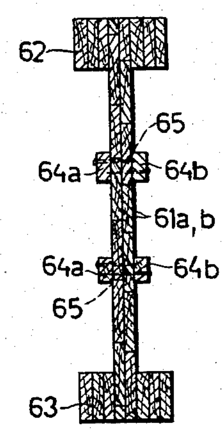

Fig. 13

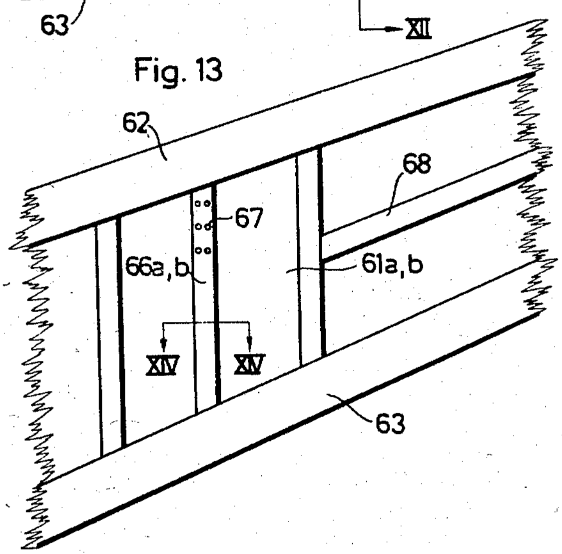

Fig. 14

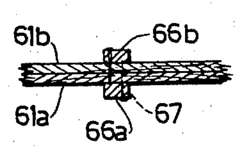

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Fig. 15

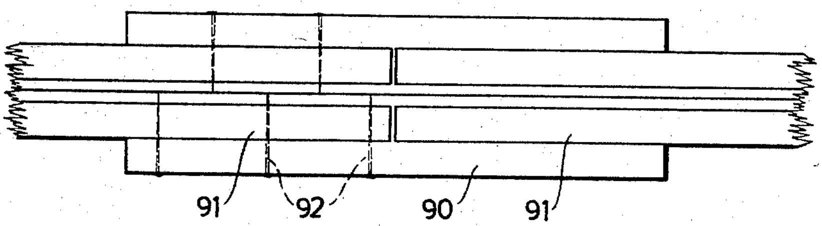


Fig. 16

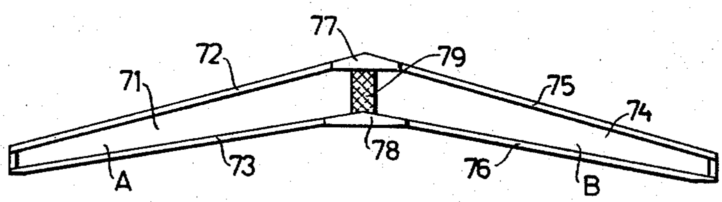
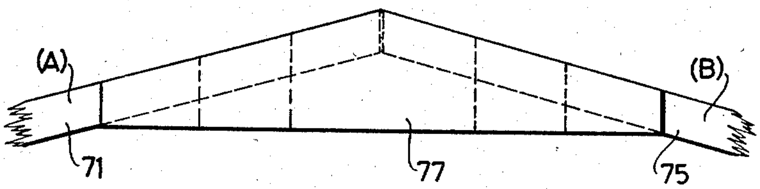


