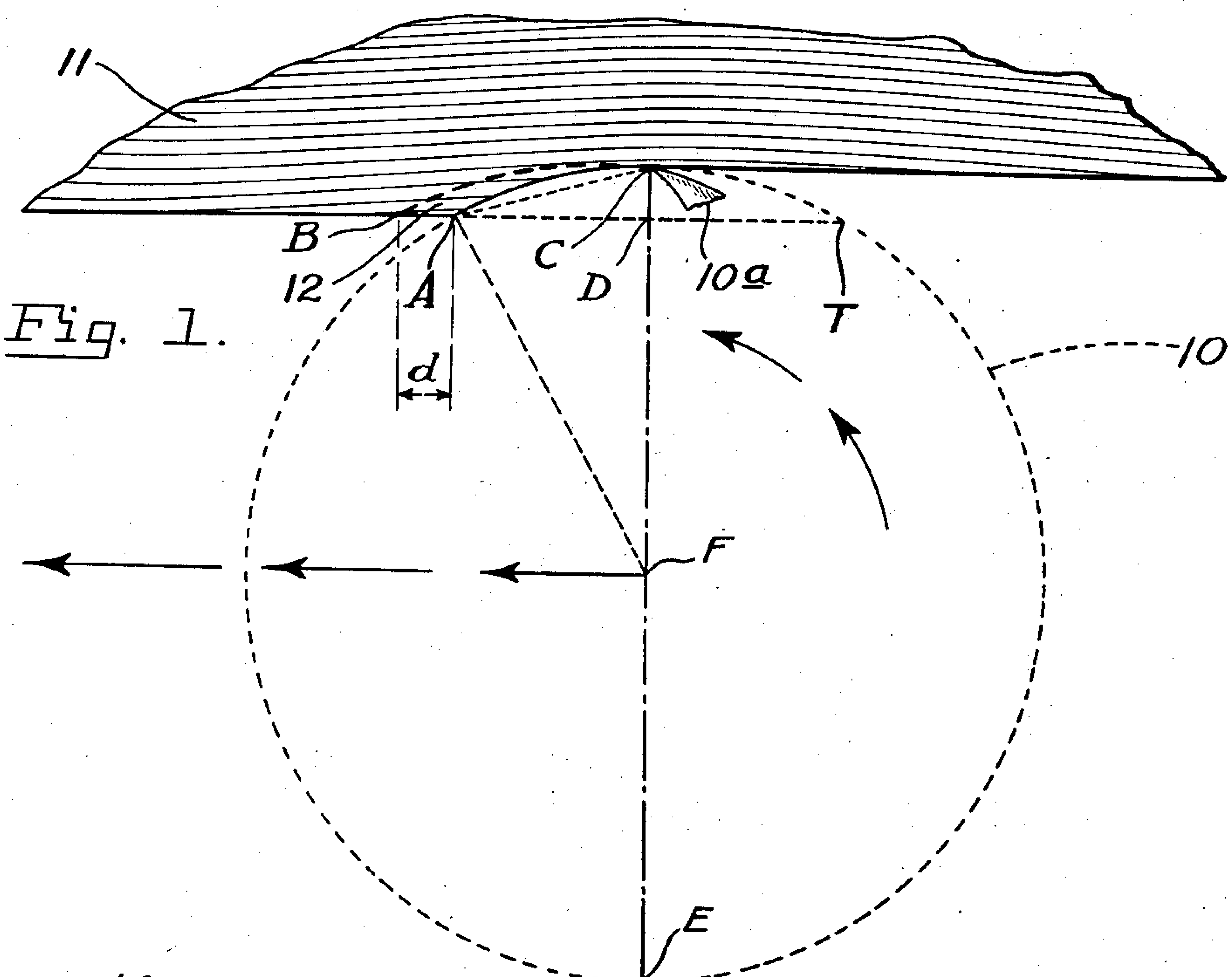

Fig. 1.

