Sept. 14, 1954 J. D'A. CLARK ET AL 2,689,092

METHOD AND APPARATUS FOR PREPARING CROSSCUT FIBER

Filed May 23, 1949 4 Sheets-Sheet 1

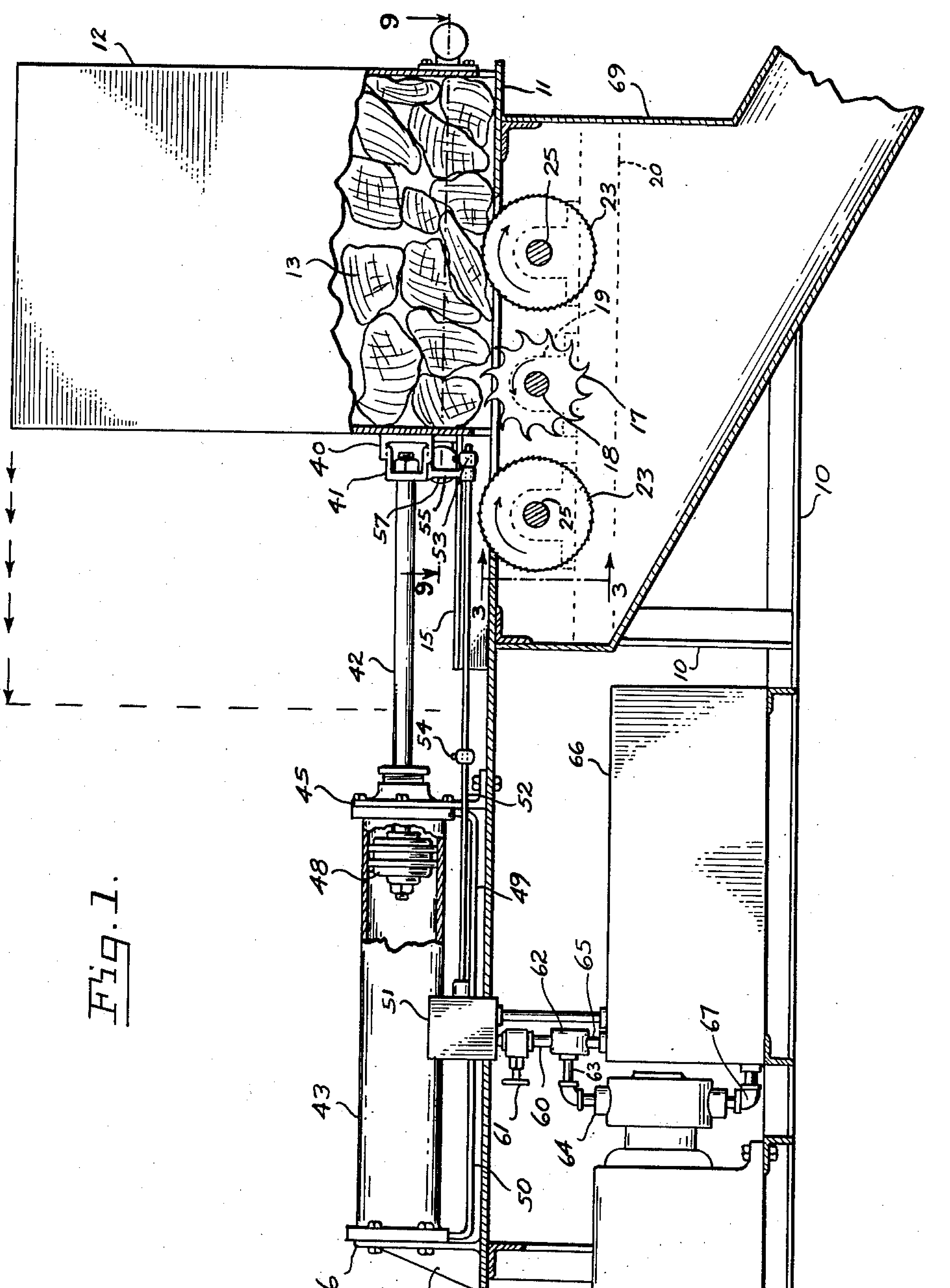

Fig. 1.

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METHOD AND APPARATUS FOR PREPARING CROSSCUT FIBER

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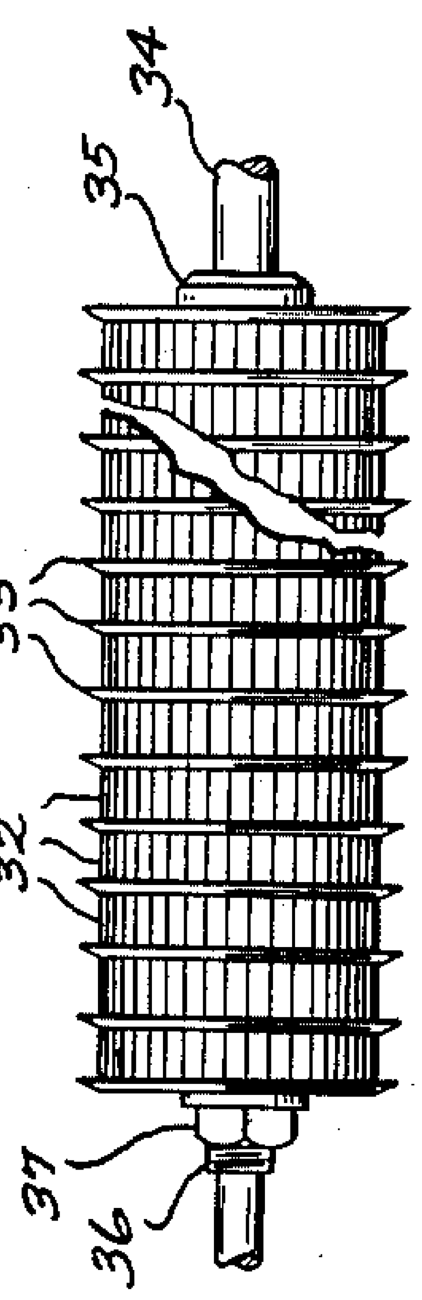

