April 27, 1965 H. H. WEBBER ETAL 3,179,983

STRUCTURAL UNIT OF RECONSTITUTED AND REINFORCED WOOD PRODUCTS

Filed Aug. 10, 1962 2 Sheets-Sheet 1

FIG. 1.

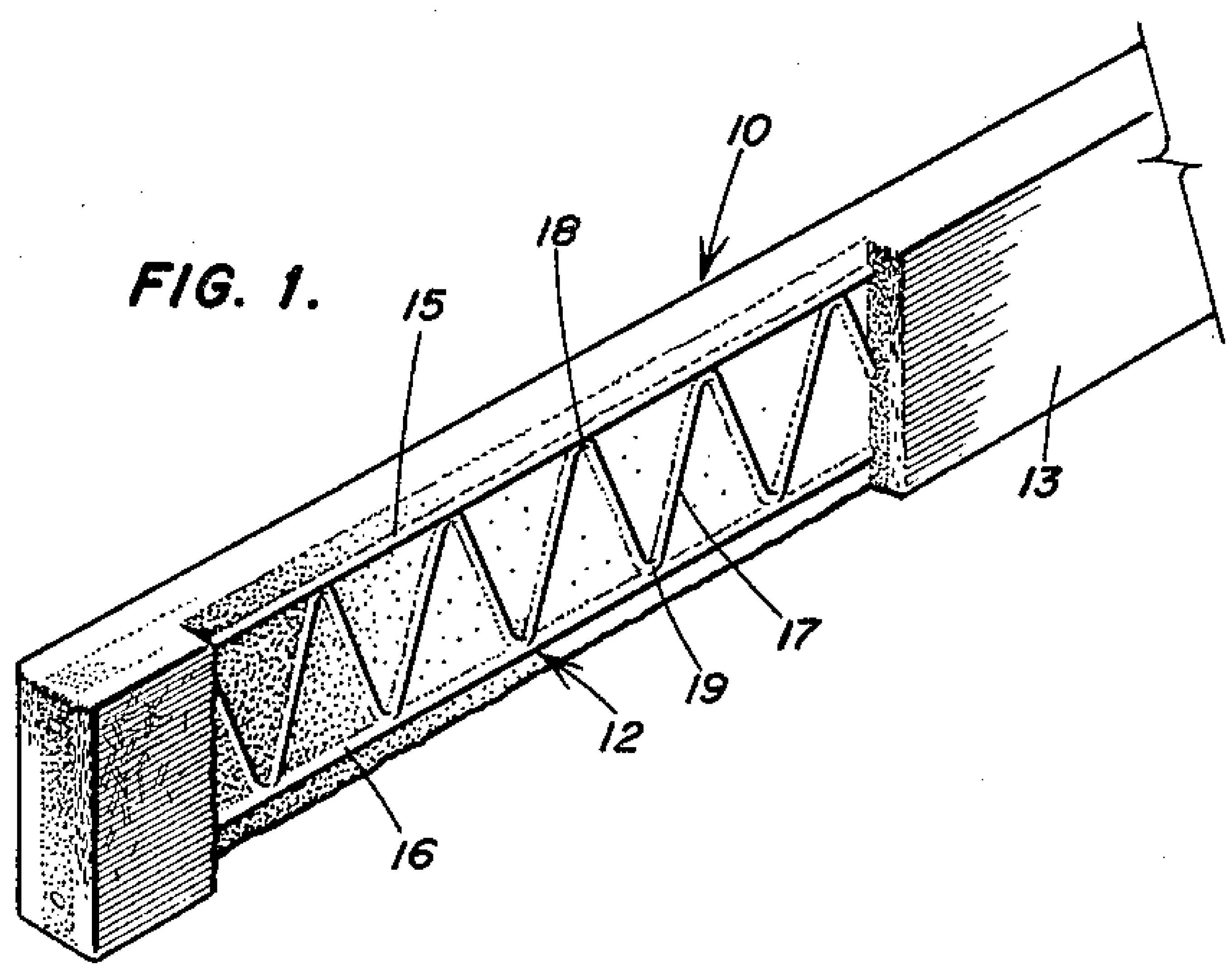
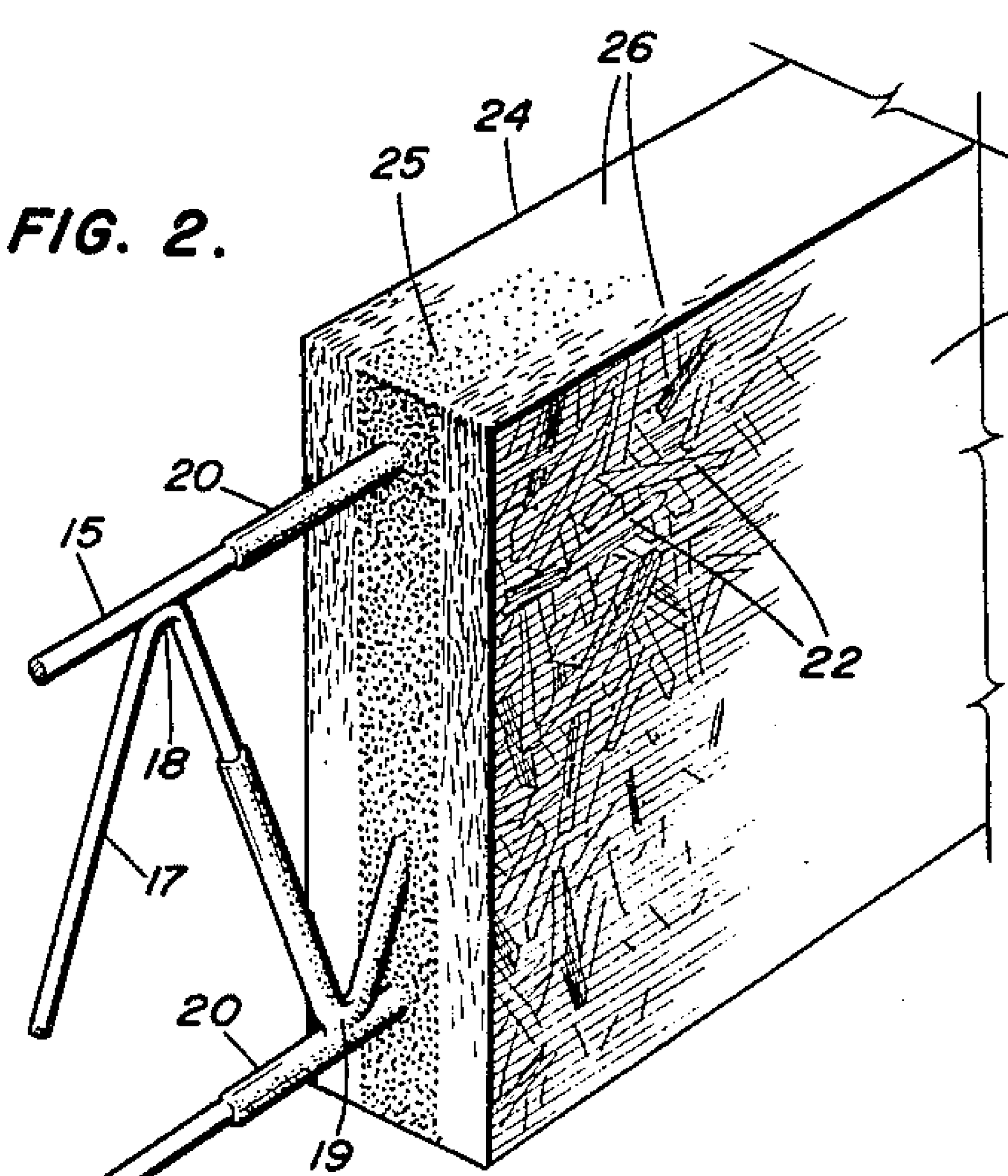