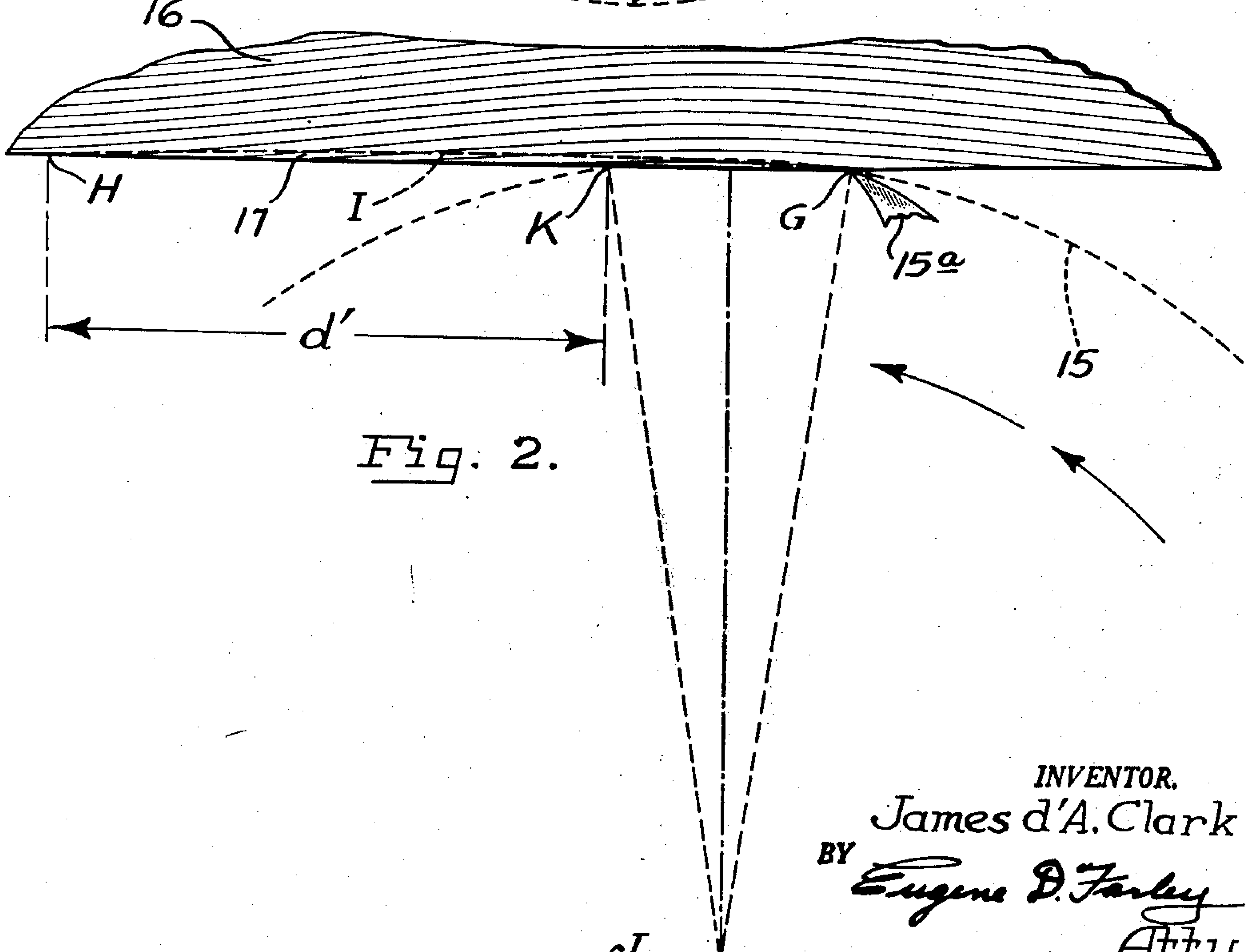

Fig. 2.

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PRODUCTION OF FIBROUS ELEMENTS FROM WOODY MATERIAL

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Fig. 3.