Fig. 4

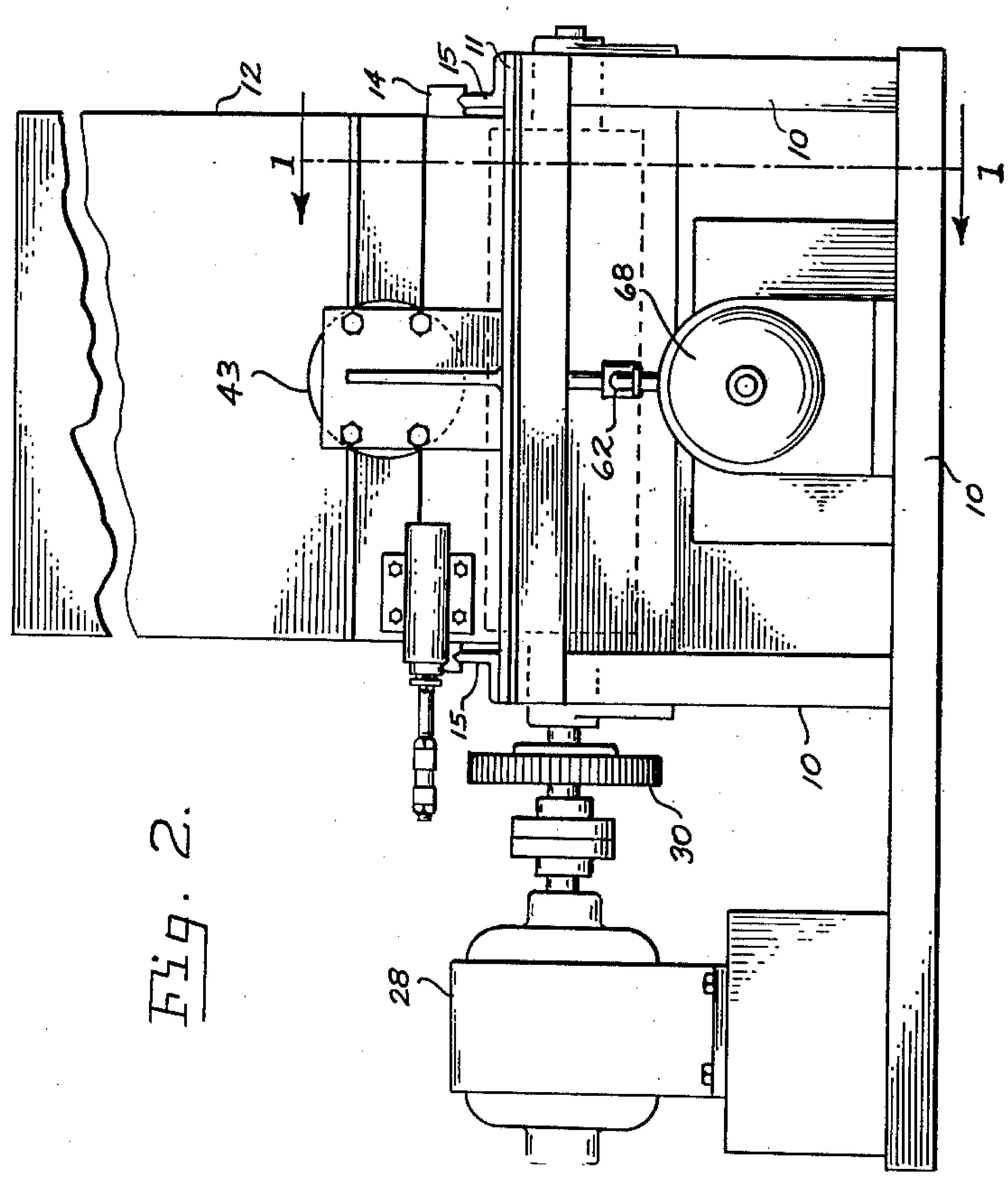

Fig. 2

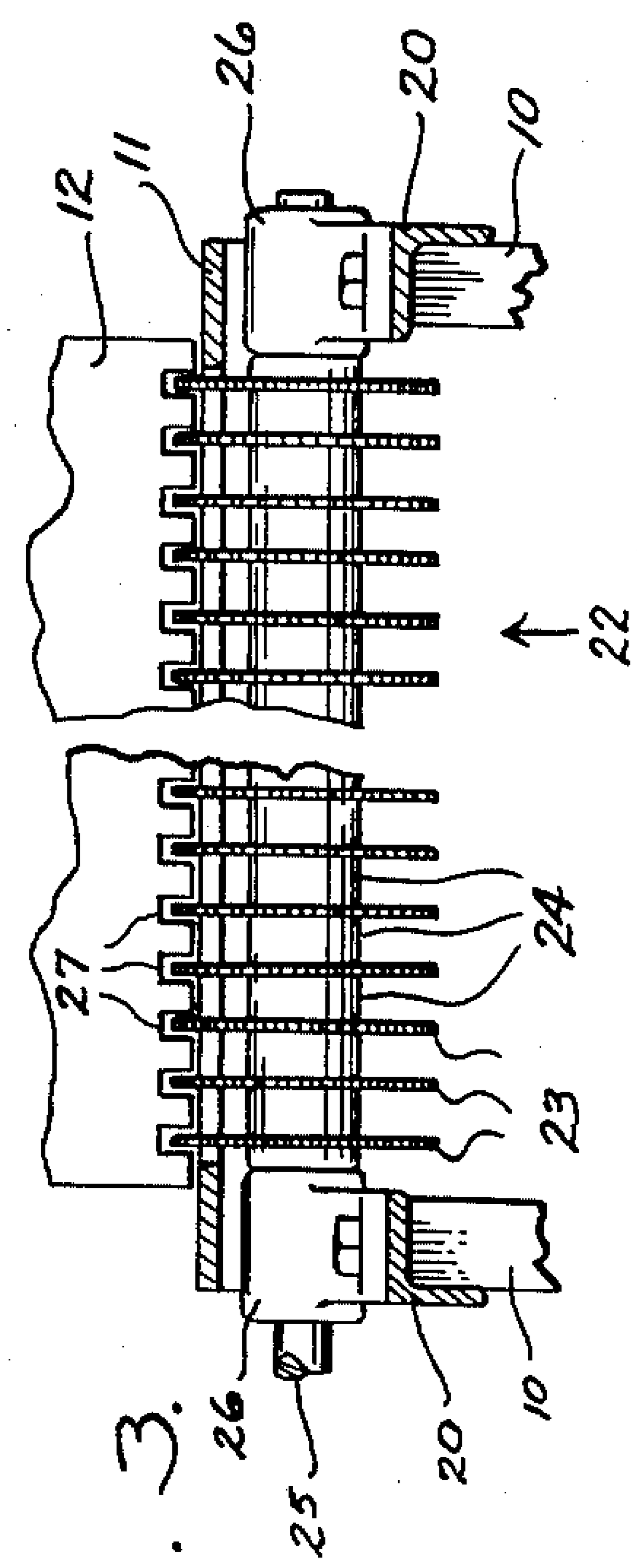

Fig. 3

Fig. 8

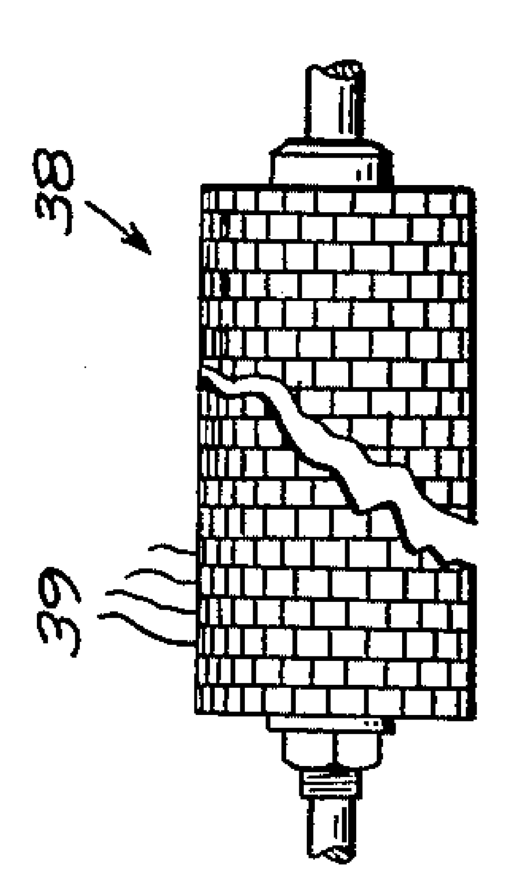

Fig. 5

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METHOD AND APPARATUS FOR PREPARING CROSSCUT FIBER

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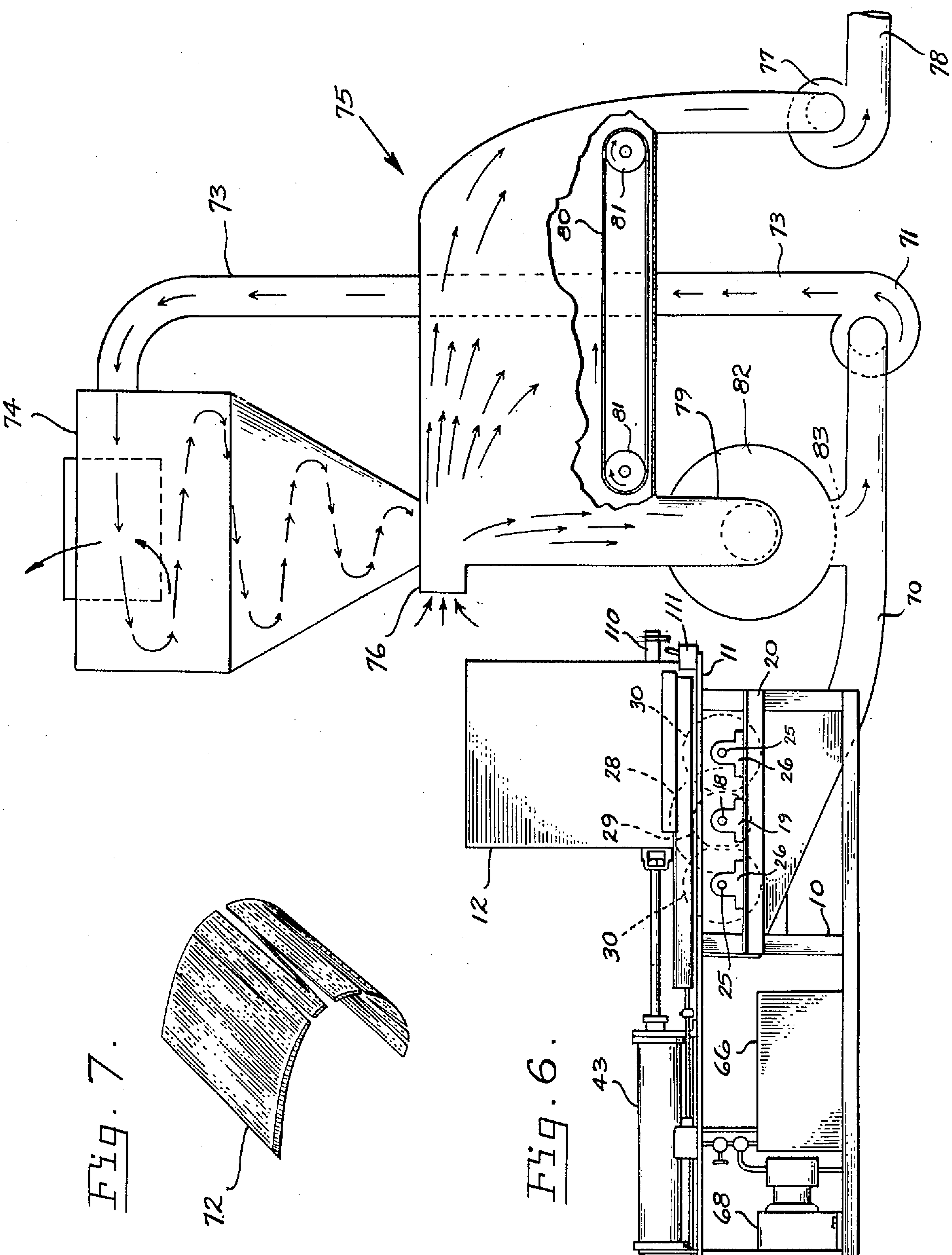

Fig. 6.

Fig. 7.

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METHOD AND APPARATUS FOR PREPARING CROSSCUT FIBER

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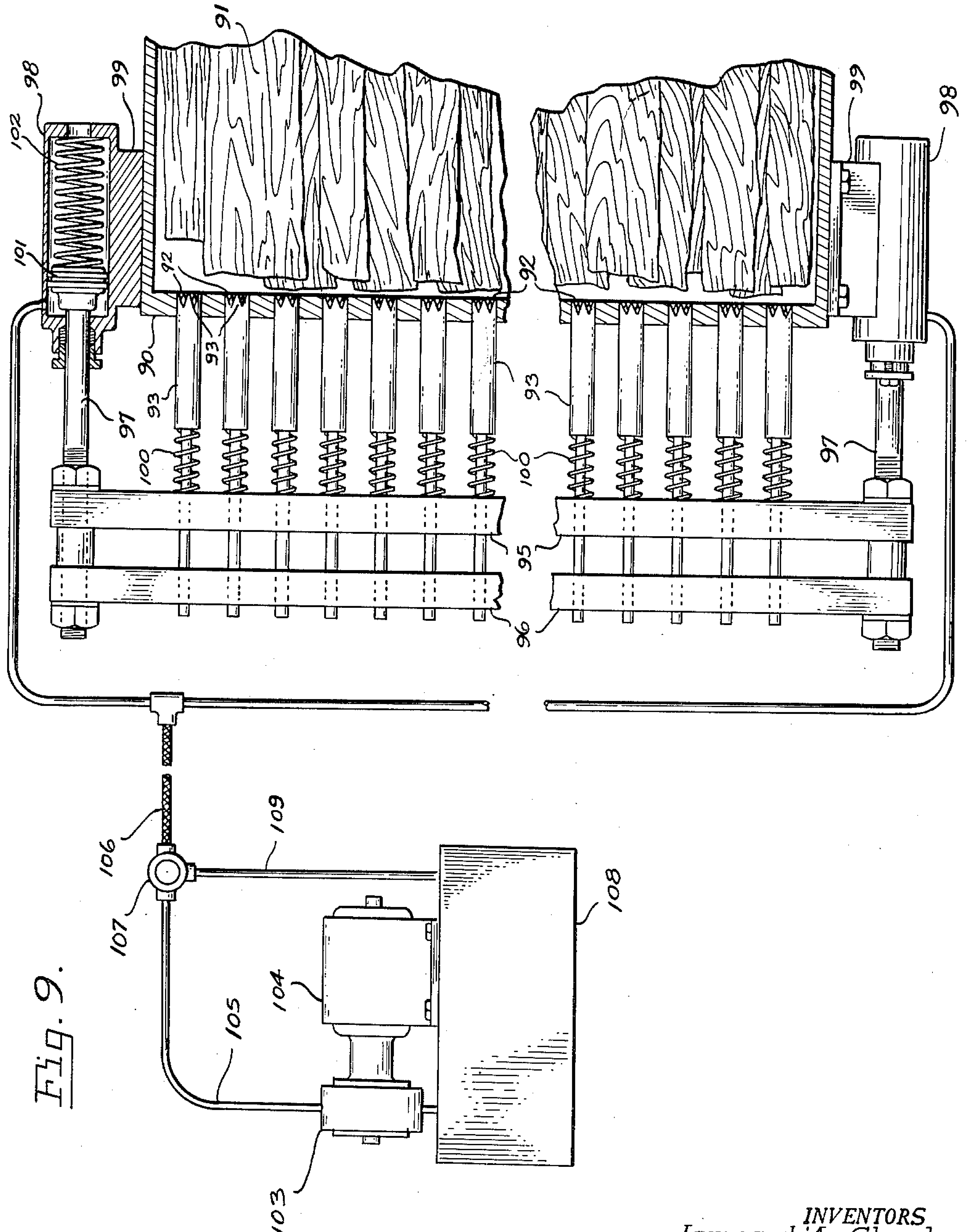

Fig. 9.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR PREPARING CROSSCUT FIBER

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Application May 23, 1949, Serial No. 94,812

17 Claims. (Cl. 241—28)

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The present invention relates to a method and apparatus for preparing crosscut fibers by cutting woody materials across the grain which product is especially suited for the fabrication of consolidated, fibrous products having a density of over 0.5.

The strength of hardboard and other highly consolidated fibrous products is determined primarily by the intrinsic strength of the individual fibers and fiber bundles of which it is composed, these in this disclosure being collectively termed "fibers." This is because the consolidated products are made by defibering appropriate materials, preparing a felt from the fibers by conventional wet forming or dry felting methods, adding binder if desired, and consolidating the felt by the application of heat and substantial pressure. During the consolidating operation, the structure is compressed and firmly bound together by the developed native binder present in certain fibrous materials as well as by a foreign binder, if such has been added. Strong lateral adhesive forces are developed between the fibrous elements in this manner, so that fracture of the consolidated product does not occur primarily because of slippage between the individual fibers of which it is composed, as is generally the case when a stress is applied to an insulating board or other consolidated product of relatively low density. On the contrary, fracture in a dense board occurs principally as a result of actual breakage of the fibers. Hence any reduction of the intrinsic strength of the fibers is reflected to a marked degree in the strength of highly consolidated boards made therefrom.