FIG. 2.



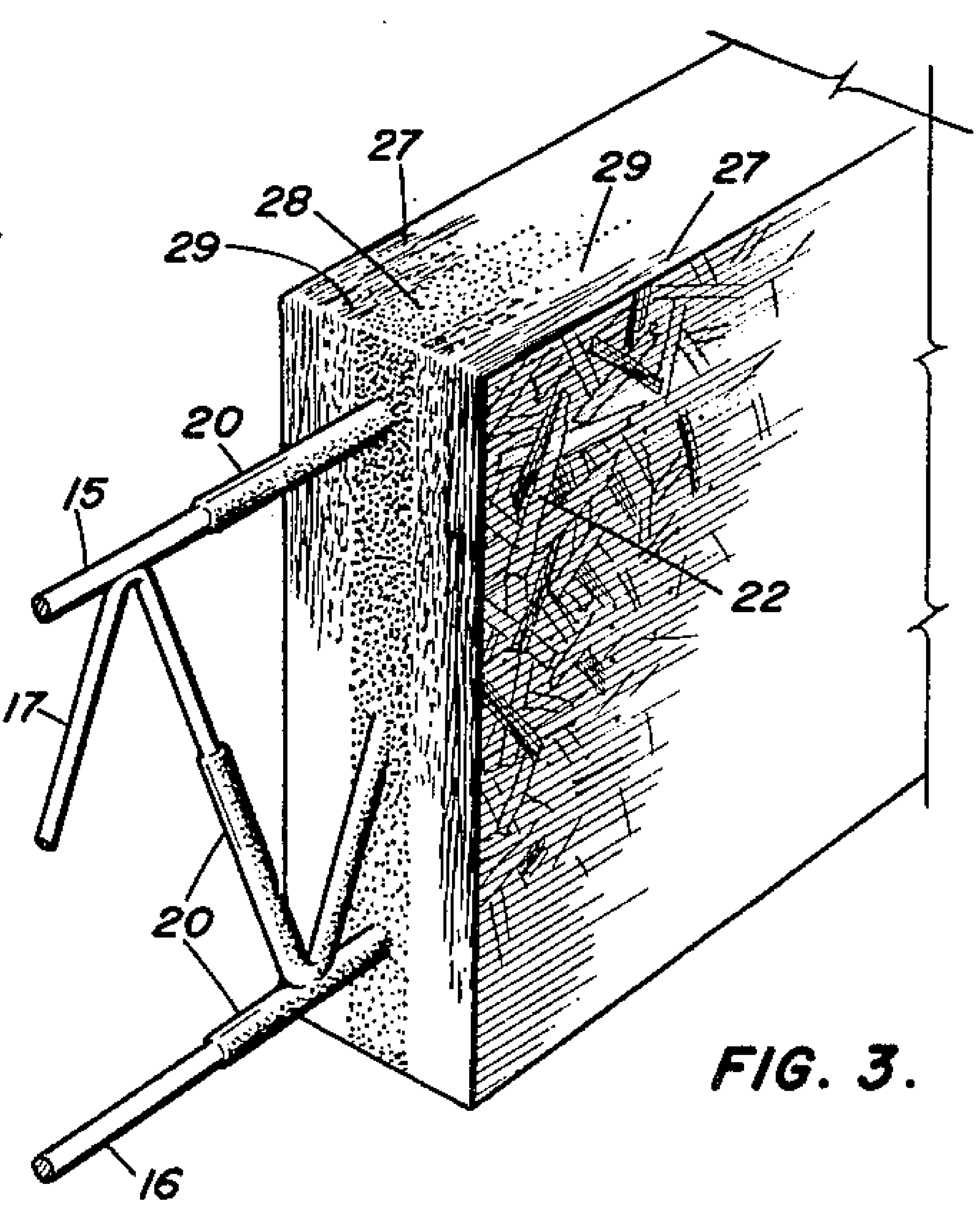


FIG. 3.