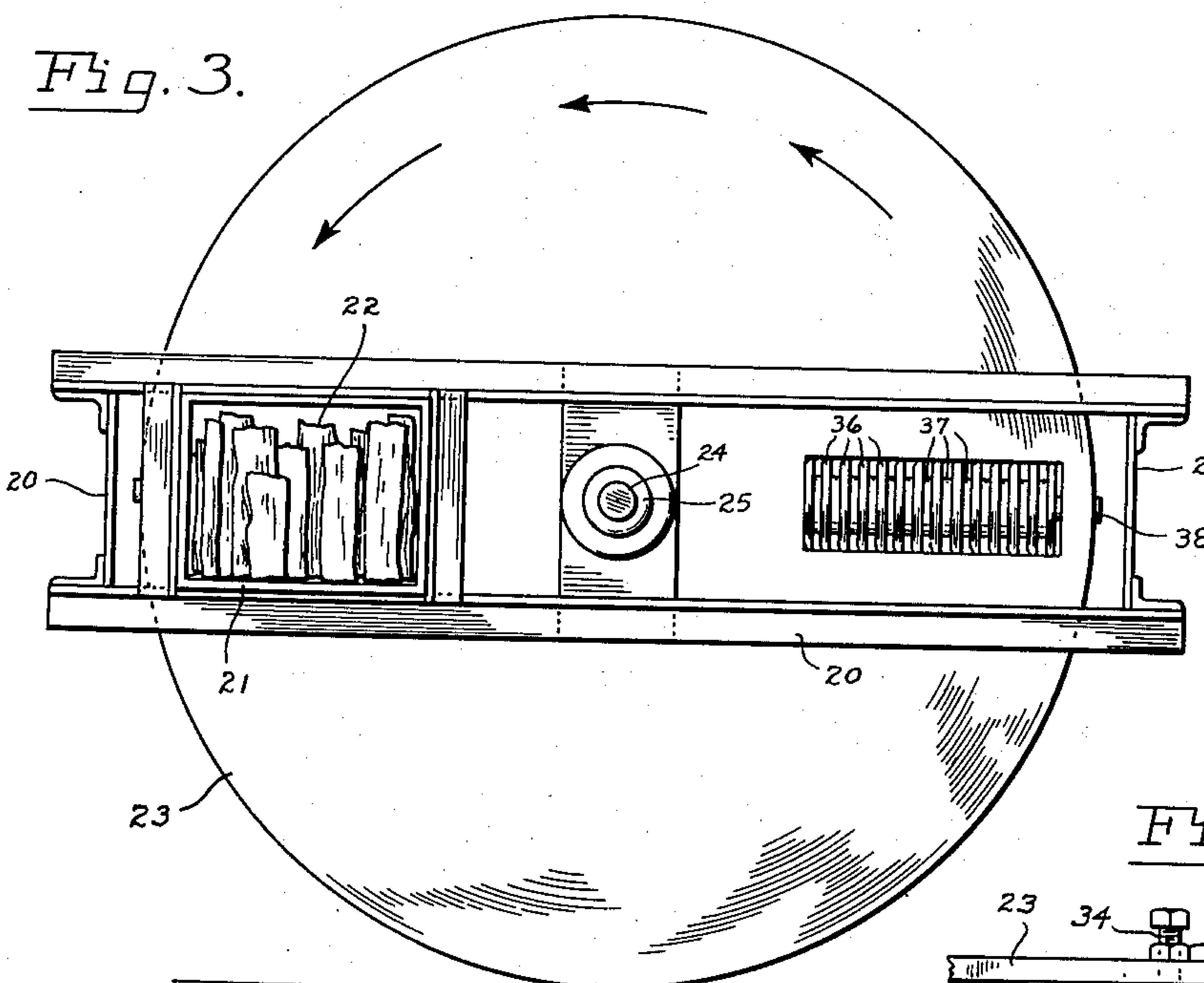


Fig. 5.

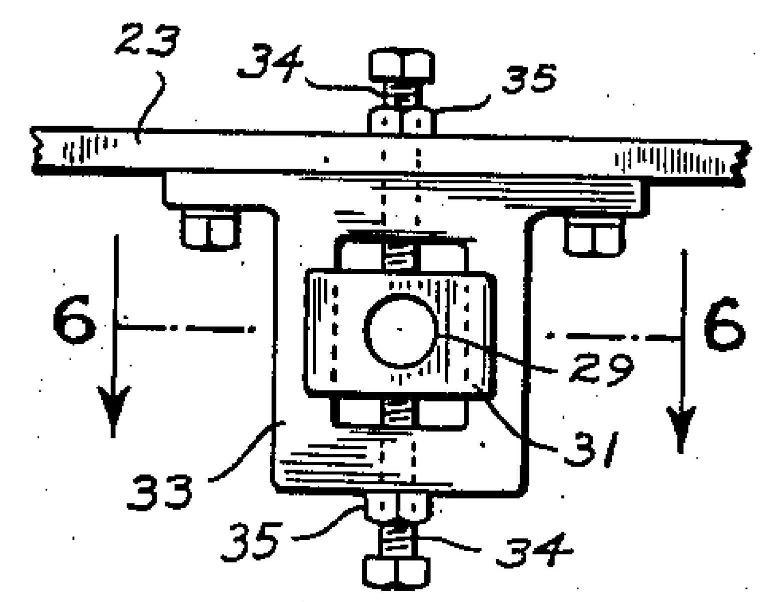


Fig. 6.

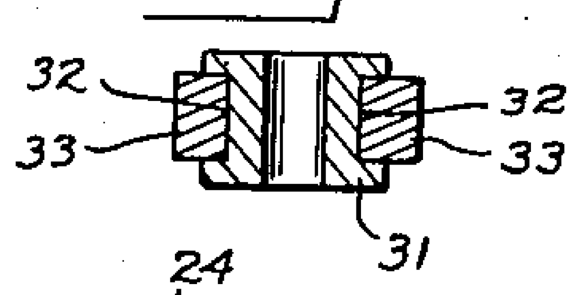


Fig. 4.