Fig. 17



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WOODEN BEAM CONSTRUCTIONS

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Fig. 18

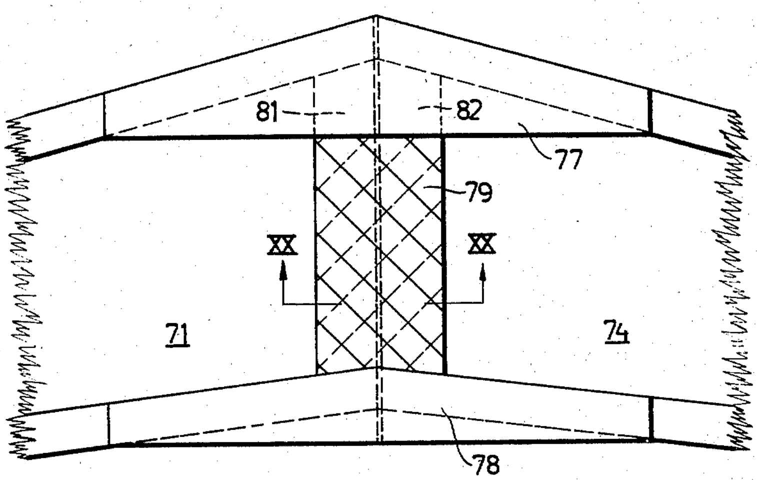

Fig. 19

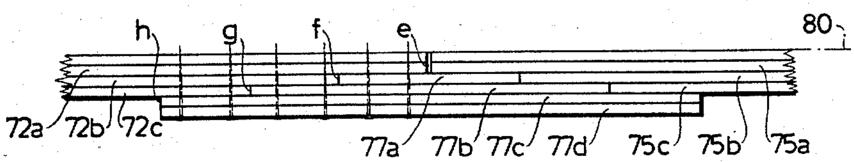

Fig. 20

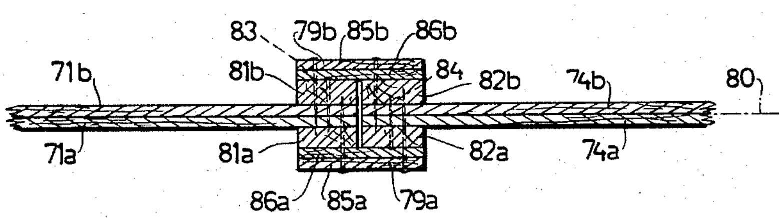

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Fig. 21

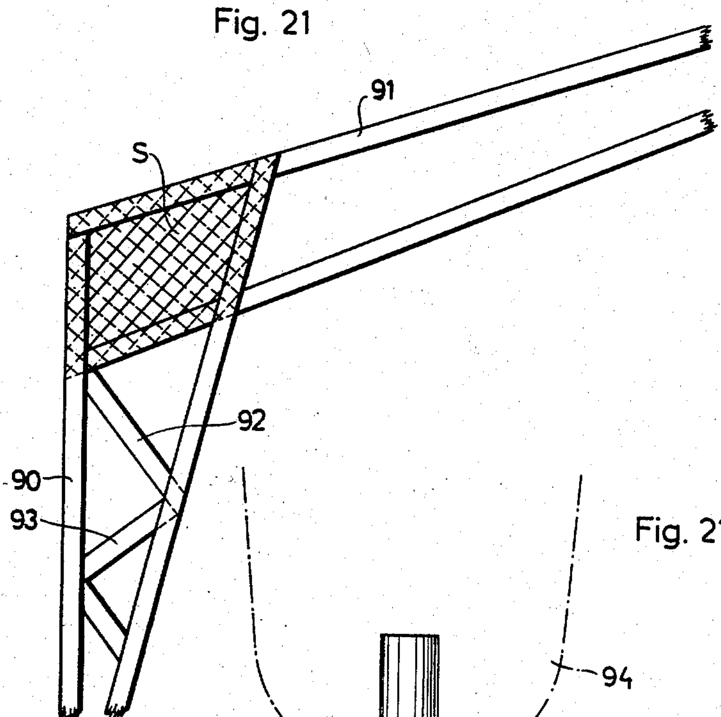
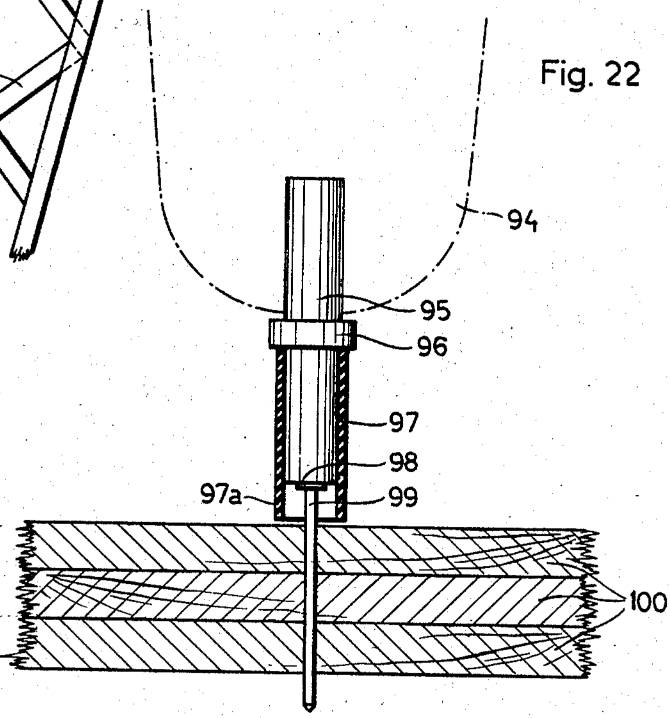


Fig. 22



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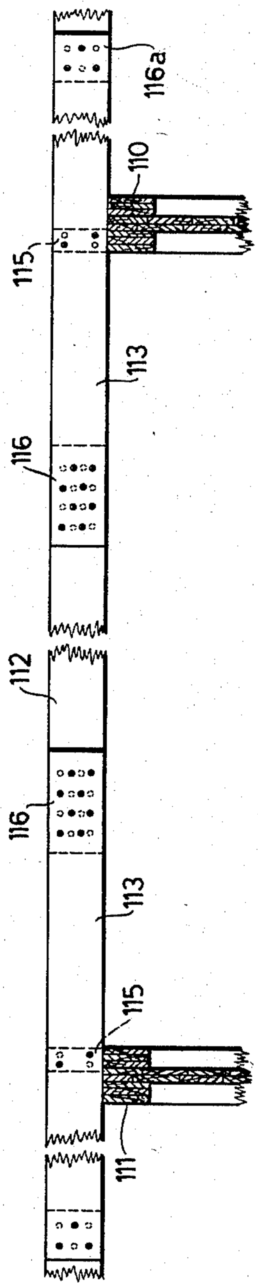

Fig. 23

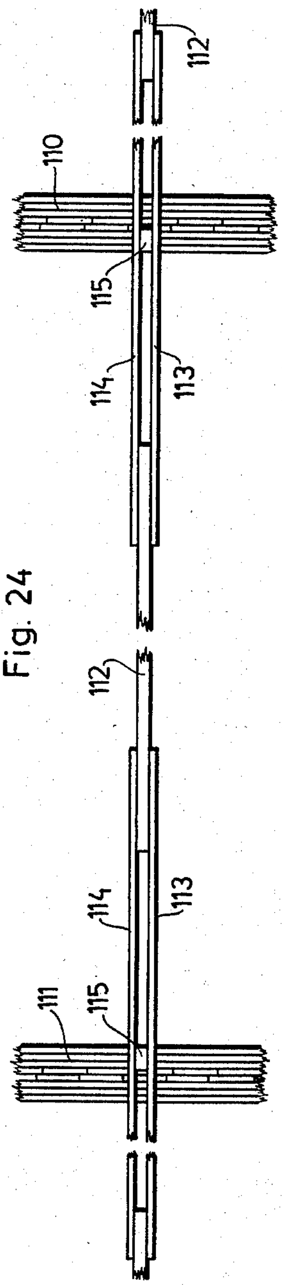

Fig. 24

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WOODEN BEAM CONSTRUCTIONS

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Application December 14, 1953, Serial No. 398,150

4 Claims. (Cl. 20—.5)

This invention relates to certain constructions of wooden beams which consist of a web of boards crossing each other diagonally and wooden flange laths or strips or frame-bars attached at the edges of this web by nailing.

According to a well-known construction said flange laths consist of ordinary solid timber which is normally to be had on the market in relatively restricted lengths. When using ordinary nails with relatively close nailing, which is often necessary for heavily loaded beams of the type now referred to, there is often the risk of splitting being caused in the rows of nails in the above-mentioned laths, resulting in a considerable reduction of the strength of the beam. This risk is particularly incurred since in beams of greater length the flange laths must be lengthened by joining further pieces of lath by means of nailing while using joint-pieces externally of the joint. In this case particularly close nailing and consequently long, and, as a rule also heavy nails or spikes are required.