The operation of the defibering methods of the prior art is such that of necessity a substantial proportion of the inherent strength of the wood fiber is destroyed by the act of defibering. Thus in one common type of mechanical defibering operation, the faces of wood blocks are prescored and traversed relative to a rotary cutter, the direction of the traverse being parallel to the grain of the wood. In this method, the fibers curl as they are formed to conform to the shape of the gullets between the teeth of the cutter, the degree of curling being dependent on the angle of the cutting edges and on the thickness being cut. The curling inevitably is accompanied by cracking and checking of the individual fibrous elements in a manner which is clearly visible, particularly upon microscopic examination. As a result, the fiber so formed is intrinsically weak and subject to fracture along any one of the numerous induced defects in its structure.

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Similarly, it is a known practice to defiber wood by traversing it with respect to a rotating cylinder, the periphery of which comprises a multiplicity of radially extending needles. As the wood is passed in the direction of the grain across the surface of the fiberizer of this construction, the needles comb out individual fibers from the wood surface. Since the needles do not exert a cutting action on the wood, the fibers are detached forcibly and are cracked and broken. Hence this method leads to the formation of a fiber which has been shortened by the defibering operation, or cracked or checked in numerous places to provide faults along which cleavage readily may occur.

Similarly, the third general mechanical defibering method also is characterized by the production of fibers which have been weakened. In this method, wood or wood chips are ground against or between grinding surfaces consisting of abrasives or grooved metal. The effect of these surfaces on the pieces of wood is to tear the fibers forcibly apart from each other. Hence as the disruptive force is applied to the fibers, the fibrous elements formed are of necessity broken, cracked, and twisted so that much of their strength is destroyed.

Furthermore, in other known methods used for reducing wood material to fibers, steam at elevated pressure and temperature is employed during the grinding of the chips in one process or prior to exploding them in another. The effect of the heat is seriously to weaken the fibers by hydrolysis or decomposition and render them more brittle when dry, an effect which becomes increasingly marked as the temperature is increased.

In all the foregoing defibering methods, a proportion of the fibers produced are too large for the manufacture of some types of products. Hence it usually is desirable to pass the fibers through a separating or screening step, in which the accepted small fibers are separated from the rejected fibers of larger dimensions. The latter, if not discarded, are subjected to an operation for reducing them to an acceptable size. Because all the varieties of conventional fibers are checked and otherwise damaged as described above, it will be apparent that any reducing operation will break them across their length at the weak points formed during defibering rather than reduce their thickness. As a result, short, stubby fibers are formed which are not well suited to the formation of strong, consolidated products. For this reason, the coarser fraction of fibrous compositions made by the prior art methods often is not reduced even when it is to be used for the manufacture of products where the presence of coarse particles is objectionable.

To overcome the foregoing and other defects of the prior art, it is the primary object of the present invention to provide a method for the defibering of fibrous material such as wood in which the material is cut across its grain rather than parallel thereto so as to form fibers which are separated cleanly from the matrix and which are not checked, cracked, or broken by the defibering operation.

It is another object of the present invention to provide a wood defibering method yielding a fibrous product which may be separated into fine and coarse fractions, the coarse fraction being susceptible to milling or other treatment to reduce the size of the constituent fiber aggregates without excessive breakage across the length of the fibrous elements.

Another object of the present invention is to provide a mechanical method for defibering wood which method is applicable on a commercial scale to the production of large quantities of fiber at low power consumption and low cost.

Another object of the present invention is to provide a defibering method applicable to brittle, woody materials such as kiln dried Douglas fir scraps to produce therefrom a fibrous product having sufficient strength to be used in the production of strong consolidated products of high density.

A further object of the present invention is to provide an integrated process whereby wood scrap may be reduced to board making fibers by defibering the wood, separating the fibrous product in coarse and fine fractions, reducing the coarse fraction to acceptable size, and combining the reduced coarse fraction with the fine fraction, all of these operations being practiced upon the fibrous aggregates substantially without breaking or cracking the individual fibers across their length, or otherwise degrading them as board-making stock.

A further object of the present invention is to provide a method of separation whereby mechanically defibered wood as it comes from the difibering mechanism may rapidly and efficiently be separated into fine and coarse fractions.

Still another object of the present invention is to provide a wood fiber, the intrinsic strength of of which has been preserved and which, therefore, is of superior board making properties.

In accordance with the present invention, the foregoing and other objects are attained by providing one or more cutters of suitable construction, or one which may operate in conjunction with a scoring mechanism, positioning blocks of wood of random dimensions with the grain of the wood running substantially parallel to the cutter blade, i. e. with the cutting surface substantially parallel to the grain direction of the wood and traversing the wood with respect to the cutter or the cutter with respect to the wood, thus making a cut substantially across the grain of the wood rather than along it. This shaves off thin slices, flakes or wafers, having a width determined by the width of the cutter or the spacing of the scoring. The thickness and length of the slices will be determined by such factors as the cutter speed, the number of teeth on the cutter, and the rate of speed if the cutter is a rotary cutter, or by the projection of the knife if the cutter is a straight cutter. The individual wafers consist of a multiplicity of individual fibers lying substantially parallel to each other. Although the wafers are curled within the inner face of the cutter, the constituent fibrous elements are not broken or checked since the direction of the curl is longitudinally of the fibers rather than transversely thereof. As a result, such breaking as does occur takes place along the natural planes of cleavage of the wood structure, separating the individual fibers rather than breaking them transversely into fragments. In this manner, the length and strength of the fibrous elements are preserved.

Furthermore, the wafers formed by the practice of the present invention lend themselves admirably to a gentle milling or reducing operation whereby their size is reduced sufficiently to enable their use in the fabrication of fine textured consolidated products. When passed through a suitable reducing mechanism, they are easily broken down into fiber bundles without breakage or cracking of the individual elements, this reduction being facilitated by the partial cleavage along the natural planes initiated by curling of the wafers within the cutter. Hence what heretofore has been a serious defect in the conventional mechanical defibering methods has become an advantage in the method of the present invention. Furthermore, the hereindescribed method provides for the first time fibers which may be milled or otherwise reduced without appreciably harming them insofar as the strength of boards made therefrom is concerned.

Because of the ease of milling the fibrous elements to reduce their particle size without damaging them, it is not necessary to score the wood or otherwise fix the width of the wafers and thus the length of the fibrous elements. Very wide wafers may be cut without prescoring, and these subsequently may be reduced to fibrous elements having an average length governed by several factors including the thickness of the wafers, the parallelism of the grain of the wood to the cutting edge, and the intensity of the reduction. The fibrous elements so made will be of mixed sizes, which are desirable for certain purposes.

It also will be observed that by providing a fibrous product which lends itself to reduction without damage to the individual fibers, the defibering method of the present invention makes possible an integrated procedure for the production of superior board making stock from wood blocks and scraps of random sizes and shapes. This comprises first reducing the wood to thin slices or wafers by traversing it across the grain with respect to a cutter, fractionating in a separator the product thus formed to separate the acceptable fine material from the unacceptable coarser material, reducing the coarse fraction in suitable milling apparatus, and recycling the reduced product to the separator to separate the fine stock formed in the reducing mill from any residual coarse material. In this manner, the entire sequence of operations necessary to the production of high quality fiber may be incorporated in a continuous, cyclic process of high speed and efficiency.

Suitable apparatus for carrying out the defibering method of the present invention is illustrated in the accompanying drawings wherein:

Figure 1 is a side elevation, partly in section, along the line 1—1 of Figure 2, of a defibering unit for reducing blocks of wood to thin wafers or flakes;

Figure 2 is an end elevation of the defibering apparatus of Figure 1;

Figure 3 is a detail view taken along the line 3—3 of Figure 1;

Figure 4 is a detail view in elevation of an alternate scoring and cutting assembly for use in the defiberer of Figure 1;

Figure 5 is a detail view in elevation of yet another scoring and cutting mechanism for use in the defiberer of Figure 1;

Figure 6 is a view in elevation of the entire mechanism for reducing wood blocks to fibers of uniform dimensions and comprising the defibering unit, the separating unit, and the reducing unit;

Figure 7 is a perspective view of a fibrous wafer produced by the defibering unit of Figure 1;

Figure 8 is a fragmentary view of the surface of a board made by consolidating the fibrous product of the present invention and illustrating the characteristic pattern thereof when the wood has been prescored to form wafers of uniform width; and

Figure 9 is a fragmentary, sectional, schematic view of a mechanism for holding wood blocks during the operation of the defibering unit of Figure 1.