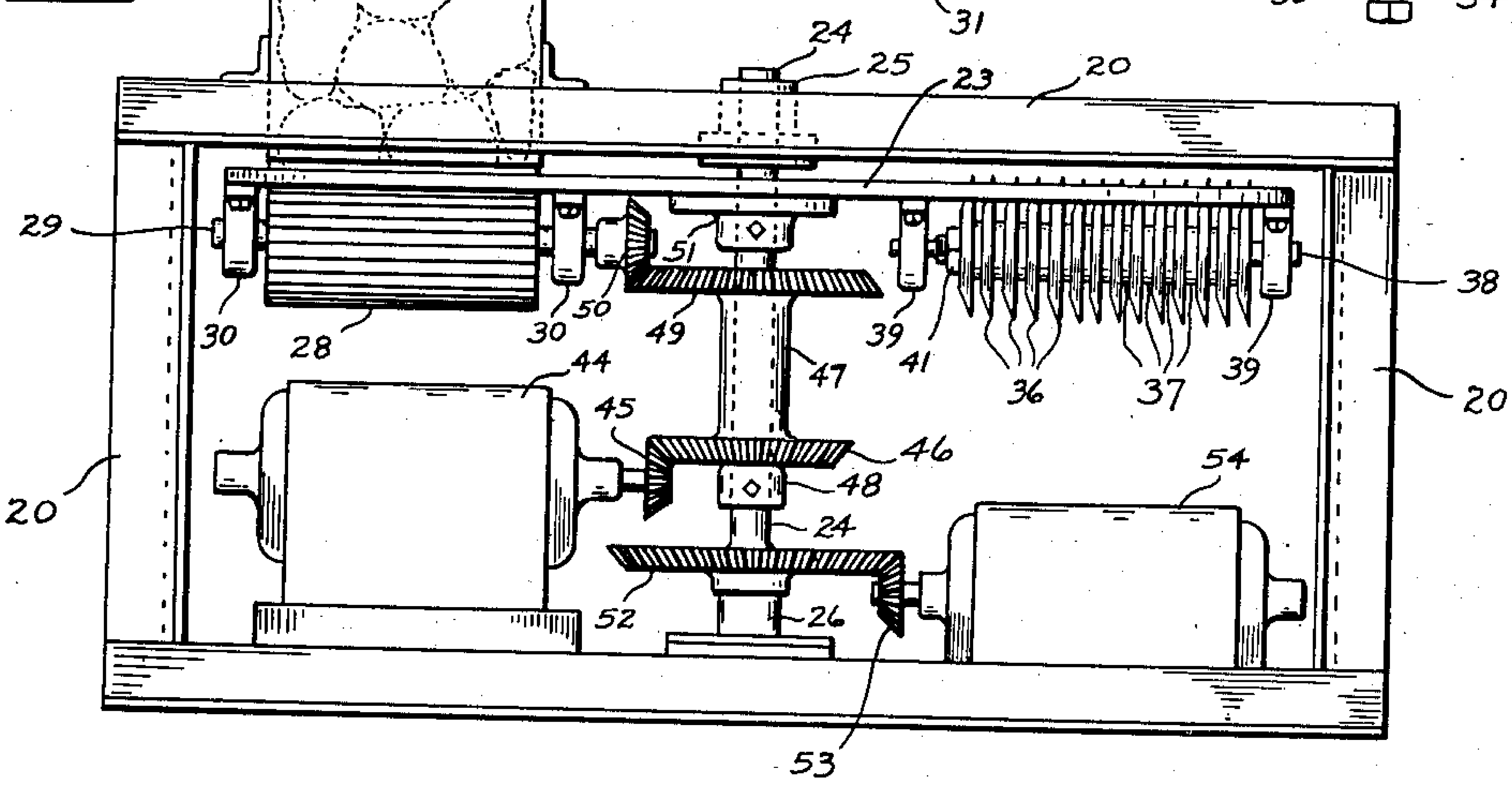
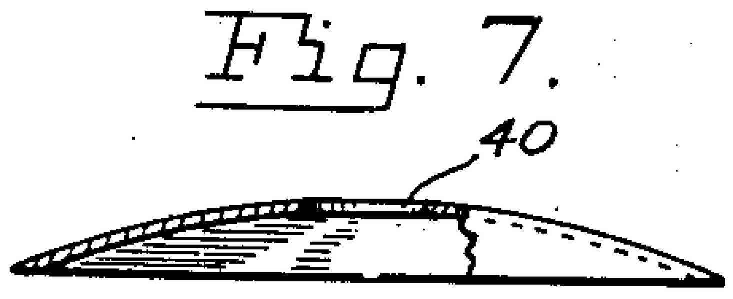


Fig. 7.



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PRODUCTION OF FIBROUS ELEMENTS FROM WOODY MATERIAL

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Application February 28, 1949, Serial No. 78,692

7 Claims. (Cl. 144—309)

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The present invention relates to a method of and apparatus for mechanically defiberizing wood and other fibrous materials. It more particularly relates to the provision of a method and apparatus by means of which long, tapered fibrous elements having controlled, uniform dimensions and being especially suitable for the composition of low density felted structures may economically and expeditiously be produced.