The main object of the present invention is to eliminate the said drawback by providing means for making large and strong beams in a most simple manner, while at the same time avoiding overlapping unattractive joints for the flange-laths. The invention relates to the type of beams in which each flange is composed of two or more layers of boards (for example of about 1" thickness), which are glued together along vertical planes and in which these flanges are arranged in pairs on both sides of a web composed of at least two layers of boards crossing each other diagonally. According to one feature of the invention the flanges are attached to this web by means of wire nails, the diameter or edgeside of which is small in relation to the length of the nails as compared with nails now in use for corresponding purpose. Preferably, the thickness of the nails does not exceed about 1/30 or in extreme cases 1/25 of the length of the nails. The maximum diameter of the nail is for instance 0.25" to 0.30".

The boards in each layer of boards of the flanges are jointed longitudinally by means of glued oblique joints, hook joints, finger joints or such like. These joints are so arranged in the longitudinal direction of the flanges in relation to the joints in adjoining layers of boards that all joints in a flange will be distributed with approximate uniformity in the longitudinal direction of the flange. Also the nails by means of which the flanges are attached to the web of the beam are distributed substantially uniformly in the longitudinal direction of the flange. In this manner the nails will function as joint-nailing by successive transmission of load, and thus they will also serve as an additional safety factor for the individual layers of boards of the flanges, should the gluing between said layers or between the joints fail to function. Finally, the nails will also act to transfer all stresses appearing between the flanges and the web and between the web boards.

When timber of limited splitting resistance is used, beams with nailed flanges according to the invention have practically no disposition to split even with relatively close nailing of the flanges. They can therefore be loaded so as to take full advantage of the strength of the wooden

material used. This is due to a cooperation of several circumstances. In the first place the actual flanges acquire in themselves a considerable splitting resistance by gluing together several different layers of boards to one another as the fibres in the different layers of boards are never completely parallel but cross one another at a certain angle so that when they are glued they will "block" one another's fibres. The flanges thus acquire a considerably greater strength and splitting resistance than ordinary timber. Secondly, also the web boards extending at an angle to the flanges will contribute to an increased splitting resistance of the flanges. The parts of the web lying between the opposite pairs of flanges are not, however, blocked in the same way as the flanges by combining several layers. Splitting of the web boards can, however, according to the invention, be otherwise counteracted, namely by carefully arranging the boards of the diagonal panelling layers close together without any intervening space between the individual boards, whereupon nailing is effected right through the flange on one side of the web, then through both the diagonal panelling layers and, finally, into the flange on the other side of the web. The flanges extending in the longitudinal direction of the beam which are glued together by vertical layers of board, will in this way "block" the boards of the diagonal panelling which are laid close together and thus prevent splitting also in the web boards.

The nails which are thin relative to the length thereof and which are used for the flanges also result in a remarkable increase in the splitting resistance of those wooden sections which are nailed through to resist splitting, or vice versa, a considerable increase in the possibilities of performing close nailing will be obtained. This in turn represents a corresponding increase in the bearing capacity and strength of the beam.

Ordinary wire nails of round section are usually characterized by the cross dimension increasing with the length of nail, and this cross size is so great with the nail lengths which are suitable for nailing the flanges that the nail is very apt, especially with hard and strong kinds of woods, to cause splitting when the nailing is close. By way of example, the ordinary round wire nail with a length of 6" has a cross dimension of 0.26", and 8" round ordinary wire nails have a cross size of 0.33", whereas for nailed beams according to the invention the most suitable cross dimension for 6" nails is only about 0.20" and the corresponding cross size for 8" nails is about 0.24". I have found that the latter size should not be increased materially even if still longer nails than 8" be used. If the beam flanges are connected to the web with these nails which are thin in proportion to their length, I have found that the risk of splitting is reduced and the bearing capacity increased to a very high degree. In addition I have found that by using nails of one and the same quantity by weight, and consequently nails of one and the same cost, the bearing capacity of the nailed assembly increases, irrespective of the risk of splitting, according as the cross dimension of the nail decreases. The nailing according to the invention, with specially thin nails in relation to the length of nail, therefore entails decided advantages from several points of view.

One object of the invention is also to provide a further improvement of the splitting resisting property of the through-nailed beam portions by arranging the nailing according to a predetermined pattern. In this embodiment the nailing between flanges and web is arranged in longitudinal rows generally along the grain, the number of which rows may be increased successively in accordance with the increasing width of the flanges. The nails in each row are staggered at either side of the theoretical line of row at a small distance from said line as viewed in the transverse direction of the flange, and the nails in every second row are displaced at a distance approximately corresponding to half the space between the rows longitudinally of the flange in relation to the nails in adjacent rows. This arrangement results in several advantages. On the one hand, the geometrically simple and definitely fixed placing of the nails facilitates a rational construction and manufacture of the beam and, on the other hand, there are obtained no splitting releasing rows of adjacent nails in any direction. Finally, in nailing according to this pattern the flange nails are prevented from being located in oblique rows coinciding with the joints between the boards of the web, independently of the magnitude of the spacing of the nails. This is very important since otherwise a great number of nails could enter the joint between adjacent boards of the web so as to be more or less inoperative, thus resulting in a reduced strength of the beam.

A still further object of the invention is to effect the nailing by means of so-called grooved wire nails made of a material of a relatively high yield limit. I have found that nails of this kind have a smaller tendency of causing splitting in the wood than ordinary nails of square cross-section having the same edge dimensions. This is also true, to a still higher extent, in respect of round wire nails of the same bearing capacity. The grooves also cause that the nails will be reinforced at the four corners, thus resulting in an increased rigidness in relation to the consumption of material. The same remarks apply to the use of material having a high yield limit. A particularly high strength of beams according to the invention may be obtained if the nails used have small edge dimensions but are as rigid and resistive as possible to deformations when subjected to load perpendicularly to the longitudinal direction of the nail. In this connection a grooved nail made of a hard material or metal has been found to be particularly advantageous.

Some embodiments of the invention are shown in the accompanying drawings in which:

Fig. 1 shows an elevation of a portion of a beam according to the invention.