As is apparent from the drawings, one form of apparatus for producing wood fiber by the practice of the present invention broadly comprises a defibering unit for converting pieces of wood to fiber wafers, a separating unit for separating the individual fibers and small bundles of fibers from the fiber wafers produced by the defiberer, a reducing mill for reducing the larger aggregates to individual fibers or small bundles of fibers of suitable size, and a suitable conveying mechanism interconnecting the defiberer, the separator, and the reducing mill to make of them an integrated apparatus adapted to continuous, cyclic operation.

The defibering unit may comprise any suitable apparatus providing means for traversing scored pieces of wood crosswise against a rotary cutter which shaves off slices or wafers cut across the grain. Suitable apparatus thus may comprise a rotary defiberer of the type disclosed in the copending application of James d'A. Clark, Serial No. 78,692, filed February 28, 1949, now Patent No. 2,655,189, for Production of Long, Tapered Fibers From Woody Material. This apparatus provides for the traversal of a rotary cutter and scoring element mounted on a rotating circular table with respect to a plurality of pieces of wood supported by the surface of the table and contained in a stationary hopper forming long, thin slices of substantially uniform thickness and having tapered ends.

Alternatively, the defibering unit employed in the present unit may comprise a rotary cutter usually operated in cooperation with scoring elements and with reciprocal means for traversing wood blocks crosswise of the grain against the cutter and scoring heads. In this embodiment, which is illustrated in Figures 1 to 4, inclusive, a frame indicated generally at 10 supports a flat, substantially rectangular table 11. Above the table is the hopper 12. This is open at the top and bottom and is adapted to be filled with blocks of wood 13 of random shape and size but placed with the grain running transversely of the table. The hopper 12 is held with its bottom spaced apart from the upper surface of the table 11, and is mounted for reciprocal movement by means of the slides 14—14 attached to opposite sides of the hopper and riding on the guides or tracks 15—15 attached to the table 11.

The cutting assembly is mounted below the table 11, the cutting elements and, if used, the scoring elements projecting upwardly through openings in the table sufficiently to engage the wood in the hopper as the latter reciprocates across the table surface. The cutter 17 is of conventional construction preferably being of the saw tooth type, as illustrated, or of the type wherein cutting blades are bolted or otherwise affixed to a central core. In either case, the cutting edges are substantially continuous and of sufficient length to be coterminous with the transverse inside dimension of the hopper. The cutter is mounted on the shaft 18 which, in turn, is journalled in bearings 19—19 bolted to the bracket bars 20—20 attached to the frame of the apparatus.

The scoring elements which may be used in conjunction with the cutter 17 by acting upon the surface of the wood to score or cut it and in this manner determine the length of the wafers cut by the cutters may comprise assemblies of properly spaced saws or knives. As is shown in Figure 1, one of these assemblies may be stationed on each side of the cutter head so that, during the reciprocating action of the hopper, the surface of the wood will be scored in advance of the cutter no matter what the direction of the traverse.

In the embodiment illustrated particularly in Figure 3, the scoring elements 22 comprise an assembly of circular saws 23 separated by spacers 24 both saws and spacers being mounted on a common shaft 25. The latter is journalled in bearings 26—26 which are bolted to the bracket bars 20—20 on the frame of the apparatus. To accommodate the saws as the hopper passes thereover during its reciprocation, there may be provided in the front and back ends thereof a plurality of slots 27 in which the saws rotate freely.

Separate drives may be provided for the cutter 17 and the scorers 22—22 or all three of these units may be coupled together and driven from a common motor. Thus the shaft 18 of the cutter may be coupled directly to an electric motor 28 and may carry the gear 29 engaging gears 30—30 of suitable ratio on the shafts 25—25 of the scoring elements. (Figure 6.)

Rather than constructing the cutter and scoring elements as separate units, these members of the assembly may be combined as a single unit as illustrated in Figure 4. In this construction, a plurality of cutters 32 separated by the scoring disks 33 having sharply beveled edges may be mounted upon the common shaft 34. The assembly of cutters and scoring disks may be attached removably to the shaft by providing the thrust bearing collar 35 at one end and the threaded sleeve 36 with nut 37 at the opposite end. Thus, by tightening up on the nut, the cutting and scoring elements may be maintained securely on the shaft. One or a plurality of these combined cutting and scoring units may be mounted on the frame 10 of the apparatus in a manner similar to that described above in connection with the cutter 17 and the scorers 22. It has the advantage of compactness and simplicity of construction, and of utilizing scoring disks rather than saws to effect the scoring, thus avoiding loss of fiber by sawdust production. On the other hand, with saws, the cutters may engage the wood pieces to a depth of an inch or more so that less traversing is required for a given production.

In another type of unitary construction (Figure

5) the cutter **38** may comprise a plurality of individual cutting elements **39** mounted on a common shaft as in the construction of Figure 4, but with the cutters in staggered relationship to each other. The width of the wafers cut then will be a little greater than the width of each cutter, and their edges will be irregular. However, the fibers produced therefrom will have tapered ends.

The hopper **12** with its content of wood and the cutting and scoring elements may be reciprocated relative to each other by any suitable driving means, mechanical or otherwise. An hydraulic drive may be employed advantageously, however, because of its positive action, uniform speed, and adaptability to long stroke applications. Such a drive to reciprocate the hopper is illustrated particularly in Figure 1. In this construction, one face of the hopper **12** carries a horizontal channel bar **40** to which is connected through the clevis **41** the piston rod **42** of the hydraulic cylinder **43**. The hydraulic cylinder may be mounted on an extension of the table **11** by means of the forward bracket **45** and the rear bracket **46** reinforced by gusset plate **47**.

A piston **48** attached to the piston rod **42** reciprocates within the cylinder as hydraulic fluid is applied to one or the other of its faces. The supply of fluid to the cylinder is maintained through the lines **49**—**50** which conveniently may enter the cylinder through the forward and rear flanges thereof, respectively. It will be apparent that, when fluid is applied to the front face of the piston **48** through the line **49**, the piston will move to the left within the cylinder thus retracting the piston rod. On the other hand, if the fluid is supplied to the rear face of the piston through the line **50** the piston will move to the right thus extending the piston rod.

The direction of flow of fluid to the cylinder is controlled by means of the four-way valve **51**. This is actuated by means of the rod **52** to which are attached the stops **53** and **54**, and on which slides the rider **55** which may be attached, for example, to the clevis on the end of the piston rod. As the piston rod reciprocates, the rider will contact alternately the forward stop **53** and the rear stop **54**. Upon contacting either one of these, it will move the rod **52** in the direction of motion of the piston, thus operating the valve **51** in such a manner that it directs the flow of fluid to the opposite side of the piston and reverses its motion.

Hydraulic fluid is supplied to the valve **51** through the line **60** in which is contained the control valve **61** and the pressure relief valve **62**. The latter communicates through line **63** with the constant displacement pump **64** and through the conduit **65** with the reservoir **66**. The pump communicates with the reservoir through conduit **67** and is driven by the constant speed motor **68**.

Hence operation of the motor **68** drives the constant displacement pump **64** and initiates a flow of hydraulic fluid from the reservoir, through the line **67**, through the pump, through line **63**, through the pressure relief valve **62** and back through line **65** into the reservoir. The valve **62** is designed to open when subjected to a pressure greater than that required to operate the hydraulic cylinder. Therefore when valve **61** is opened, valve **62** closes automatically, and the flow of fluid is directed into the four-way valve **51**, and thence to one end or the other of the cylinder as determined by the valve setting. This activates the piston and initiates the drive of the hopper on the defibering unit. Operation of the drive is continued for the desired time, when it may be terminated by closing the valve **61**. This opens the valve **62** so that the pump **64** returns to its idling position until the valve **61** again is opened, or until the motor **68** is shut off.

Any suitable form of collecting apparatus may be used to collect and convey away the product of the defiberer. In the embodiment illustrated, however, it comprises the hopper **69** disposed beneath the cutting and scoring elements in such a manner that it receives the flakes and delivers them into conduit **70**. Since the fibrous product tends to pack and mat together, it is desirable to provide a paddle bladed fan **71** with which the conduit **70** communicates, thus providing a fluid conveying medium.