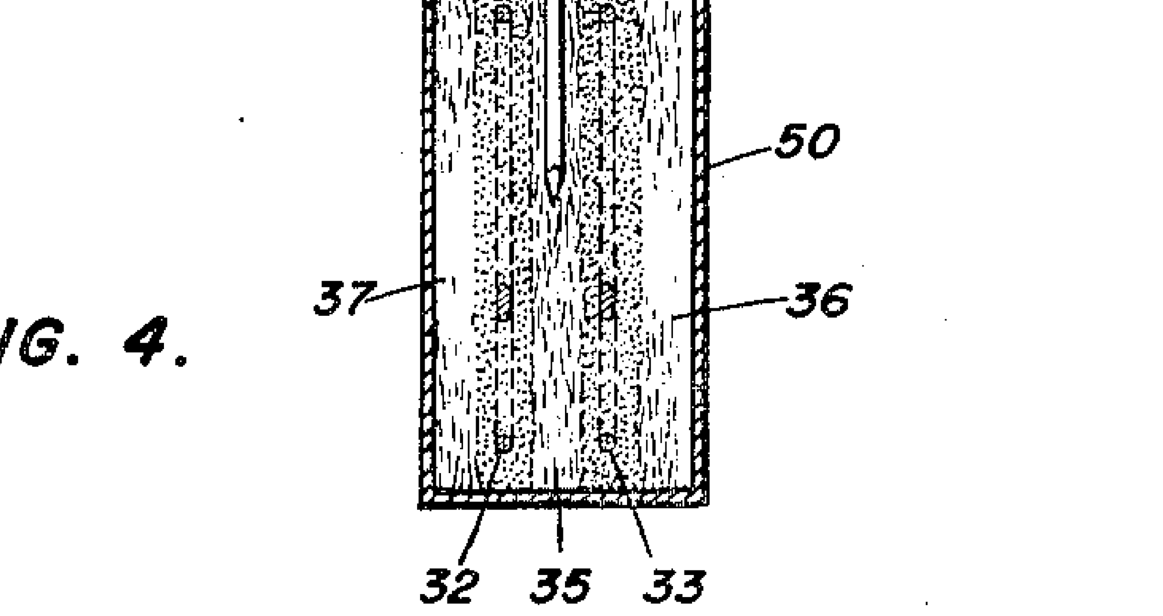


FIG. 4.

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STRUCTURAL UNIT OF RECONSTITUTED AND REINFORCED WOOD PRODUCTS

Filed Aug. 10, 1962 2 Sheets-Sheet 2

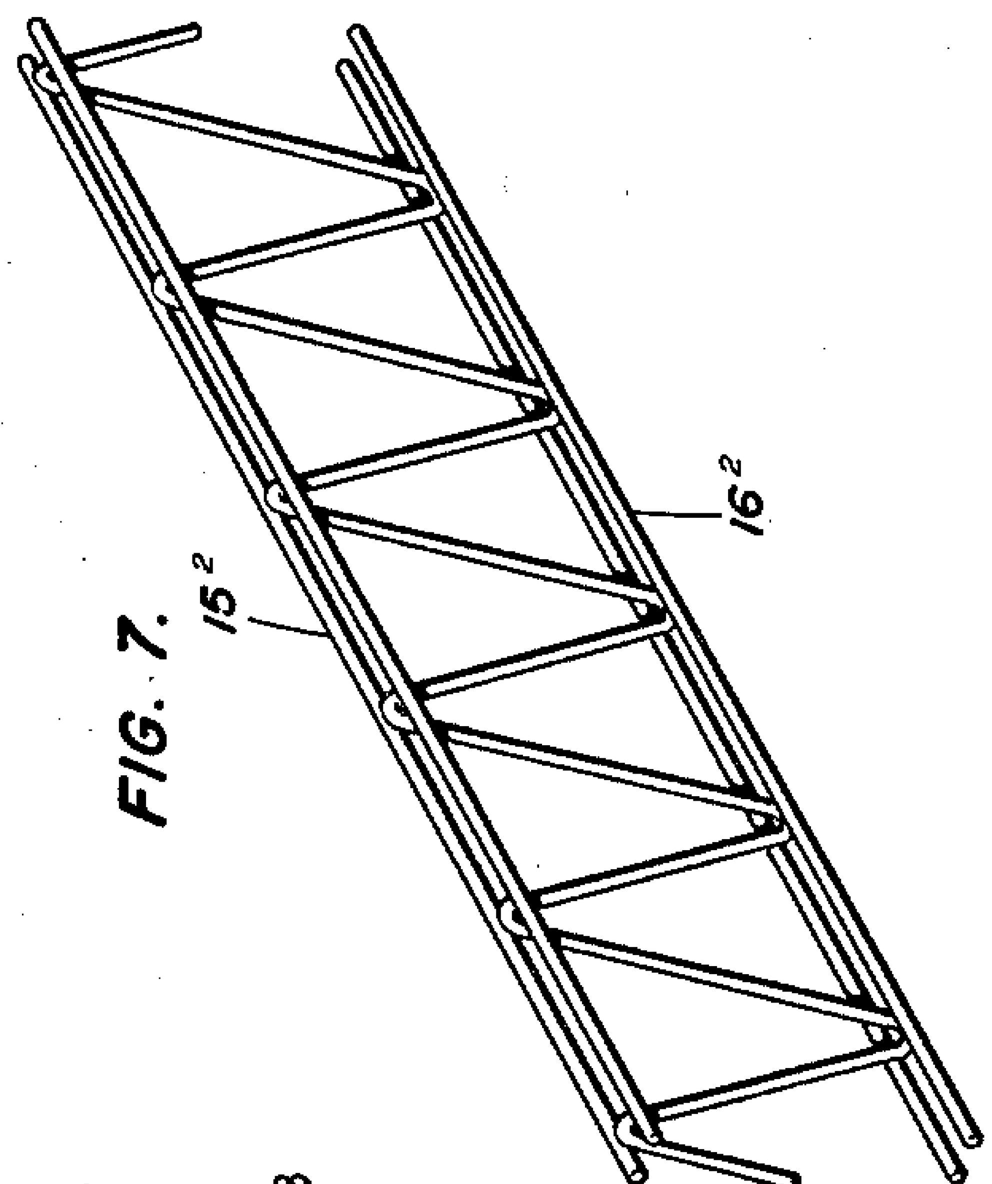

FIG. 7.