The present invention and its relationship to the prior art are considered herein with reference to the accompanying drawings wherein:

Figure 1 is a schematic illustration of the manner of forming fibrous element from a solid piece of wood by conventional mechanical methods;

Figure 2 is a schematic illustration of the manner of forming fibrous element from a piece of wood by the presently disclosed method;

Figure 3 is a plan view of apparatus suitable for use in the practice of the herein disclosed method of producing fibrous element from pieces of wood;

Figure 4 is a view in elevation of the apparatus of Figure 3;

Figure 5 is a detail view in elevation of a mechanism for adjusting the cutter in the apparatus of Figures 3 and 4;

Figure 6 is a sectional view of a bearing for mounting the adjusting mechanism of Figure 5; and

Figure 7 is a view in elevation partly in section of a resilient spacing element for use in the scoring mechanism of the apparatus of Figures 3 and 4.

As is well known to those versed in the fiber art, the form and dimensions of the individual fibrous elements comprising a fibrous felt are primarily determinative of the structural properties and appearance of the consolidated products fabricated therefrom. This is particularly true where the consolidated products are of low density, e. g. of a density of about 0.5 or less. The properties of the fibrous elements also are of very great significance in determining their suitability for use in the felting and consolidating mechanisms of conventional board making plants. If they are too long in relation to their width or thickness, they tend to mat together so that their conversion into a felt of uniform thickness is difficult. If, on the other hand, they are too short in relation to their width or thickness, they do not interlace well during the felting and consolidating operations and a product of low strength is produced. If the length of the fibrous elements is cut at an angle to the grain

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of the wood, instead of strictly parallel to the grain, the individual fibrous elements are intrinsically weak and easily broken. This fact again tends to make a weak consolidated product. If the fibrous elements are of non-uniform dimensions in any respect from batch to batch, it is difficult if not impossible to produce a series of consolidated products of reproducible strength and other properties. If the ends of the fibrous elements are square or blunt, they do not intertwine well, and the surface of the consolidated product is not as smooth as where the fibrous element ends are gradually tapered to a point.

Although mechanisms for converting wood to fibrous elements by contacting it with one or a plurality of cutting elements have the advantages of simplicity of construction, high capacity, and economy of operation, the conventional mechanisms of this class uniformly possess the disadvantage of not producing a fiber product having the controlled, uniform dimensions necessary to the production of consolidated products of optimum properties as described above. Thus, it is well known reciprocally to traverse wood blocks lengthwise against a rotary cutter which may comprise a large number of needles suitably mounted about a common axis and rotated at high speed. This apparatus gives very little control over the length, width, or thickness of the fibrous elements produced, and the fibrous element character changes with the direction of the traverse and with wear of the needle points during use of the machine.

Similarly, excelsior type fibrous element has been produced by traversing wood blocks with respect to serrated cutter blades which plane off fine filaments having the same length as the blocks. Alternatively, the blocks may be scored longitudinally and passed across a continuous knife which planes off the filaments. This type of apparatus gives control over the width and thickness of the fibrous elements but not of their length; and auxiliary means are required to shorten the long filaments. Such auxiliary shortening means furthermore, may be of impractical construction, or, if practical in operation, produce short fibrous elements having square cut ends. As is brought out above, fibrous elements of this character do not lend themselves well to the production of consolidated products of acceptable properties.

In still another type of mechanical defibrator, and one which is of particular interest in connection with that disclosed herein, the face of a wood block is scored in a preliminary operation, after which it is passed across a planing head or other rotary cutter, which forms fibrous elements by shaving off the scored face of the block. In a modification of this type of apparatus, the use of a prescoring operation is eliminated by employing a cutter consisting of multiple circular saws bolted together upon a common axis. In apparatus of this type, the width of the fibrous elements is controlled by the spacing of the scoring in the one embodiment or to some degree by the thickness of the individual saw blades in the other. However, since it is conventional practice to pass the wood block across the cutter face at a traversing speed which is negligible as opposed to the peripheral speed of the cutter, i. e. at a traversing speed of usually considerably less than about 200 linear feet per minute as opposed to a peripheral cutter speed of the order of about 6,000 linear feet per minute, the thickness and length of the fibrous element produced are functions solely of the diameter of the cutter and the depth of the cut. This will be more apparent from a consideration of Figure 1.