As indicated above, the product formed by the action of the rotary cutter **17** on the wood blocks **13** comprises a multiplicity of thin flakes or wafers **72** cut across the grain of the wood and, when narrowly scored, having the general appearance illustrated in Figure 7. The flakes are composed of a large number of individual fibers having lengths determined principally by the transverse dimension of the flakes and lying parallel to each other. The individual fibers are substantially unbroken since the flakes are cut away cleanly by the cutting edges of the cutter and are not checked and cracked or broken by being cut lengthwise of the grain or by being torn loose forcibly from the woody matrix as is the case when applying the defibering mechanisms of the prior art.

The curling which occurs as the flakes progress into the gullets of the cutter during the cutting operation is parallel to the long dimension of the fibers. Hence the resultant checking or cracking takes place along the natural planes of cleavage between the individual fibers and serves the useful purpose of providing a preliminary reduction of the flakes to small units, retaining substantially their original length, rather than having the harmful effect of breaking the fibers transversely thereby cracking or shortening them and, in this manner, adversely affecting their board-making properties. Such reduction in size of the flakes by disintegration of their thin ends takes place to a considerable (and sometimes sufficient) degree as the flakes are formed in the defiberizing and fiber handling apparatus, being induced by the action of the cutter itself as well as by the frictional contact of the flakes with each other and with the walls of the collecting apparatus and particularly by contact with the blades of the paddle bladed fan **71**.

The defibered product thus comprises a mixture of substantially intact flakes, large bundles of fibers remaining after disintegration of the thin portions of some of the flakes, some slivers resulting from the incomplete reduction to flakes of the wood blocks in hopper **12** and a proportion of small fiber bundles and of substantially individual fibers. While this mixture may be used without further reduction in the production of many consolidated products, it may be desirable in other applications further to reduce the flakes and larger bundles of fibers. These products lend themselves admirably to such a process, since as already pointed out the individual fibers comprising them have not been cracked or checked by the defibering operation and the reduction therefore will occur along the natural planes of cleavage separating the fibers.

As a preliminary step to the reduction of the larger particles, the entire product of the defibering unit preferably is passed first through a separating unit for separating the acceptable small fibers from the larger bundles (thicker portions of the flakes) in need of further reduction. The reduction may be effected by either wet or dry processes. In the former, the fibrous product is placed in water suspension, using sufficient water to form a ½% or less by weight suspension. This is passed through a conventional screen having a mesh size adapted to pass those fibers of acceptable size, and to reject the larger fibers. The latter then are put through a refiner or Jordan of conventional construction, and the thus treated fibers used directly or recycled through the screen.

To avoid the use of large volumes of water and other attendant disadvantages of the wet process, it is preferred to effect the separation and the reduction of the fibrous products emanating from the defiberer by a dry process such as simple screening or air separation, which may operate on either centrifugal or gravitational principles. When air separation is used, the fibrous product is conveyed from the conduit 70 by the fan 71 into conduit 73 and thence into the collector or cyclone separator 74. The latter is of conventional construction and is employed to dissipate the fluid medium in which the fibers are being conveyed prior to their entry into the air separator. It will be apparent that, if such introduction were to be effected in the presence of a blast of air, an effective air separation could not be obtained. Hence, in the cyclone separator, the air blast is dissipated from the top of the unit, while the fibrous product drifts gently and continuously downwardly toward the bottom of the separator.

The fibers feed from the cyclone 74 into the air separator or grader indicated generally at 75. This unit comprises a housing having an opening or port 76 at an upper end thereof adjacent the point of introduction of the fibrous feed, and communicating with a paddle bladed fan 77 leading into the duct 78 at the opposite corner of the unit. The fan exhausts air from the housing, at a rate governed by its speed. This produces a current of air of controlled volume entering the unit through the port 76 and entraining the fibrous product as it enters from the cyclone separator.

The individual fibers thus entrained will be carried substantially horizontally by the air current to a distance which is dependent on their surface and inversely proportional to their weight. Hence the fluffier and lighter fibers will be carried to the extreme opposite end of the separator and exhausted by the fan 77 through the conduit 78 to storage. These constitute the accepted fraction. The heavier fibers, however, will tend to separate from the air stream by gravity, dropping down into that portion of the separator which is relatively close to their point of entry. These may constitute the rejected fraction in need of further processing although if desired they may be collected and applied to some uses, as for core stock in the fabrication of thick, strong, laminated structures. This fraction falls directly down into a chute or trough 79 which may be formed integrally with the air separator.

To enable collection of a selected intermediate fraction, there may be provided within the body of the air separator 75 a fraction cutter of suitable construction. It may comprise, for example, an endless conveyor 80 carried by the pulleys 81—81 and stationed at the bottom of the air separator intermediate the chute 79 and the fan 77. The volume content of the intermediate fraction collected in this manner will be determined by the length of the conveyor and its position relative to the chute and fan. Hence, by predetermining either the length or position of the conveyor, or both, means are provided for collecting more or less of the intermediate fraction, which then may be directed by the control of the direction of motion of the conveyor into either the accepted fraction or rejected fraction, as deemed expedient. When the conveyor 80 discharges into the chute 79, the intermediate fraction will be combined with the heavy fraction dropping directly in the chute.

If size reduction is desired of the rejected fractions, which may contain some slivers, such fractions may be fed by gravity through the chute into a suitable mill 82. This may be of any conventional construction wherein the fiber aggregates are contacted with attrition means effecting a reduction in their size.

The mill may be provided at its bottom with a screen 83, this being of suitable mesh size to pass fibers sufficiently reduced. It opens directly into the duct 70 so that the fine material produced by the reducing mill is combined with the product emanating from the defibrator and passed via fan 71, conduit 73 and cyclone separator 74 into the air separator where it is again subjected to a fractionation process. In this manner there is provided an integrated, cyclic process for the continuous reduction of pieces of wood to a uniform fibrous product of predetermined characteristics.

It usually is desirable to hold the wood blocks within the hopper rigidly as they are operated upon by the cutter, so that more uniform wafers may be cut. Means for so doing are illustrated in Figure 9. The hopper 90 of that figure is arranged to reciprocate with respect to a cutting mechanism in a manner similar to the arrangement of hopper 12 of Figure 1. Contained within the hopper are a number of blocks of wood 91 disposed with the grain running parallel to the cutting edges of the cutter. The opposite sides of the hopper adjacent the ends of the wood blocks are provided with a plurality of openings 92 (or, alternatively, a longitudinal slot) designed to provide access for a corresponding number of prong elements 93 adapted to penetrate the ends of the wood blocks and hold them fast during operation of the knife. The openings preferably are spaced at close intervals so that at least two are opposite each end of each block.

Means synchronized with the driving mechanism for the hopper also are provided for driving the prong elements into the ends of the wood blocks and for holding them there while each traverse of the hopper with respect to the knives is in progress. At the conclusion of the traverse, however, the prongs are withdrawn, thereby permitting the wood blocks to fall of their own weight so that a fresh wood surface is made available for the operation of the cutter during the next traverse.

Thus the prongs 93 on each side of the hopper may be fastened to a common pair of bars 95, 96 attached to the piston rods 97, 97 of hydraulic cylinders 98, 98, the latter being mounted on the ends of the hopper by means of the brackets 99, 99. Resilient fastening of the prongs to the bars may be achieved by mounting them slidably on the bars 95, 96 interposing a compression spring 100 between the base of each prong and the bar 95. In this manner adequate compensation is made for irregularities in longitudinal dimension of the wood blocks within the hopper, and contact of the prongs with even the short blocks is assured.

Within the hydraulic cylinders **98, 98** there reciprocate pistons **101, 101** to which are attached piston rods **97, 97**, compression springs **102, 102** being placed between the piston and the rear ends of the cylinders. Hence as fluid under pressure is applied from an hydraulic pump **103** driven by motor **104** to the front faces of the pistons through the line **105** and flexible conduit **106**, the pistons are driven back, but against the compression of the spring, thereby clamping the pieces of wood with the prong assembly. Upon the release of the fluid pressure, the springs will drive the pistons forward, thereby retracting the prong assembly.