Fig. 2 is a cross section of this beam on the line II—II in Fig. 1, and

Fig. 3 is a longitudinal section of the beam on the line III—III in Fig. 1.

Fig. 4 shows a favourable pattern of nailing in the beam flanges according to Fig. 1 and

Fig. 5 shows, by way of comparison, how one type of a joint of the beam flanges has hitherto been made in a known manner with external joint pieces.

Fig. 6 shows, in elevation, a beam with a broken or angular outline composed of two individually straight beam sections, which are shown in detail in Fig. 7 when taken apart.

Fig. 8 shows on a larger scale a corner joint of such beam portions after being assembled, and

Fig. 9 shows a view of one of the beam portions on the line IX—IX in Fig. 7.

Fig. 10 is a similar view of the other beam portion, viewed on the line X—X in Fig. 7.

Fig. 11 is a side view of a piece of beam constructed according to the invention and having special web stiffeners.

Fig. 12 shows the same beam seen in cross section, on the line XII—XII in Fig. 11.

Fig. 13 shows an elevation, and Fig. 14, a cross section on the line XIV—XIV in Fig. 13, of a further embodiment of such a beam.

Fig. 15 shows an example of a known joint and Fig. 16 a joint according to the invention, between two individually straight assembled beams so as to form a combined beam with great bending strength and with an apex at the joint.

Fig. 17 shows on a larger scale, seen from the side, a joint-piece for this construction of beam, and

Fig. 18 shows a side view of the whole joint on the same scale.

Fig. 19 shows a plan view of the joint and

Fig. 20 is a cross section of the joint according to Fig. 18, viewed along the line XX—XX.

Fig. 21 shows an embodiment illustrating a modified use of the beam corner construction according to the invention.

Fig. 22 illustrates diagrammatically a view of a tool which may be used in the nailing operation.

Fig. 23 shows a side view of an embodiment of a purlin arrangement made according to the invention, and

Fig. 24 shows the same arrangement in top plan view.

In Figs. 1 to 3, **1** and **2** indicate the boards of which the web of the beam is composed and which are arranged in two layers crossing each other diagonally. When constructing and nailing the beam said boards are laid close together without any intervening space in order to ensure greater security against splitting of the web. Flanges **3**, **4** and **5**, **6** respectively, each consisting of at least two layers of laminated boards, for example *a*, *b*, *c*, mutually glued together are attached to the upper and lower edges of the web of the beam. Each such lamination consists in its turn of a number of boards jointed longitudinally. Fig. 3 shows some oblique joints **6*s*** shaped as hooks for the laminated boards *a*, *b*, *c* of flange **6**. It should be noted that in Fig. 3 the length of said hook joints are shown on a reduced scale in relation to the width of the boards.

The end of the beam is preferably fitted with vertical strips or laths. These strips as well as the horizontal flanges are attached to the web by means of nails **9**, **10** driven in alternately from both sides of the beam in such a way that they entirely penetrate the nearest flange (for example flange **5**) and both layers **1**, **2** of the diagonal panelling web, and partly penetrate into the other flange (for example flange **6**). According to Fig. 1 the nails which are driven in from the "front" of the beam are indicated by the symbol ".", and those nails which are driven in from the back of the beam are indicated by the symbol "$\otimes$".

Fig. 4 illustrates diagrammatically a favourable pattern of nailing in the flanges. The "theoretical" row lines are indicated at E, F, G and H. The spacing of the nails driven in from the same side of the flange is indicated at t. As shown in Fig. 4 the nails are displaced by the distance δ from the theoretical row line on either side of this line in the transverse direction of the flange. The distance between adjacent rows is indicated at r and it is seen that the displacement between the nails in the longitudinal direction of the flange in relation to the nails of adjacent rows is about

$$\frac{r}{2}$$

The arrangements according to the invention enable the manufacture of beam constructions which with many kinds of wood, such as Douglas fir, yellow pine etc. would not be possible to make in any other manner, at least not if the strength of the wood in the flanges is to be utilized to full extent.

Some of the advantages of the invention will be clear by a comparison with Fig. 5 which illustrates a known construction of joining ordinary solid flange strips or laths to stress transferring flanges of great length.

In Fig. 5 **21**, **22** indicate the two layers of diagonal panelling in the web of the beam to which flanges **23**, **24** of "solid" timber are joined. The flanges **23**, **24** are joined in a known way at transverse joints **23*s***, **24*s***. External joint-pieces **25**, **26** arranged on the outside of these joints, are joined to the ends of the beams to be jointed by means of nails **27**, **28** and at the same time transmit the forces which the joints **23*s*** and **24*s*** are unable to take. It should be observed that, in principle, joints **23s**, **24s** could be made as glued oblique joints in the same way as in the beam in Figs. 1 to 3, but in practice such a joint does not require anything like the same strength or reliability as when it is arranged according to Figs. 1 to 3.

The thickness of the flanges of the beam is the same in Fig. 5 as in Fig. 3 but yet there is required considerably longer and thus also heavier nails in the beam according to Fig. 5 than in the beam according to Fig. 3. The increased length of the nails in Fig. 5 and the resulting increase of the cross-section of the nail causes a considerably increased weight and cost of the nails required and also an increase of the splitting tendency of the jointed flanges and thus also a reduced strength of the latter. It should be noted also, that flange joints according to Fig. 3 have a considerably nicer appearance than according to Fig. 5.

When using especially hard or brittle timber the splitting resistance as a result of close nailing can, according to a further development of the invention, be increased in a high degree by special arrangements. Thus according to one form of construction the flanges are made of hard or high grade timber which is generally also characterized by great strength and is primarily ensured against splitting by gluing together, as described above, several layers of strips with partially crossing grains. The web boards, on the other hand, may be made of low-grade or less hard and less strong timber, full advantage being taken of the good nailing properties of the web boards. As a matter of fact the stresses in the web boards, which merely have to transmit the transversal forces (shear) in a beam of the present type, have been found to be of a lower magnitude than the axial and bending stresses in the flanges. As a rule such stresses are, at the most, about ⅓ to ½ of the stresses in the flanges which are decisive of the dimensions. Several advantages may be attained by using a combination of lower grade, but softer and tougher timber in the beam web, and high-grade or hard timber which is more inclined to split in the flanges. The advantages include a lower cost for the assembled beam, increased security against splitting for the web of the beam, and also a slightly lighter beam, and this is attained without the bending strength of the assembled beam being reduced as in first line this is determined by the high-grade timber in the flanges. It should be observed in this respect that the web boards in the present case have to take the relatively low stress right cut to the upper and lower edges of the beam, and in this respect distinguish considerably from, for example, so called "glued laminated beams" in which the stresses in the entire beam section increase continuously from the central section towards its edges.