In Figure 1, the numeral 10 represents the periphery of a rotary cutter rotating in the indicated direction. Upon traversal of the cutter by a piece of wood 11 at the conventional low rate of speed, as compared with the high peripheral speed of the cutter, a tooth *10a* of the latter will cut from the piece of wood a fibrous element 12 having the illustrated configuration ABC. The length (AD, approximately) of the fibrous element produced in this manner will be determined by the diameter (DE, approximately) of the cutter and the depth (CD) of the cut. It will be approximately equal to the square root of the product of the depth of cut and the cutter diameter, since, by familiar geometrical principles:

$$AD \times TD = DE \times CD$$

or

$$(\text{Fibrous element length})^2 = \text{cutter diameter} \times \text{depth of cut}$$

and

$$\text{Fibrous element length} = \sqrt{\text{cutter diameter} \times \text{depth of cut}}$$

It will be apparent further that a fibrous element so cut will be tapered at one end only, the other end being relatively thick and chunky. Also, the grain of the wood will, on the average, lie at an angle CAD to the fibrous element so cut and thus make it intrinsically weak. Variations in fibrous element length to meet varying product specifications will be impossible to obtain except by varying the cutter diameter or depth of cut taken. However, it will be seen that the deeper the cut, the more the fibrous element will lie across the grain of the wood rather than parallel thereto with the result that it will be weaker and more wedge shaped, with one end very blunt, when deep cuts are made.

For the foregoing reasons, it would be desirable to provide a method of and a rotary cutting apparatus for producing fibrous elements which are relatively long as compared with their thickness, which are cut substantially parallel to the grain of the wood, and which have tapered ends. It would further be desirable to provide a method of and apparatus for defiberizing wood in which the width and thickness as well as the length of the fibrous elements produced may be controlled to within predetermined limits to form fibrous elements which are of optimum shape and characteristics for various applications, particularly the fabrication of low density boards. It would also be desirable to provide an apparatus in which fibrous elements of controlled dimensions may be produced, economically, continuously, in large volume, and with a minimum production of wood dust, slivers, and fibrous elements of random shape.

In accordance with the present invention, the foregoing and other objects are attained by traversing the wood and a rotary cutter relative to each other at a speed which is at least comparable to the peripheral speed of the cutter. Thus, whereas it is conventional practice to traverse the wood at a linear speed of less than about 200 feet per minute using a cutter having a peripheral speed of more than about 5,000 feet per minute, in the practice of the present invention the traversal speed of the wood is increased to at least one-tenth preferably at least one-fifth of the peripheral speed of the cutter, for example 500 to more than 1,000 feet per minute where the cutter peripheral speed is 5,000 feet per minute. When such is the case, each cutting edge exerts a pronounced planing effect along the grain of the wood in addition to its normal cutting action, and the fibrous element produced is elongated correspondingly.

The shape of the fibrous element produced by the present method is illustrated in Figure 2, wherein a rotary cutter 15 is depicted traversing the piece of wood 16, the tooth *15a* engaging the wood to produce fibrous element 17 having the configuration GHI. It will be noted that the fibrous element 17 is relatively long and thin, tapered at both ends and with a major proportion cut substantially parallel to the grain. Its maximum thickness equals the depth of cut made by each tooth. Furthermore, its length is equal to the square root of the product of its thickness times the cutter diameter, as developed above, plus a substantial traversing speed. The effect of this increased traversing speed will be evident from a comparison of Figures 1 and 2. In the conventional method of Figure 1, the cutter engages the wood as it rotates through the angle AFC to produce the fibrous element 12. During this time, the traverse of the wood relative to the cutter is represented by the distance *d*, which adds but little to the fibrous element length. In the method of the present invention, as illustrated in Figure 2, the cutter engages the wood as it rotates through the angle GJK to form fibrous element 17. During this time the traverse of the wood equals the distance *d'*, which adds considerably to the length of the fibrous element.

Since the length now has become a substantial function of the traversing speed, a convenient means is afforded for controlling the fibrous element length by varying the rate of traverse relative to the cutter speed. To increase the fiber length, all that is necessary is to increase the traversing speed or decrease the peripheral speed of the cutter, or both. Conversely, to decrease the fibrous element length, the traversing speed may be decreased, the cutter speed increased, or both. This offers a simple but very effective manner of controlling the fibrous element length to any desired degree.

Not only may the fibrous element length be controlled by the practice of the present invention, but precise control also is afforded of the fibrous element width and thickness. The width may be controlled by scoring the wood in advance of the cutter, the desired width being obtained by selective spacing of the elements of the scoring device. Alternatively, it may be controlled by employing in place of a continuous cutter one which comprises a plurality of circular saws or cutting elements bolted or otherwise secured to a common axis. In this case, the fibrous element width will be determined to some degree by the thickness of the cutting elements. The fibrous element thickness may be controlled by varying the setting of the cutter to take either a light, intermediate, or heavy cut as desired. In this manner, there may be produced a fibrous element of variable but controlled and uniform dimensions which is best suited to conform to predetermined specifications.

The apparatus whereby fibrous element of the above described controlled dimensions of length, thickness and width may be produced broadly comprises means for holding one or more pieces of wood, a rotary cutter, and means for traversing the wood and the cutter relative to each other at a rate which is at least comparable to the peripheral speed of the cutter, being at least one-tenth of the latter. Suitable apparatus is illustrated in Figures 3 to 5 of the drawings, to which attention now is directed.