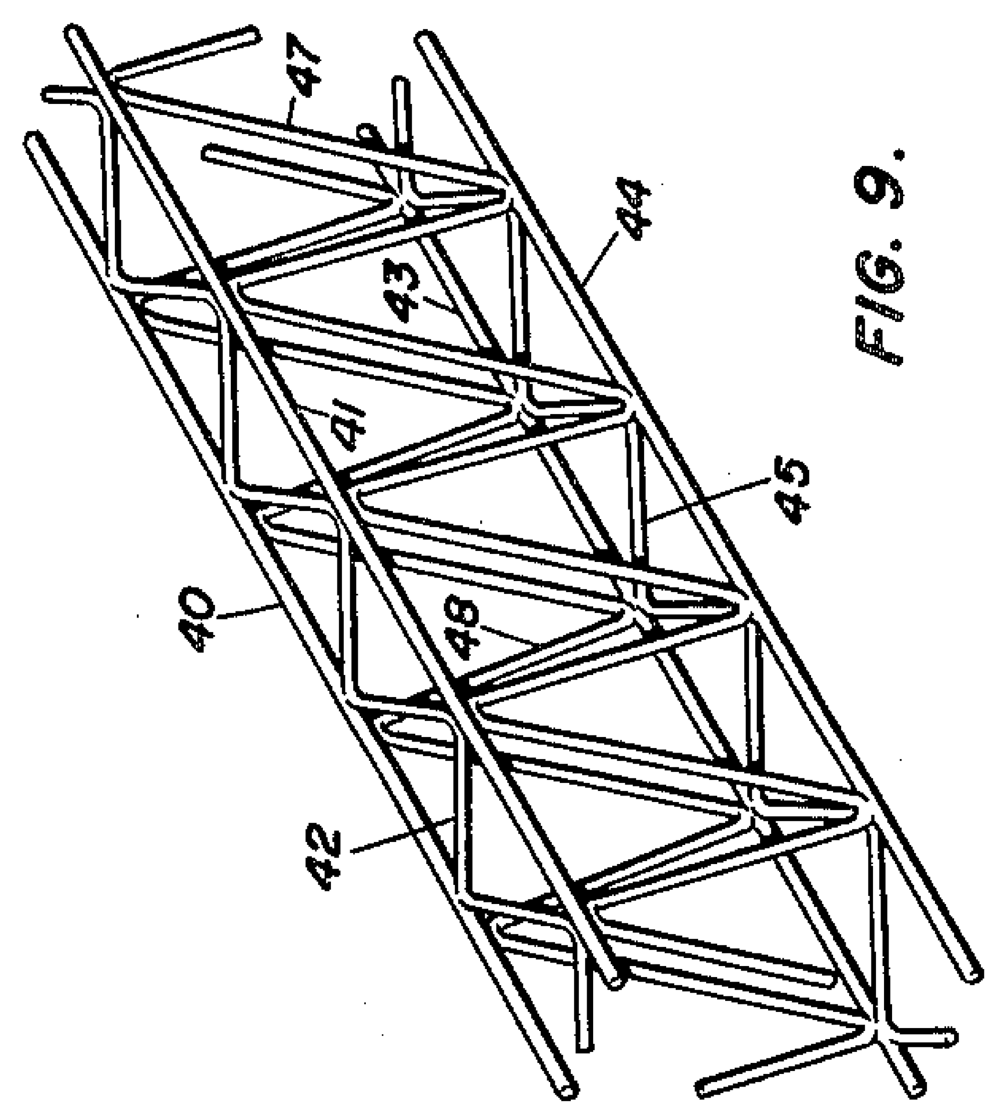

FIG. 9.

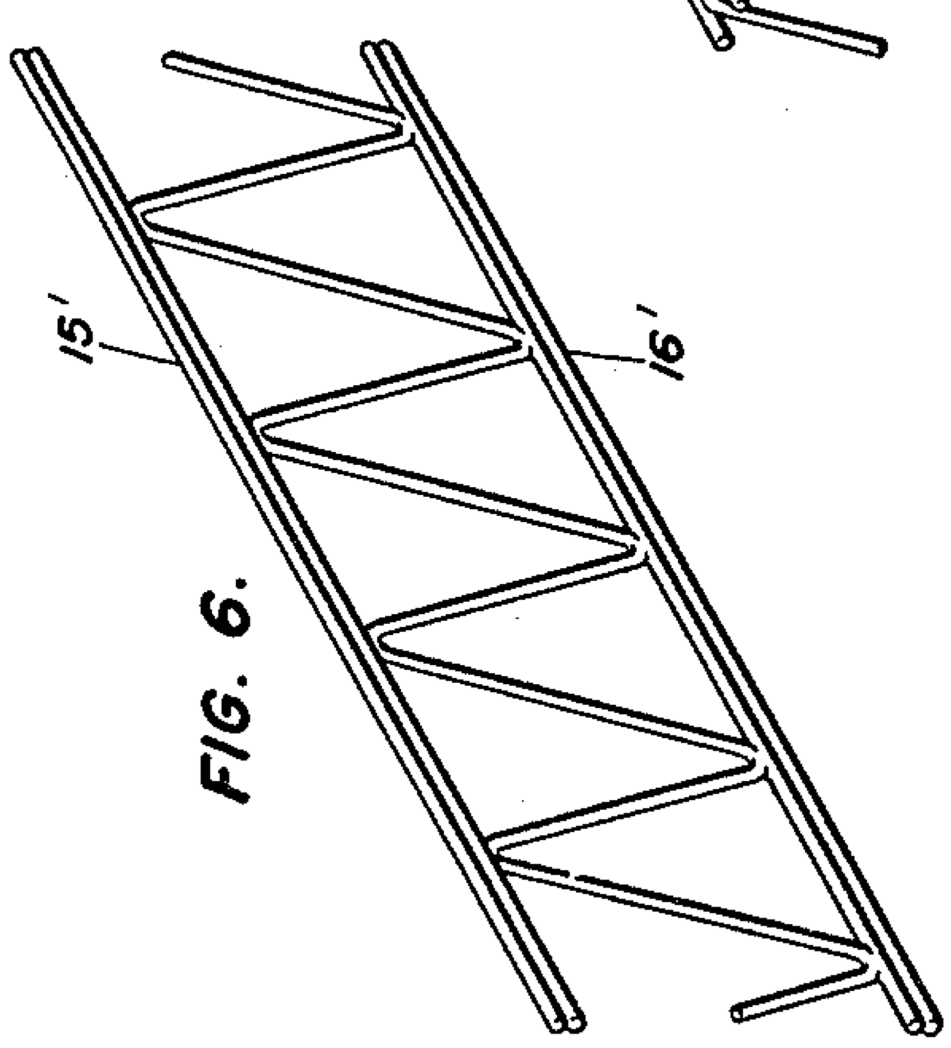

FIG. 6.