The web may also be made of boards of different kind of wood but having mutually the same thickness. Boards of wood having high strength, particularly a high strength to the local pressure from the nails, are placed in those portions of the web of the beam (usually in the vicinity of the supports of the beams) where the transversal forces are great while the remainder of the web of the beam is made of timber having the lower strength. A combination of this kind enables a further increase of the strength and a reduction of the costs for the timber required for the beam, and also a favourable contrast effect, for instance between timbers of different colours.

As an example of suitable embodiments according to the invention I may mention beams having flanges of Douglas fir of higher strength quality and webs of Douglas fir of a lower strength quality, further, beams with flanges of Douglas fir and web of spruce, and also beams with flanges of Douglas fir, web of Douglas fir in the vicinity of the support of the beam and web of spruce in other parts of the beam. Of course, the beams may also be made entirely of the same kind of timber and also of other timber classes than those now mentioned, for instance, of hemlock, yellow pine and other timbers which can be nailed.

In the web of the beam according to the invention I may use short pieces of boards (having a length of for instance 4′–8′), which often are obtained as a kind of inferior by-product in the production of ordinary saw timber dimensions. In this manner an essential part of the timber required for the construction of the beam may be obtained at an extremely low cost which as a rule is not possible in other types of supporting wooden constructions of the class now described.

The invention also allows for an arrangement for connecting two beams of the type in question in a bending resistive manner at angles to each other. Such bending resistant "beam corners" occur in many types of constructions, such as frame constructions, arches, beams with broken outline etc. It is also possible by means of the invention to produce simply and cheaply larger frame and arched structures of such a nature on a factory-scale, such structures being too bulky to transport fully assembled. They can, however, made in accordance with the invention, be transported as separate, straight and easily transportable parts which on the building site can be assembled to the frame corners etc. which have a good strength to bending stresses and which are required for the stability of the built-up supporting units. A remarkable advantage of the invention is that the joint at an angle between two parts of the beam can be carried out on the building site solely by means of nailing. Then again the bend-resisting bonds according to the invention can be made with the same resistance to bending stresses as both the connected beam sections individually, and this can be made without the dimensions of the corner joints being larger than those of the respective beam sections.

A construction of the kind above indicated is illustrated in Figs. 6 to 10 showing that of the two beams I and II which are to be interconnected in a manner enabling great resistance to bending stresses one beam I at one end is constructed as a stiff plate which is resistant to bending stresses in all directions of the plane of the beam and is in the form of a quadri-lateral **S**. This stiff part is formed by the part of the web of double diagonal panelling **51**, **52** of beam I within the said quadrilateral, also of parts of flanges **53**, **54** of beam I which are arranged within said quadrilateral, and, finally, of one or more special transversals **55** and, if desired, **56** arranged between the said flanges **53**, **54** and extending in the same direction as the flanges of the second beam II. Then again beam II is equipped with freely protruding fork-shaped flanges **59a**, **60a** which at the building site are mounted so as to embrace the said transversals **56** and/or **55** on both sides of beam I. Flanges **59a**, **60a** of beam II are then connected to transversal **55** or transversals **55**, **56** of beam I together with the diagonal panelling of the latter beam. Simultaneously the transversals for beam I are also connected to the web of diagonal panelling of the same beam by nailing through the flanges, transversals and the web of the beam. This is done with nails the edge-side of which is small, normally about $\frac{1}{30}$ or in extreme cases $\frac{1}{25}$ of the length of the nail, similarly to what has been set forth above.

According to Figs. 6 to 10 beam I thus consists of a web of diagonal panel boards **51**, **52** and flanges **53**, **54** which are joined to the web by nailing, and extend along the whole length of the web. The transversal **55** or transversals **55**, **56** are also connected to the web. Of these, transversal **55** should have the same thickness as flanges **53**, **54**, whereas transversal **56** can be thinner or be omitted by being substituted altogether by flange **59** in beam II. Transversal **55** or transversals **55**, **56** in Fig. 7 are appropriately only connected with a relatively few "retaining nails" to beam section I when the beam sections are being manufactured at a factory.

The sections of the diagonal panel boards of beam I enclosed within the quadrilateral 53, 55, 54, 56 should preferably be parallel to both the respective diagonals of the quadrilateral. In the remaining part of beam I, however, the direction of the diagonal boards can be adjusted, if desired, by separate oblique boards so that both layers of the diagonal panelling slope or incline equally to the mean longitudinal direction of the beam.

Beam II also consists of a web of diagonal panel boards 57, 58 with flanges 59, 60 and preferably with a lath or strip 61 which forms a terminal or termination for the diagonal web 57, 58. This last mentioned web terminates along line *a—a* in Fig. 6, corresponding to the other edge of flange 54 in beam I in the assembled structure. The flanges 59 and 60 continue with their outer ends in fork-shaped extensions 59*a*, 60*a* (Fig. 7). The lengths of these latter are adjusted so that when the forks are disposed along the respective transversals 56 and 55 at beam I they reach the outer edge of the outer flange 53 of beam I. It must also be taken into consideration in this connection that the mutual free distance (in the transverse direction of the beam) between flanges of the same pair of flanges, for example 60*a*, shall be so adapted (by a suitable design of the flanges, Fig. 9) that when the "flange forks" 59*a*, 60*a* of beam II are disposed along the transversals 55, 56 of beam I no substantial clearance will arise between connecting parts of beams I and II. When beams I and II have thus been placed together nails (the thickness of which, in similarity with the nailing of the flanges, shall be small in relation to the length of the nail) shall be driven right through flange forks 59*a*, 60*a* and into transversals 55, 56 together with the intermediary parts of the diagonal panel webs 51, 52. As a rule the flange portions 54 and 61 of Fig. 8 should also be interconnected for transferring transversal shear which can be effected by connecting a plate of thick plywood or of double diagonal panelling to the parts 54 and 61 by means of nails.