In the apparatus of these figures, a frame work **20** of suitable construction supports a hopper **21** adapted to contain a plurality of pieces of wood **22**. The hopper may be of any desired dimensions as determined principally by the size of the wood pieces it is designed to accommodate, and is open at the top and at the bottom. To support the wood within the hopper and also to provide a mounting for the cutter, there is provided the horizontal disc or table **23**. This is mounted rotatably upon the vertical shaft **24** journaled at its upper end in the bearing **25** and at its lower end in the pedestal bearing **26**. Table **23** preferably has a relatively large radius in comparison with the length and width of the hopper so that the wood in the latter will be cut substantially parallel to the grain.

Attached to the table **23** are the cutting elements for reducing to fibrous element the wood contained in the hopper. These may comprise a plurality of individual cutting elements secured to a common shaft, this being of known construction and not illustrated. If very fine fibrous elements are desired, the cutter may consist of an abrasive wheel or of a cylinder covered with abrasive paper. In this case, each of the abrasive particles serves as an individual cutter which shaves off a thin fibrous element having a thickness and width determined substantially by the size of the abrasive particles. Illustrative of a suitable abrasive cutter is one comprising a cylinder covered with floor surfacing emery paper having 20 mesh grit spaced on the average about 3.5 mm. apart. At low traversing speeds such a cutter produces a kind of wood flour or sander dust not well suited for use in the manufacture of fibrous boards. At the high traversing speeds disclosed herein, however, it produces elongated fibrous elements of superior board making properties. This will be apparent from a consideration of the examples given below.

Alternatively, the cutter may comprise a continuous rotary cutter operated in conjunction with a scoring device as illustrated in the drawings (Figures 3 and 4). In the embodiment illustrated, the cutter **28** consists of a cylinder on a shaft **29** and having on its periphery a plurality of continuous, longitudinally disposed cutting edges of suitable size and pitch. Rotatable mounting of the cutter is secured by attachment

of the shaft **29** in bearings **30—30** which may be bolted or otherwise secured to the under side of the table **23** preferably so as to be adjustable with respect thereto. Its length is substantially coextensive with the width of the hopper **21** and its upper edge extends upwardly through an opening of suitable dimensions in the table **23**. Since the wood in the hopper is supported by the table, the distance to which the cutter projects above the upper surface of the table determines the depth of cut taken in the wood and hence the thickness of the fibrous elements. The extent of cutter projection may be varied in any suitable manner, as by means of jack screws (Figures 5 and 6). In this construction, the cutter shaft **29** is journalled in bearings **31** provided with guideways **32**, **32** and slidably mounted on brackets **33** bolted to the table **23**. The bearings **31** are held between screws **34**, **34** with lock nuts **35**, **35**. Hence, by adjustment of the screws, it is possible to vary the setting of the cutter as desired.

The scoring device which cooperates with the cutter **28** may be of any suitable construction and may comprise for example a plurality of circular disks **36** having cutting edges and separated by a plurality of spacing elements **37**. Both cutting disks and spacing elements may be mounted slidably on the common shaft **38** journalled in the bearings **39**, **39** which are attached to the under side of the table **23** by means of bolts or other suitable means. The scoring disks **36** project upwardly through an opening of appropriate size and disposition in the table **23**. The depth of the scoring thus is dependent upon the amount by which the scoring disks extend above the table. Its spacing is determined by the distance apart of the disks, which, in turn, is determined by the thickness thereof and also the thickness of the spacing elements **37**. By changing either of these variables, the distance apart of the scoring may be varied as desired.

To secure adjustment of the distance between the cutting disks and the scoring mechanism without rebuilding it or replacing it, there may be provided resilient spacing elements which by proper means may be compressed or expanded to move the cutting disks closer together or farther apart respectively. The spacers may be constructed out of a material such as natural or synthetic rubber which inherently is resilient, or from metal, using a construction designed to impart the desired resiliency. Thus they may consist of perforated, thin, cupped metal disks **40** (Figure 7) which are compressible and expansible upon the application and release of pressure. Such pressure may be applied through any suitable means, as by means of a nut **41** threaded onto the shaft **38** of the scorer. Such a nut may be provided at one end only of the shaft, as shown, or one may be provided at each end. Taking up on the nut compresses the resilient spacers and moves the cutting disks closer together. Releasing the nut allows expansion of the resilient spacers and corresponding separation of the disks. Obviously in this construction the entire scoring unit should be made sufficiently long so that it is at least as long as the bottom of the hopper even when the resilient spacers are compressed by the maximum amount.