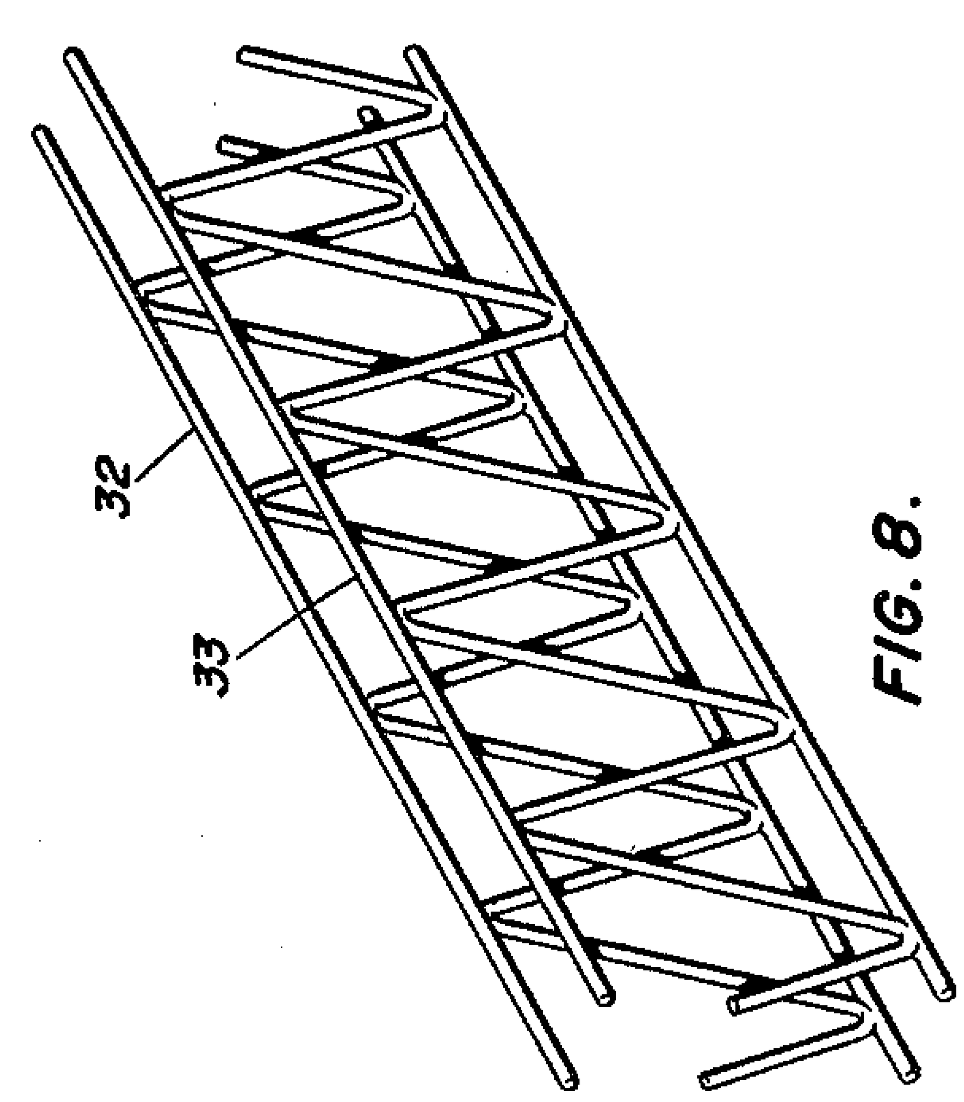

FIG. 8.

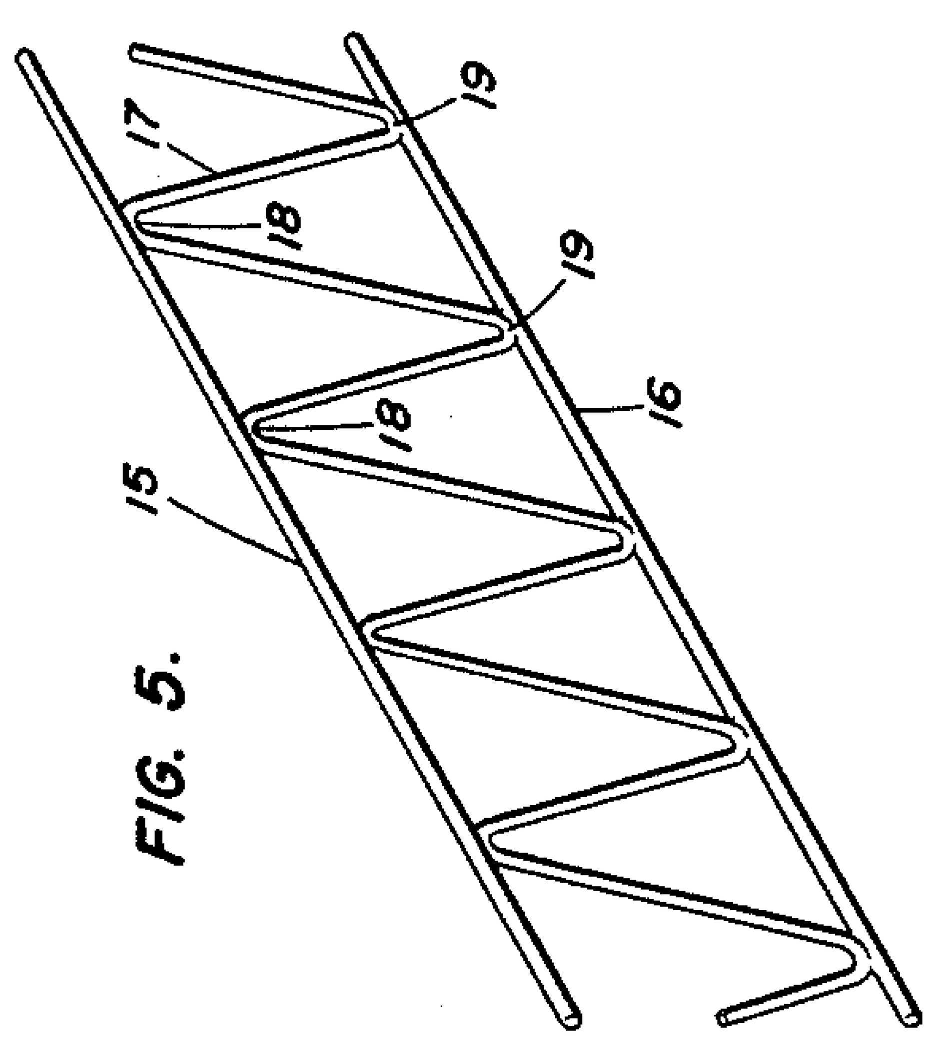

FIG. 5.