It has been found that if the nailing between the "flange forks" of beam II and the transversals of beam I is carried out approximately as closely as the nailing between the flanges and the web, the connecting arrangement now described between two beam sections which form an angle can transmit bending moments and normal forces which correspond to full utilization of the strength in the beam sections outside the corner joint.

It is also an object of the invention to make possible the production of specially deep, or highly loaded, beams having webs of two layers of diagonal panel boards while using thin boards (for example 1″) without the web of the beam acquiring any tendency to buckle laterally. To this purpose there are arranged on each side of the web of the beam, pairs of laths or strips which are weak in relation to the flanges. Said strips extend mainly parallel or at right angles to the beam flanges. The strips which are parallel to the flanges are placed so that they divide the free height of web between the inner edges of the flanges into two or more partial heights. Nails are then driven in from both sides of the beam through the said strips, further right through the web of the beam and, finally, through part of the opposite strip. Opposite strips of the same pair will now become mutually anchored to each other so as to resist stresses and this is made possible by interconnecting the strips through the beam web by the nails which are driven in from both sides. It is advisable, however, to prevent the nailing from penetrating to the outer edge of an opposite strip. In this manner every pair of opposite strips hereby will receive a rigidity and strength which is many times greater than the rigidity and strength of the individual lath or strip. At the same time the pairs of strips thus mutually interconnected will join together both layers of the diagonal panelling of the diagonal panel beam effectively. Of both these layers the boards of one layer are normally exposed to tension stresses throughout their entire length, thereby automatically tending to keep straight, whereas the boards of the other layer are exposed to compression stresses which tend to buckle the last mentioned boards sideways or laterally. It has now been found that the coupling of the boards, subjected to compression stresses, to the boards subjected to tension stresses, by the medium of, and under cooperation with the interconnected pairs of strips as described above greatly increases the buckling strength of the diagonal panel boards.

According to a modification of the invention the laths or strips nailed together in pairs are arranged in a direction at approximately right angles to the beam flanges instead of parallel to them. They are placed between the inner edges of the beam flanges at a mutually free distance which is less than the free height or depth of the beam web (that is the height between the inner edges of the beam flanges). According to still another modification a series of pairs of strips or laths arranged at right angles to the flanges can alternate with pairs of strips of laths arranged on certain lengths of the beams and parallel to the flanges. In doing so I prefer to use the first-mentioned type when the transversal force in the beam is relatively great, and the last-mentioned type when the said force is small.

Some embodiments of the invention according to the construction now indicated are shown in Figs. 11–14. The beam shown in Figs. 11 and 12 comprises a web of diagonal panel boards 61*a*, 61*b* having flanges 62, 63. On account of transversal forces in the beam, for example, the panel boards 61*a* are compressed and the boards 61*b* are tensioned in a certain part of the beam. Laths 64*a*, 64*b* are arranged on both sides of the web. They are interconnected in pairs through the web by means of nailing 65 of the character described.

Figs. 13 and 14 show another arrangement of the web stiffeners. Here also 61*a*, 61*b* indicate the beam web, and 62, 63 the flanges. In this case the web on the left part of the beam, according to Fig. 13, is reinforced or stiffened by means of vertical laths 66 intercoupled in pairs on both sides of the web by means of nails 67 of the character described. The right hand section of the beam is fitted with web stiffeners 68 of the same type as 64*a*, 64*b* in Fig. 11. It can be pointed out here that it is also possible, and often appropriate, to combine web stiffeners of the type shown in Fig. 11 with the type shown to the left in Fig. 13 by using the first-mentioned type in beams subjected to relatively small shearing forces and the last mentioned type in beams subjected to large shearing forces.

The invention also has the object of rendering possible interjoining of short beam elements into very long beams at the building place simply by nailing. In this respect the principle of joining flanges to such beams is in itself known according to the method shown in Fig. 15, that is with superimposed joint-pieces 90 of the same strength as the jointed flange 91. Apart from the fact that such a joint looks clumsy it is not possible either to obtain any great strength as the long, and consequently also heavy, nails 92 which are required for such a joint are inclined with the close nailing to split the timber in the joint pieces 90 and flanges 91. This applies particularly to heavier loading. These drawbacks are eliminated according to one embodiment of the invention by interjoining two beams in a bending resisting manner by connecting their flanges by means of joint pieces, consisting of interglued boards of mainly the same thickness as the boards in the flanges which are to be jointed, the joint pieces being connected to the corresponding beams by nails of the character described. Said boards are also so arranged as to always be connected to another board by means of gluing, whereby there is obtained a high resistance to splitting in through-nailing.

An embodiment of this kind is illustrated in Figs. 16–20 which show the interjoining of two individually straight beams A and B to a single beam having good resistance to bending stresses and forming an apex at the joint. By interjoining two beams in this way (which can be done at the building place), several advantages are gained. Firstly, the transport of large beams is considerably facilitated by only necessitating transportation of individually straight and relatively short beam sections A and B. Secondly, the jointing arrangement also makes it possible to produce roof girders with a relatively slight slope on both sides (the arrangement shown in Figs. 6–10, on the other hand, is most suitable for joining beams with a greater angle between the beams). On the other hand, the necessity of jointing a roof girder according to Figs. 16–20 in its middle section where the stress is greatest naturally places great demands on the strength of the joint.