0.125 inches thick and having a density of 1.0.

In Example 6, the "long, long-cut" fibers were made in accordance with the method disclosed in the copending application Serial Number 78,692, referred to above, wherein the rate of traverse of the wood relative to the cutter is high. In Example 7, the "short, long-cut" fibers were made by the conventional method of traversing wood lengthwise of the grain at a relatively slow speed relative to the peripheral speed of the cutter. The superiority of the "long, long-cut" fibers over the conventional "short, long-cut" fibers will be apparent, boards made from the former having moduli of rupture of about 25% greater than boards made from the latter. Neither one, however, is anywhere near the equal of the crosscut fibers of the present invention with respect to its hardboard forming properties.

Table I

Ex. No.	Fiber Type	Wood Condition	Rupture Modulus of Board (p. s. i.; Average of several samples)
1	Crosscut (1" scoring)	Green pieces	7,700
2	Crosscut (unscored)	do	7,000
3	Serrated metal disk	Green chips	5,300
4	Needle cylinder	Green pieces	5,700
5	Crosscut (1" scoring)	Kiln dry pieces	6,500
6	Long, long-cut (Ser. No. 78,692)	do	3,250
7	Conventional Short, long-cut	do	2,600

To synchronize the mechanism with the reciprocation of the hopper, there may be provided in the hydraulic circuit the three-way solenoid operated valve **107**, this valve being operated by appropriately disposed limit switches **110, 111** (Fig. 6) on the frame of the cutter. Upon suitable actuation of the valve, a flow of hydraulic fluid will be directed against the rear face of the piston, extending the piston rod and prongs, stabbing the blocks and holding them firmly while they are passed across the cutter. At the conclusion of the traverse, the valve is opened so that, urged by the springs **102**, the pistons move forwardly, the fluid returning to the reservoir **108** of the hydraulic circuit via line **109**. This withdraws the prongs from the wood blocks, and permits the latter to settle. Then as the next traverse is initiated, the valve **107** again is actuated by the limit switch to close off the line **109**, and reinstate the flow of fluid into the cylinder. This again causes the prongs to penetrate and hold the wood blocks. In this manner, a positive, easily applied mechanism is provided for synchronizing the action of the prongs with the reciprocation of the hopper.

The superiority of the herein described crosscut fibers in making highly consolidated fibrous products is illustrated in the following examples (Table I) in which the properties of hardboard made therefrom are compared with the properties of board made from conventional fibers formed by cutting wood along the grain, by grinding the wood between serrated disks, or by combing out the fibers with a needle cylinder. In all of the examples, the moisture content of the fiber was adjusted to about 10% by weight by exposing them to air, after which the fibers were mixed thoroughly with 5% by weight of —150 mesh phenolic resin. The mixture was sifted through a coarse screen into a mold to give a uniform layer of material. The resultant mat then was pressed in an hydraulic press between heated platens at 350° F. for five minutes. Sufficient pressure was applied to form a board

By comparing the results of the foregoing examples, it will be seen that use of the cross-cut fiber of the present invention in the manufacture of hardboard beneficially and significantly improves the strength of the board product. This obviously makes possible the fabrication without any increase in cost, or use of increased amounts of adhesive binder, of premium grade boards suitable for use in applications where high strength is necessary or desirable.

Of particular interest are the results of Examples, 5, 6 and 7 in which the fiber employed was made from kiln dry Douglas fir. As is well known, this material is so brittle that it hitherto has not been considered a suitable source of fiber for use in board making operations. This conclusion is indicated by the results of Examples 6 and 7 in which board was made from fibers formed by cutting kiln dried Douglas fir along the grain in the usual and in an improved manner. The boards formed from this fiber had moduli of rupture of only 2600 and 3250 p. s. i., respectively, which is too low for many applications. The result given in Example 5, however, obtained from 4 tests each on 9 different sample boards prepared from kiln dry Douglas fir fiber made by cutting the wood across the grain showed an average modulus of rupture of 6500 p. s. i., which is more than the 6000 p. s. i. required to meet U. S. Government specifications for hardboard. Hence the practice of the defibering method of the present invention makes possible the commercial utilization in the manufacture of hard pressed consolidated products of a raw material not heretofore believed suitable for this purpose.

It will be understood that throughout this specification and claims, the term "wood" may be broadly construed to mean any wood or fibrous material such as bamboo, reeds, and plant stems of various kinds. Also, the transverse direction of cutting is presumed to be across the grain at a right-angle or substantially so, that is, with the cutting edge substantially parallel to the wood fibers. With certain woods, especially green wood, and for certain purposes where shorter fibers may be satisfactory, cutting the wafers at a somewhat lesser angle to the grain than 90°, say down to perhaps as low as 60°, would give some of the advantages disclosed but to a lesser extent than when cutting at an angle of about 90°, but which nevertheless might be enough to be sufficient for those purposes.

Having now described our invention in preferred embodiments, we claim as new and desire to protect by Letters Patent:

1. The method of defibering woody material which comprises incising a surface of the woody material across the grain at spaced intervals, cutting away the material between the spaced incisions, the direction of the cut also being across the grain of the woody material, thereby forming flakes having a width determined by the spacing of the incisions and comprising a plurality of individual fibrous elements of substantial length lying adjacent each other and being substantially unbroken transversely of their length by the cutting operation, milling the flakes to reduce their size by cleavage along the natural cleavage planes present between the individual fibrous elements without breaking or cracking the individual fibers transversely of their length, thereby forming an acceptable fraction comprising fiber aggregates of suitable size for a contemplated application, and a non-acceptable fraction comprising fiber aggregates too large for use in the said application, separating the acceptable fraction from the non-acceptable fraction, and subjecting the non-acceptable fraction to a second milling operation whereby to reduce further in size the component fiber aggregates thereof.

2. The method of claim 1 wherein the separation of the acceptable fraction from the non-acceptable fraction is accomplished by entraining the combined fractions in a gaseous current of predetermined velocity, and permitting the separation by gravity of the relatively heavy non-acceptable fraction from the relatively light, acceptable fraction.

3. The integrated, cyclic method for the large-scale production of a fibrous product suitable for use in the manufacture of consolidated fibrous articles, which comprises traversing a quantity of woody material with respect to cutting means of a predetermined width, the direction of the traverse being across and the plane of the cut being parallel to the grain direction of the woody material whereby to form flakes having a width determined by the width of the cutting means and each comprising an aggregate of fibers lying in side by side relationship to each other and being substantially unbroken transversely of their length, separating the product into a first fraction comprising the larger fiber aggregates and a second fraction comprising the smaller fiber aggregates, subjecting the larger fiber aggregates comprising the said first fraction to a gentle abrading and attrition action calculated to reduce them in size by cleavage along the natural cleavage planes present between the component fibers thereof without causing substantial breakage and cracking of the individual fibers transversely of their length, and combining the reduced product with the small fiber aggregates comprising the said second fraction.

4. The integrated, cyclic method for continuously reducing wood to a fiber product adaptable to the manufacture of high strength, consolidated fibrous articles, which comprises traversing a quantity of wood relative to cutting means and in contact therewith, the direction of the traverse being across the grain of the wood, thereby forming flakes having a width determined by the width of the cutting means and each comprising an aggregate of fibrous elements disposed substantially parallel to each other as in the native wood and being substantially uncracked and unbroken transversely of their length, gently abrading the flakes to reduce their size, winnowing the abraded flakes, thereby separating a relatively light fraction from a relatively heavy fraction, reducing the size of the particles comprising the heavy fraction by splitting them along the natural cleavage planes present between the individual fibrous elements, and winnowing the reduced material for further separation of the same into light and heavy fractions.