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1

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STRUCTURAL UNIT OF RECONSTITUTED AND REINFORCED WOOD PRODUCTS

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7 Claims. (Cl. 20—.5)

This invention relates to structural units of the composite type wherein a metal reinforcing structure is encased in, adherent to, and supported by a surrounding mass of reconstituted cellulose products suitably bound together and dimensioned to replaced less desirable building material.

More particularly, the invention resides in a unit such as a beam, column, arch or the like which is a composite of a metal reinforcing structure for strength and resistance to bending and an encasement of resin-bound reconstituted wood supporting the reinforcement, resisting bending of its compression members, protecting it against corrosion and itself being receptive to or suitable for fastenings such as nails and other securing systems.

It is a general object of the present invention to provide a novel and improved structural unit formed as a composite of metal reinforcements and reconstituted cellulosic materials to provide behavior superior to that of either component alone.

An important object of the invention resides in so combining the properties of the components of the structural unit that each enhances those of the other without in anywise detracting from its own.

Another important object of the invention consists in forming a composite of an internal structural metal system such as one composed of wire rod or the like, fabricated generally into a truss configuration as a skeletal support which is embedded centrally or otherwise in a matrix of wood particles, flakes or fibers and a suitable resin plastic of desired dimensions to accept fastenings such as those of the friction held type or others and to provide sufficient compressive strength to resist buckling or bending of the truss members whereby the composite unit will offer added stiffness when loaded in flexure.

A further important object of the invention resides in so grading the wood flakes or other encasing material that they closely encompass and contact the full surface of the truss members throughout and desirably adhere strongly thereto to effect maximum strength from a minimum of materials.

A still further object of the invention consists in the arrangement of multiple truss members in certain styles of structural units whereby they accept fastenings such as those of the nail type in prearranged areas between truss members for use as flooring joist, studs, rafters and the like to which attachments must be readily secured.

Other and further objects and special features of the invention will be more apparent to those skilled in the art upon a consideration of the following specification and the accompanying drawings wherein are disclosed several exemplary embodiments of the invention with the understanding that such changes and modifications may be made therein as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawings:

FIGURE 1 is a perspective view, partially broken away, of a representative structural unit, constructed in accordance with the present invention;

FIGURE 2 is a perspective view, on a larger scale, of a structural unit with a portion of the embedment broken away to expose the truss reinforcement and illustrating one arrangement of embedment material;

2

FIGURE 3 is a view similar to FIGURE 2 but showing a different disposition of embedment flake sizes from center to surface;

FIGURE 4 is a transverse cross-section of a unit, constructed in accordance with one embodiment of the invention, showing a fastening nail inserted therein between spaced trusses for securing sheathing or the like thereto; and

FIGURES 5 to 9, inclusive, illustrate in perspective, various forms or dispositions of trusses for use with structural units of the present invention.

Many industries find a wide variety of uses for lumber products, some of which users are not critical of the inefficiencies inherent in the utilization of these traditional materials in their natural form since their end uses suffer but little therefrom. Such uses depend principally on beauty of grain, ease of finishing, light weight, ready workability, etc. However, wood in its natural form and in most composite and assembled arrangements is subject to so many variations in performance as to require most structures to be greatly over-engineered. Thus, the large size of many components, especially in structural framing and the like, frequently reflect uncertainties regarding expected performance, such as strength characteristics, dimensional stability, the holding power of fasteners and the like.

The building industry, a large user of lumber products for structural framing, has become increasingly cognizant of the many inefficiencies in the utilization of this traditional building material and as cost competition in home building, fostered by high costs and wages, becomes sharper and engineering knowledge develops, the inherent non-uniformities of natural wood materials become limiting factors in their utilizations.

Reconstituted wood products in the form of particle, chip, splinter, fiber and flake boards and their many variations have to a degree compensated for some of the failings of natural lumber, since some control may be exercised over physical properties and dimensional stability in a manufactured product. However, the inherent natural order of the fiber structure is to a degree destroyed in the chipping and flaking operations and, consequently, strength per unit of cost is sacrificed. The loss in flexural strength and in Young's modulus of elasticity or stiffness is particularly significant in many end uses. This constitutes a severe limitation in usage which if it can be removed will open attractive new markets for the materials for many uses now denied them.

The present invention therefore proposes to use in a reconstituted wood or similar board an internal structural system composed of metal members fabricated into a truss configuration as a skeletal support. Such a system is preferably made of wires which, as an example only, may be of the order of one-eighth inch in diameter, or may be formed at least of members small enough to be embedded as a single or multiple truss in the matrix of the flake board. Such a system has excellent structural properties on its own, but since the members are relatively thin may fail ultimately by buckling or bending. However, when embedded in matrix material of sufficient compressive and tensile strength the truss members can be expected to be provided with columnar support so as to restrain buckling or bending, and thus each be allowed to express that portion of its high tensile and compressive strength required when a beam is loaded in flexure. Behavior of the composite material is thus superior to that of either component alone, or just the sum of the two.

Referring now to the drawings for a better understanding of the invention and first to the perspective view of FIGURE 1, it will be noted that the structural member 10, shown therein, is essentially a composite, comprising a metal reinforcing structure **12** encased in, adherent to, and supported by a surrounding mass **13** of any one of a number of suitable reconstituted cellulose products held together by a resin-bonding plastic as a result of compressing and heating operations when necessary, and is suitably sized to replace any of the more common pieces of dimensioned lumber used structurally in the building industry, more particularly, but not necessarily, the home building one.

The few components of this composite structure may take many forms depending upon the end uses and desired strength of the structural unit. As shown in FIGURES 1, 2 and 3 a single truss, generally of the Warren type, is indicated, for example, as positioned in approximately the median plane of the shortest dimension of the unit and may extend through all of its length and most of its width as preferred. This truss member, as shown more clearly in FIGURE 5, is composed of top and bottom, straight, longitudinal members or chords **15** and **16** substantially parallel to each other, for the usual straight constructions, and joined by means of a continuous zigzag or sinuous member **17** bent into a generally sawtooth form with apices **18** and **19** along opposite edges thereof joined by welding against the abutting longitudinals **15** and **16**. The diameter of the wire, or size of other types of members, is subject to variation, of course, in accordance with the size of the structural unit in which it is embedded. As an example only, wires of the order of one-eighth inch in diameter are representative in size for trusses to be used in such structural units as may be substituted for the usual natural wood building studs of two or three by four inches. Rafters and joists units capable of substituting for six, eight and ten inch depths by approximately two inches in thickness of natural lumber as used in normal house constructions, may require larger wire or other type members. It should be borne in mind that truss structures of the nature illustrated, if unembedded, would be likely to fail relatively early by buckling or bending of the compression members, but because of the compressive and tensile strength of the embedment material **13**, which closely surrounds and is adherent to the members of the truss, these are given columnar support and the truss, when forming a part of the composite structure illustrated, presents greatly increased strength over an unsupported one and can, thus, be much lighter in weight.