Beam A consists of a web **71** with flanges **72, 73,** and beam B consists of a web **74** with flanges **75, 76.** Flanges **72** and **75** are jointed by means of joint pieces **77** and the flanges **73, 76** are jointed by means of joint pieces **78.** Beam webs **71, 74** are jointed by means of special joint pieces **79.** Figs. 17 and 18 show details of joint piece **77** seen from the side, and Fig. 19 the same joint piece seen from above, though only for one half of the beam flange (on one side of the symmetry line of beam **80**). Each of the flanges **72** and **75** which are to be jointed consists, for example, of three layers of boards **72***a*, **72***b*, **72***c* and **75***a*, **75***b*, **75***c* respectively. The corresponding joint piece **77** likewise consists of three layers of boards **77***a*, **77***b*, **77***c* each of the same thickness as the layers of boards in the flanges. The joint piece **77**, however, can in addition be provided with still another layer of boards **77***d*. This can be considerably less thick than the other layers of the joint piece. All layers *a, b, c, d* are mutually interglued and thereby block one another against the risk of splitting in close nailing because of the dissimilar fibres in the layers. When jointing flanges with a smaller or larger number of layers of boards than the number shown in Figs. 19 and 20, the number of layers in joint piece **77** is reduced or increased to the same extent as in the flanges.

In the joint-piece **77** in Fig. 19 the layer **77***a* can be regarded as joining material for the layers of boards of flanges **72***a* and **75***a*; the layer of the joint piece **77***b* can be regarded as joining material for the flange layers **72***b* and **75***b*, and the layers **77***c*, **77***d* can be regarded as joining material for the flange layers **72***c* and **75***c*. The joint piece **77** is connected to flanges **72** and **75** by means of nailing, if desired in combination with gluing. The lengths *ef, fg, gh,* in Fig. 19 are adjusted so as to allow space for the number of nails required to transmit the force in flange section **72***a* to flange section **77***a* of the joint piece, and to provide on the distance *fg* a corresponding space for nailing the joint between flange layer **72***b* and the layer of the joint piece **77***b*, etc.

The joint-piece according to the invention has several decided advantages as compared with the known lapping joint shown in Fig. 15. Thus the length of the requisite joint nails, and consequently also their heaviness, is thus considerably reduced. The cost of nailing is hereby reduced, and the risk of splitting is reduced, the strength of the joint thus being increased. Finally, the joining pieces **77, 78** according to the invention (Figs. 17, 18) acquire a much more attractive appearance than the superimposed joining piece **90** shown in Fig. 15.

Joining pieces according to the invention can also be used to interjoin short beam pieces so as to obtain continuous straight beams of great length. Irrespective of transport difficulties beams of practically unlimited length can be produced by nailing at the building place short beams which are factory made but transportable. In such a case the joint pieces are made of uniform width in contrast to the joint piece with broken outline shown in Fig. 17.

The invention also comprises an arrangement for joining the web when interjoining two beams to form a single beam, which shows great resistance to bending stresses. According to this arrangement the web of both beams is provided, at the joint, with laths extending in the longitudinal direction of the joint. These laths are united with corresponding laths in the associated beam by means of joining plates of thick plywood, for example or by double layers of boards mutually interglued temporarily and crossing one another diagonally. Such joining plates are fixed by nailing to the aforesaid laths and the internal webs.

An embodiment of this kind is shown in Figs. 18 and 20. Each beam web **71** and **74** of the beams the webs of which are to be interjointed consists of two layers of boards **71***a*, **71***b* and **74***a*, **74***b* respectively, arranged diagonally. Close to the joint each web is terminated by laths **81***a*, **81***b* and **82***a*, **82***b* respectively, which are provisionally fixed to one another and to the respective beam webs by spaced nailing **83, 84** of the character described. Said laths are finished before the joining, for example when the beams are made at the factory.

For the joint I use joint plates which if desired can be made of thick plywood though I prefer to make them, for example, of two layers of diagonal boards **85***a*, **86***a* and **85***b*, **86***b*, respectively, which are provisionally glued together. The joining plates are connected at the point of assembly to joining laths **81** and **82** of both beams by nailing. This is done with nails of the character described. The intergluing between both layers of the diagonal panelling of the joining plates cannot be expected to hold in the long run because the fiber directions of the glued, relatively thick layers of boards cross one another at right angles, or almost right angles. The gluing in question has therefore been indicated here as being provisional. Nevertheless the gluing is of great importance since when the joining plates are carefully stored until they are ready for assembly the gluing causes both layers of boards to interlock in the close nailing made on assembling by means of the plates. As a result of this interlocking effect such close nailing can be carried out without any risk of splitting of the individual boards of the joining plates. It is true that this gluing loses its strength after some time, but the joining plate is nevertheless found to retain its anti-splitting capacity. This appears to be due to the wood of the plate adjusting itself plastically to the nailing in time, but such adjustment cannot take place already when the momentary assembling nailing is made.

Fig. 21 shows an embodiment of the invention in which the quadrilateral **S** according to Fig. 7 is arranged at the joint between a lattice-girder **90** and a beam **91.** In the beam **90** the web is substituted by separate diagonals or laths **92, 93** connected to the wooden flanges of the beam. The quadrilateral **S** is made of two layers of diagonal boards with nailing substantially as described with reference to Figs. 6 to 8. Beam **91** may or may not have any diagonal panel web between its wooden flanges.

In many cases it is not economical to effect the nailing according to the invention manually but by means of a tool, for instance by means of a percussion tool operated by compressed air or by other means. A special tool has been developed to this purpose and is shown diagrammatically in longitudinal section in Fig. 22. It comprises a percussion tool **94** of ordinary type having a cylindrical pin or bolt **95** which is operated by compressed air in known manner so as to perform a percussion movement. The pin **95** has an enlarged head or flange **96** serving as an abutment for a sleeve **97** of rubber, plastic or other elastic but not too soft material. The sleeve **97** is extended slightly at **97***a* beyond the free end **98** of the bolt **95** which is adapted to engage the head of the nail **99** so as to drive the latter into the wooden pieces **100**, for instance the flange strips of the beam described, on operating the percussion bolt **95.** One function of the rubber sleeve **97** is to guide the bolt **95** so as to prevent it from sliding off the head of the nail 99 during the percussion operation. Another remarkable effect of the rubber sleeve 97 is due to its extension 97a which for instance has a length of about 10 mm. When the tool is caused to engage the head of the nail and the compressed air is supplied the said extension 97a will be compressed according as the percussion tool is acting to drive the head of the nail into the wood so that this sleeve will protect the wood around the head of the nail from being damaged by the tool, yet without preventing said head from being driven in close to the wooden surface.