5. The method of defibering woody material which comprises incising a surface of the woody material across the grain at spaced intervals, cutting away the material between the spaced incisions, the direction of the cut also being across the grain of the woody material, thereby forming flakes having a width determined by the spacing of the incisions and comprising a plurality of individual fibrous elements of substantial length lying adjacent each other and being substantially unbroken transversely of their length by the cutting operation, milling the flakes to reduce their size by cleavage along the natural cleavage planes present between the individual fibrous elements without breaking or cracking the individual fibers transversely of their length, thereby forming an acceptable fraction comprising fiber aggregates of suitable size for a contemplated application, and a non-acceptable fraction comprising fiber aggregates too large for use in the said application, and separating the acceptable fraction from the non-acceptable fraction.

6. The method of defibering woody material which comprises cutting from the material flakes of predetermined width, the direction of the cut being across the grain direction, the flakes comprising a plurality of individual fibrous elements lying adjacent each other and being substantially unbroken transversely by the cutting operation, milling the flakes to reduce their size by cleavage along the natural cleavage planes present between the individual fibrous elements without substantial transverse breakage of the fibers, thereby forming an acceptable fraction comprising fiber aggregates of suitable size for a contemplated application, and a non-acceptable fraction comprising fiber aggregates too large for use in the said application, and separating the acceptable fraction from the non-acceptable fraction.

7. The integrated, cyclic method for continuously reducing wood to a fiber product adaptable to the manufacture of high strength, consolidated fibrous articles which comprises incising a surface of the wood transversely of the grain direction at spaced intervals, cutting away the wood between the spaced incisions, the direction of the cut also being transversely of the grain direction, thereby forming flakes having a width determined by the spacing of the incisions and each comprising an aggregate of fibrous elements disposed substantially parallel to each other and being substantially unbroken transversely, abrading the flakes to reduce their size, winnowing the

abraded flakes, thereby separating a relatively light fraction from a relatively heavy fraction, reducing the size of the particles comprising the heavy fraction by splitting them along the natural cleavage planes present between the individual fibrous elements, and winnowing the reduced material for further separation of the same into light and heavy fractions.

8. The method of reducing wood to a fiber product adaptable to the manufacture of high strength, consolidated fibrous articles which comprises cutting from the wood a plurality of flakes, the cutting being effectuated across the grain direction of the wood, each of the flakes comprising an aggregate of fibrous elements disposed substantially parallel to each other and being substantially unbroken transversely, abrading the flakes to reduce their size, and winnowing the abraded flakes, thereby separating a relatively light fraction from a relatively heavy fraction.

9. The method of reducing wood to a fiber product adaptable to the manufacture of high strength, consolidated fibrous articles which comprises cutting from the wood a plurality of flakes, the cutting being effectuated across the grain direction of the wood, each of the flakes comprising an aggregate of fibrous elements disposed substantially parallel to each other and being substantially unbroken transversely, abrading the flakes to reduce their size, winnowing the abraded flakes, thereby separating a relatively light fraction from a relatively heavy fraction, and reducing the size of the particles comprising the heavy fraction by splitting them along the natural cleavage planes present between the individual fibrous elements.

10. The apparatus for the production of crosscut lignocellulose fibers suitable for the production of consolidated fibrous products which comprises in combination cutting means for forming crosscut flakes of lignocellulose material, conduit means positioned for collecting the flakes, entraining means positioned for receiving the flakes from the collecting means and for entraining them in a gaseous stream, attrition means stationed for receiving the entrained flakes and for splitting at least a portion of the flakes along the natural cleavage planes present between the constituent fibers thereof, substantially without breaking the fibers transversely of their length, and winnowing means positioned for receiving the gaseous stream emanating from the attrition means and for dividing it into two streams, one entraining flakes of a first predetermined size, and the other entraining flakes of a second predetermined size.

11. The apparatus of claim 10 wherein the attrition means comprises a fan through which the flakes are passed and included in the entraining means.

12. The apparatus for the production of crosscut lignocellulose fibers suitable for the production of consolidated fibrous products which comprises in combination cutting means for forming crosscut flakes of lignocellulose material, conduit means positioned for collecting the flakes, entraining means positioned for receiving the flakes from the collecting means and for entraining them in a gaseous stream, attrition means stationed for receiving the entrained flakes and for splitting at least a portion of the flakes along the natural cleavage planes present between the constituent fibers thereof, substantially without breaking the fibers transversely of their length, winnowing means positioned for receiving the gaseous stream emanating from the attrition means and for dividing it into two streams, one entraining flakes of a first predetermined size, and the other entraining flakes of a second predetermined size, and fraction cutting means positioned for separating and collecting separately the flakes of said first and second predetermined sizes.

13. The method of reducing wood to a fiber product adaptable to the manufacture of high strength, consolidated fibrous articles which comprises cutting from the wood a plurality of flakes, the cutting plane being parallel to and the cutting traverse being across the grain direction of the wood, the flakes comprising aggregates of fibrous elements disposed substantially parallel to each other and being substantially unbroken transversely of their length, abrading the flakes to reduce their size by splitting them along the natural planes of cleavage present between their constituent fibrous elements, and separating the abrading flakes into fractions of relatively large and small particle sizes.

14. The apparatus for the production of crosscut lignocellulose fibers suitable for the production of consolidated fibrous products which comprises in combination cutting means for forming crosscut flakes of lignocellulose material, collecting means positioned for collecting the flakes, attrition means stationed for receiving the flakes from the collecting means and for splitting at least a portion of them along the natural cleavage planes present between the constituent fibers thereof, substantially without breaking the fibers transversely of their length, and separating means positioned for receiving the split flakes from the attrition means and for separating them into two fractions, one comprising flakes of a first predetermined size and the other comprising flakes of a second predetermined size.

15. The apparatus for the production of crosscut lignocellulose fibers suitable for the production of consolidated fibrous products which comprises in combination cutting means for forming crosscut flakes of lignocellulose material, collecting means positioned for collecting the flakes, attrition means stationed for receiving the flakes from the collecting means and adapted to split at least a portion of them along the natural cleavage planes present between the constituent fibers thereof, without substantial breakage of the fibers transversely of their length, and winnowing means positioned for receiving the reduced flakes from the attrition means and for separating them into two fractions, one comprising flakes of a first predetermined size and the other comprising flakes of a second predetermined size.

16. In the process of making consolidated fibrous products, the step of reducing woody material which comprises cutting from the material a plurality of flakes, the cutting surface being substantially parallel to and the cutting traverse being substantially perpendicular to the grain direction of the material, and separating from the flakes component fibrous elements thereof by breaking the flakes along the natural cleavage planes present between the fibrous elements, while preserving the fibrous elements substantially unbroken transversely of their length.

17. In the process of making consolidated fibrous products, the step of reducing woody material which comprises cutting from the material a plurality of flakes, the cutting surface being substantially parallel to and the cutting traverse being substantially perpendicular to the grain

direction of the material, and dividing the flakes into fiber bundles by breaking them along the natural cleavage planes present between their component fibrous elements, while preserving the fibrous elements substantially unbroken transversely of their length.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
201,938	Nickerson	Apr. 2, 1878
324,387	Jones	Aug. 18, 1885
1,046,130	Widdis	Dec. 3, 1912
1,473,545	Collier	Nov. 6, 1923
1,587,799	Puttaert	June 8, 1926
1,883,876	Brown	Oct. 25, 1932
2,182,131	Maede	Dec. 5, 1939
2,355,512	Contratte	Aug. 8, 1944
2,380,214	Burrell	July 10, 1945
2,392,844	Fairchild	Jan. 15, 1946

Number	Name	Date
2,402,554	Irvine et al.	June 25, 1946
2,446,304	Roman	Aug. 3, 1948
2,468,321	Bland	Apr. 26, 1949
2,485,587	Goss	Oct. 25, 1949

FOREIGN PATENTS

Number	Country	Date
197	Great Britain	Jan. 25, 1856
923	Great Britain	Apr. 6, 1871
1,828	Great Britain	of 1870
20,140	Germany	Nov. 18, 1882
39,588	Germany	June 22, 1887
390,318	Great Britain	Apr. 16, 1933
568,707	Germany	Jan. 24, 1933
608,252	Great Britain	Sept. 13, 1948

OTHER REFERENCES

"Two Men Operate Crushing Plant" from Rock Products, March 1947, pages 74–75.