The embedment may take many forms, more generally a combination of cellulosic fibrous material and a suitable adhesive, but reconstituted wood is preferred and this preference extends essentially to what is known as chip or flake board, i.e. a mass of pre-formed wood flakes in which the moisture content has been reduced to the order of two to six percent before mixing with the adhesive, which may be selected from among a number of well known synthetic resins, such as phenol-formaldehyde, any of the various urea resins, and many others from which a suitable one, or mixture of several, may be chosen for specific and desirable characteristics, such as cost, adhesiveness, ease of curing, moisture proofness, mildew resistance, insect immunity, etc.

In the manufacture of units any desired wood particles and chosen plastic, the latter to a percentage of say three to ten, but preferably about five percent, are premixed prior to the known felting operation, and if a proper adhesive has been selected, may be stored for a period of hours in suitable bins to insure against shut down of the felting and pressing apparatus due to lack of flakes.

The resin selected as the adhesive may be of the water dispersable type, when uncured, and may be diluted with water to reduce its viscosity for more uniform distribution such as by spraying onto the particles, and this moisture must be eliminated during the pressing and heating operations which follow the felting. The actual manufacture of the composite structural unit may follow

one of the several usual practices in forming particle, splinter, or flake board, wherein the materials are sprinkled, showered or otherwise deposited onto a stationary or a travelling conveyor to the requisite unpressed thickness and lateral dimensions. The mat thus formed is then compressed to reduce it to the desired final thickness, using pressures of the order of 300 to 700 pounds per square inch with heating to appropriate temperatures to thermo-set the plastic adhesive, if such is used, and to evaporate the water, the whole process being under satisfactory automatic controls for uniformity of strength, density and the like.

The method of manufacture also includes forming a suitable layer of the granular or flake material onto the conveyor or onto caul boards, then introducing the truss or trusses, the wires of which may be pre-coated with the same or a compatible plastic in order to increase the adhesive bond of the embedment material to the surfaces of all of the wires, or they may be otherwise treated to insure bond. This coating is illustrated, and perhaps somewhat exaggerated, at **20**, in FIGURES 2 and 3. Then a finishing layer of flake covers the truss.

To insure adequate encasement of the metal of the truss and complete adherence of its entire surfaces to the embedment material it is preferred that this material be graded, with the fines close to the metal, intermediate grades next and the coarsest of the material at the surfaces. One such surface is seen in FIGURES 2 and 3, showing at **22**, flakes, platelets, chips or the like, preferably of relatively uniform thickness but irregular in size both as to length and width, and randomly oriented in planes substantially parallel to the faces of the unit for overlapping and adherence to each other to give the final product the maximum strength, resistance to bending and the best surface appearance. The random positioning of the platelets is to offer substantially uniform stiffness in all directions when loaded in flexure.

The sizes of the flakes vary considerably and particularly those at the surface, or at least some of them, may be well over an inch in length, and between an eighth and an half an inch in width by several thousandths of an inch in thickness. It will be readily appreciated that flakes of this size and shape cannot be readily compacted about and engage most all of the surfaces of the members of the metal truss. It is therefore proposed that the flakes, chips or the like vary in size with the maximum at the surfaces (not the edges) of the main faces as indicated at **23**, and its opposite face **24**, to be graded to relatively fine particles where they contact and are adherent to the truss members so that maximum direct contact with and adherence to their surfaces is achieved. It is contemplated that the gradation may be in sandwich form, multi-laminar of successively smaller grades as the laminae approach the truss, or the whole mass of more or less continuous reduction in particle sizes from surface to truss. In FIGURE 2 the sandwich structure is illustrated where a layer **25** of fines encases the members of the truss and the layers **26** of larger flakes form the outer covers therefor, making a three-layer sandwich-like construction.

In FIGURE 3 the outer layers **27** are thinner, in a unit of the same overall thickness as illustrated in FIGURE 2, the center layer **28** of fines is thinner and intermediate layers **29** are arranged between the surface layers **27** and the fines layer **28**. It is believed to be simpler to use one of these multi-laminar arrangements, rather than a continuous gradation from coarse to fine, then the truss, and fine to coarse for the finish in the manufacturing process, but the invention also contemplates this continuous gradation which would be extremely difficult to illustrate.

It is essential to provide for the acceptance of fastening means whereby structural units such as studs, rafters and joist may be used in the customary manner and have laths, sheathing, flooring materials or other building components secured thereto. Customary fastening means such as ordinary nails or the like are preferred for obvious reasons, but rivets, bolts, adhesive bonds, timber fasteners, etc. may all be used. In order to achieve this result where edge nailing or similar fastening is required it is preferably to use as an alternative a double truss structure, such as illustrated in FIGURE 8 and also in the cross section of FIGURE 4. Here two wholly independent trusses **32** and **33**, each of which may be exactly as illustrated in FIGURE 5, are contemplated, but are spaced apart and substantially parallel to each other, and as shown in FIGURE 4 may each be encased in a layer of fines, between which a layer **35** of coarser materials with greater strength and better holding power may be sandwiched. The two outer layers **36** and **37** are also of coarser and preferably surfacing grades of flakes. The arrangement shown in FIGURE 4 then permits the insertion or driving of a fastening such as a nail or the like **38** through, for instance, a sheathing, flooring or the like and into the material between the fines layers which encase the two trusses.

In FIGURE 6 a truss formation is illustrated which differs from that shown in FIGURE 5 only in providing contiguous, parallel, longitudinal **15'** and **16'** each composed of two wires welded one above the other and all four being in the same general plane. This arrangement increases the strength of the longitudinals without increasing the overall thickness of the truss and without requiring especially rolled shapes.