The invention also includes a favourable construction of a purlin or joist of a roof with the use of nailing of the character described. Figs. 23 and 24 illustrate an embodiment of this kind. In these figures 110, 111 indicate two roof beams or trusses, for instance constructed in accordance with any of the embodiments now described. On the top of said trusses the purlins which carry the roofing (boards, sheet metal etc.) extend transversely to the longitudinal direction of trusses. In many cases the purlins now in use are made in the form of separate beams of solid timber or lumber having substantially the same length as the space between the trusses, and freely supported by said trusses, but the purlins may also be made continuous, for instance by causing the purlins to overlap one another on the trusses. However, this last mentioned construction necessitates the use of purlin beams having a greater length than the space between the trusses and the consequence of this is that rather great timber lengths are required for the purlins. It is often difficult to obtain timber of sufficiently great lengths if the space between the trusses is great and in any case the costs will increase with increasing lengths of the timber. This disadvantage is very serious since for other reasons it is desired to arrange the trusses at so great a distance as possible from one another so as to reduce the number of trusses for a given roof area. On the other hand continuous purlins or joists have the advantage of providing a more favourable distribution of the moments and a reduced bending than freely supported purlins having a span equal to the space between the trusses.

Now, according to the invention there is provided an arrangement which enables obtaining a favourable distribution of moments simultaneously with the great economy of material inherent with the continuous purlins, yet without necessitating great length of the timber or lumber, and which, in addition, enables an adjustment of the cross-sectional area of the purlin to the bending moment. A combination of these advantages results in a very remarkable economy of material in relation to the ordinary type of purlins which are laid freely between the trusses. The saving of the volume of material is theoretically about 50%, and since it is possible to utilize rather short lengths of timber the costs per unit of volume will be low.

As illustrated in Figs. 23 and 24 these advantages are gained, according to the invention, by using wooden purlin elements 112 of shorter length than the distance between the trusses or beams 110, 111, such short elements being lengthened by a pair of double wooden pieces 113, 114. The single wood piece 112 is arranged in the central part of the field between the supporting trusses 110, 111 and the double wooden pieces 113, 114 are arranged on the top of the supporting trusses. Each pair of wooden pieces 113, 114 is adapted to receive the respective end of the purlin element 112 in a fork-like manner between the individual wooden pieces of each pair as shown in Fig. 24, so that the end of the element 112 will overlap the ends of the pieces 113, 114. To this purpose the wooden pieces in each pair are spaced at a distance corresponding to the width of the intermediary element 112. If desired, spacers 115 may be arranged between the wooden pieces 113, 114 and fixed thereto by means of nails. The purlin element 112 is

joined to the double wooden pieces 113, 114 by nailing 116 which is to be dimensioned so as to bear the moment stresses and thus render the joint resistive to bending stresses. The nailing joints 116 should preferably be placed at such a distance from the supporting means 110 or 111, that the bending moments at the place of the joint will be as small as possible. As shown at 116a, the nailing for every second purlin 112, can be made in a more simple manner so as to bear the shear stresses only. In this case the joints will be made as articulations. It is easily seen that this arrangement renders it possible to adjust the distance of the joints 116, 116a from the support on the trusses 110, 111 and to adjust the distribution of the moments on and between said supports so as to utilize the strength of the wooden pieces 112—114 in an extremely advantageous manner.

If a tendency of splitting should arise at the places of nailing 116, 116a metal sheets may be interposed between the overlapping wooden parts and the nails are driven through these sheets and into the wooden parts.

The pairs of wooden pieces 113, 114 may be attached to the trusses 110, 111 by means of oblique nailing, for instance.

At the ends of the roof the free ends of the purlin elements 112 may rest on suitable supports without any lengthening arrangement 113, 114, if desired.

What I claim is:

1. A wooden beam construction comprising a web of at least two layers of boards disposed in each layer in edge to edge relation to each other and with their lengths in angular relation to the lengths of the boards in the other layer, said lengths in each layer extending diagonally with respect to the length of the beam, flange members of wood disposed with the lengths thereof generally parallel to the grain extending along the respective opposite lengthwise edge portions of the beam at opposite faces of said web, each flange member comprising at least two boards in laminated face-to-face relation to each other and to said web at the adjacent face of the web, and nails driven through the boards of the respective flange members into said web, said nails being disposed in a plurality of rows lengthwise of said flange members and staggered in each row with respect to the general line of the grain of the wood of said flange members, said nails being disposed in groups along said rows with the nails that are disposed in adjacent rows staggered in relation to each other along respective lines transverse to said rows, said lines being spaced along said rows, the spacing in each group between the nails staggered along the transverse line of said group being approximately ½ the spacing between said adjacent rows of nails.

2. A wooden beam construction as defined in claim 1 in which all of the nails of a given group are at the same side of the respective lines of the rows, the nails of two adjacent groups along the flange member being disposed at opposite sides of the respective lines of the rows.

3. A wooden beam construction as defined in claim 1 which comprises wooden strips disposed in face-to-face relation to the respective faces of said web and extending with their lengths in registering relation to each other over a portion of the extent of said web between said flange members and generally parallel to said flange members so as to divide the space between said flange members into at least two portions extending longitudinally of the beam.

4. A wooden beam construction as defined in claim 3 in which additional strips in face-to-face relation to the respective faces of said web extend transversely of said flange members so as to divide the space between said flange members into portions spaced longitudinally along the beam.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

2,064,939	Nutt	Dec. 22, 1936
2,234,448	Prosnack	Mar. 11, 1941
2,385,142	Lank	Sept. 18, 1945
2,389,944	Winkel	Nov. 27, 1945
2,390,180	Sahlberg	Dec. 4, 1945
2,433,677	Thomas	Dec. 30, 1947
2,541,784	Shannon	Feb. 13, 1951
2,607,959	Brosenius	Aug. 26, 1952

FOREIGN PATENTS

108,235	Sweden	Aug. 17, 1943
111,493	Sweden	Aug. 15, 1944
111,712	Sweden	Sept. 5, 1944
114,478	Sweden	July 10, 1945
124,866	Sweden	Mar. 10, 1949