In FIGURE 7, however, an arrangement is illustrated wherein the longitudinals $\mathbf{15^2}$ and $\mathbf{16^2}$ are doubled in strength without increasing the overall width of the truss, but increasing its thickness since the two spaced wires of each longitudinal are welded to opposite faces of the diagonals closely adjacent the bends therein, as clearly seen. This construction does not permit of the attachment of the two wires of each longitudinal to each other at any point, but they are connected through each of the bends of the diagonals by welding in the usual manner, and contribute added resistance to bending not only in the plane of the truss, but normal thereto.

Finally in FIGURE 9 there is illustrated a box-type girder, which upon close examination will be seen to comprise two of the trusses, such as illustrated in FIGURE 5, spaced apart somewhat farther than illustrated in FIGURE 8 with their longitudinals **40** and **41** at the upper edges or corners connected by a sinuous wire **42** whose peaks are welded thereto, and with the lower longitudinals **43** and **44** similarly connected together by a second sinuous wire **45**. Obviously the peaks, of what may be termed the horizontal sinuous wires **42** and **45**, may coincide in spacing and positioning with the peaks of the vertical sinuous wires **47** and **48**, as illustrated, or as variations the pitches of the various wires may be different from those shown and from each other, varying between the sides and/or the top and bottom in any manner desired. Preferably, however, the sinuous wires are of the same pitch, but the peaks of the horizontals may be spaced intermediate the peaks of the verticals where they join the longitudinals. These types of constructions are unusually good for very thick structural units subject to stressing and loading in several different directions. Obviously the spacing between pairs of longitudinals on a side may be adjusted in respect to the spacing of a pair of longitudinals at top and bottom to suit the desired dimensions of the structural member and to better take the types of load to which it may be subjected.

Other variations of truss structures present themselves such as ones curved in their plan to facilitate the manufacture of arches or the like.

Since the final product, the finished structural unit, is a composite of metal and wood plus a small percentage of plastic and is substantially compressed during manufacture, the density is somewhat greater than all but the heaviest woods and usually runs to the order of 35 to 55 pounds per cubic foot depending, of course, on the ratio of wood to metal and the actual density of the wood, of which many varieties are relatively satisfactory for use. This finished product, because of its truss-like reinforcement plus the columnar strength given the members of the truss by the encasement, has much greater overall strength per unit of weight than the customary building lumbers, is less subject to bending and sagging in the direction of the maximum strength of the truss and has many other advantages, which may include greater uniformity than natural wood, the capability of better treatment of the wood against rot, attacks by insects, moisture absorption and the like, which can be handled by the appropriate selection of ingredients of the binder material and/or pretreatments of the flakes.

In accordance with the modular theory of building, structural units may be made in modules or can be easily cut transversely with saws having suitable hardened teeth. As illustrated in FIGURE 1 the truss wires may extend to the ends of the units or they may be encased, as they are at the edges, if so desired, where modular lengths are manufactured and sold. For convenience in nailing the surfaces may be appropriately marked with the positions of the truss components therein, except where only edge nailing is required and double trusses of the type illustrated in FIGURE 8 or in FIGURE 4 are used or otherwise where the nail receiving areas are obvious. The only precautions necessary here are to maintain the nailing close to the centers of the edges, as seen in FIGURE 4. Units exhibit adequate holding for suitably selected nails and other fastenings and strongly resist the type of splitting so common with many natural lumbers. Lengths of beams, timbers and arches is, in many cases, limited only by economics and handling possibilities.

The structural components outlined above, and their possible variations present a new form of building material of obvious merit because of its added strength, rigidity, facility of use and for many other reasons appearing throughout the specification.

The structural units as defined above may form the cores of composites whose surfaces may be encased or covered with various materials, such as covering **50** shown in FIG. 4, for enhancing their appearance, increasing their strength or both. Thus, the surfaces of boards constructed as described above may be overlaid with other materials to add structural or decorative properties or both. Wood, paper, plastic or cloth veneers provide both properties as do foils or thin sheets of aluminum, stainless steel and the like. Wire meshes or foraminous sheets are of value and quite decorative but do not provide the imperviousness to moisture of some of the other suggested materials.

We claim:

1. An elongated structural building unit of generally rectangular cross section about a longitudinal axis and composed of metal members, wood particles and a hardened thermo-setting plastic, said metal members being in the form of a truss having chords parallel to said axis, and connecting diagonals, said chords extending longitudinally of the unit, one near each of two opposite edges thereof, said wood particles and thermo-setting plastic encasing said truss, and providing columnar support for the members thereof, said unit being shaped externally to predetermined size, constructed to accept and hold fastenings such as nails, and said wood particles being in the form of layers of substantially flat flakes randomly oriented in planes which are parallel to the major axis of the unit, the wood flakes being variable in size, with the larger flakes forming layers at the wider faces of the unit and the smaller flakes forming a layer surrounding the truss, the small flakes being sized substantially to effect maximum surface contact thereof with members of the truss.

2. The structural building unit of claim 1 in which the surfaces of the truss members are pre-coated with uncured plastic to improve adhesion of the said small sized wood particles thereto.

3. The structural building unit of claim 1 in which said truss forms one side of a box girder composed of two such trusses transversely spaced and connected by zigzag spacer members having their apices welded thereto.

4. An article of manufacture as defined in claim 1 in which at least one of the larger surfaces of said building unit is overlaid by an adhered covering of a material contributing structural strength to the unit.

5. An article of manufacture as defined in claim 1 in which at least one of the surfaces of said building unit is overlaid by an adhered covering of a material contributing decorative effect to the unit.

6. The structural building unit of claim 1 in which the truss chords are welded to the connecting diagonals, and these diagonals are in the form of a continuous zigzag member.

7. The structural building unit of claim 1 in which there is an additional truss laterally spaced from and parallel to said truss, and said additional truss is also encased in the smaller size wood flakes and thermo-setting plastic.

References Cited by the Examiner

UNITED STATES PATENTS

1,335,910	4/20	Munroe	162—105
1,941,211	12/33	Inglee	50—492
2,066,734	1/37	Loetscher	161—162
2,268,311	12/41	Sheehan	50—492
2,401,281	5/46	Webb	20—91
2,425,883	8/47	Jackson	50—268
2,826,521	3/58	Robinson	20—91 X
2,847,733	8/58	Roy	20—91
2,921,463	1/60	Goldfein	50—268
2,947,654	8/60	Chapman	161—162

FOREIGN PATENTS

519,621	1955	Canada.
448,746	1927	Germany.

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