The cutter **28** may be driven either directly or indirectly by means of any suitable prime mover, for example by cutter motor **44** the shaft of which is attached to the miter gear **45**. The latter drives the miter gear **46** attached to the sleeve **47** which is freely rotatable about the vertical shaft **24** and is supported by the thrust bearing collar **48**. Also attached to the sleeve **47** is the miter gear **49** which drives the miter gear **50** secured to the shaft **29** of the rotary cutter. Hence operation of the cutter motor drives the cutter at a speed determined by the speed of the motor as well as by the ratios of the various gears in the linkage.

Rotation of the table **23** and hence of the cutter **28** and scorer mounted thereon may be obtained by securing the table directly to the vertical shaft **24** by means of the collar **51**. Also attached to the vertical shaft **24** is the miter gear **52**, which cooperates with the gear **53** on the shaft of the motor **54**. Hence operation of the table motor **54** rotates the table **23** at a speed determined by the gear ratios and motor speed.

In operation, a plurality of blocks of wood are placed in the hopper **21**. These may be of random length and shape, since their weight causes them to bear down on the top of the table sufficiently so that the cutter may engage them, and since the rotation of the table against which they rest serves to abut all of them against a common wall of the hopper as shown particularly in Figure 3. The cutter motor **44** and the table motor **54** then are started and operated at relative speeds such that the table will traverse the wood at a rate which is at least one-tenth of the peripheral speed of the cutter. Obviously the direction of rotation of the table should be in the direction of motion of the cutting edges of the cutter. Thus where the motion of the latter is clockwise viewed facing the left-hand side of the apparatus in Figure 4, the motion of the table as viewed from above should be counterclockwise.

As the cutter and the scorer traverse the wood, fibrous elements will be produced which drop down below the cutter into suitable, well known collecting apparatus such as a duct leading to the intake of a conveyor fan (not shown). As the production of fibrous elements continues, the blocks of wood within the hopper feed downwardly by gravity and are replenished as necessary. If it is desired to increase the capacity of the apparatus, a plurality of cutters and scorers may be mounted on the table **23** so that all operate upon the wood within the hopper as the table rotates. Furthermore, a plurality of hoppers may be stationed at suitable intervals around the frame **20** above the table, so that a maximum wood surface is presented to the cutters.

The dimensions of the fibrous element produced may be controlled in the manner indicated above. Thus the fibrous element length may be varied by varying the relative speed of the table and of the cutter. To increase the fibrous element length, the table motor may be accelerated, the cutter motor decelerated, or both. Conversely, to decrease the fibrous element length the rate of the table motor may be decelerated, the speed of the cutter motor accelerated, or both. To secure maximum production from the apparatus, it is preferred to drive either the cutter motor or the table motor at its maximum practical speed, the other motor being adjusted as necessary to produce the desired speed ratio. The fibrous element width and thickness also are easily controlled, the former being adjusted by varying the spacing between the disks on the scorer, and the latter being regulated by varying the depth of cut made by the cutter.

Thus by the present invention there is provided for the first time an apparatus for reducing economically large volumes of scrap wood into fibrous elements all of the dimensions of which may be determined as desired. The fibrous elements, moreover, are relatively elongated, tapered on both ends, and cut substantially parallel to the grain. These properties make them admirably suited to the fabrication of a variety of felted and consolidated wood products such as resilient fibrous blankets and the various grades of fiber board, particularly the softer grades. Their significance in determining board properties is illustrated in the following examples in which are compared the properties of insulating boards made from the convention fibrous elements produced mechanically by means of a cutter and scorer traversing wood blocks and the long, tapered fibrous elements produced by the herein described method of traversing the wood at a speed comparable to the peripheral speed of the cutter.

In all cases, the boards were made by reducing the kiln dried wood to fibrous elements under the specified conditions, mixing the fibrous element with enough water to give 15% by weight of moisture, and thoroughly mixing with 5% by weight of liquid (40% solids) phenolic resin, and sifting the material through a coarse screen into a mold to give a uniform layer of material. The resulting mat was pressed between heated platens at 350° F. for 15 minutes with sufficient pressure to give a product having a thickness of ½ inch.

Example 1

Kiln dried Douglas fir was reduced to fibrous elements using a rotary cutter having continuous blades set to make a cut 0.015 inch deep and operated in conjunction with a scoring device which scored the surface of the wood ahead of the cutter at intervals of 0.015 inch. The peripheral speed of the cutter was 2,520 feet per minute, and the traversing speed of the wood relative to the cutter was 656 feet per minute. The fibrous elements produced were long, thin, and tapered at both ends. Boards made therefrom in the manner described above had a rupture modulus of 410 pounds per square inch at densities of 0.33. A board made from fibrous elements produced on the same apparatus and in the same manner but employing a traversing speed of only 60 feet per minute and the same cutter speed had a modulus of rupture of only 225 pounds per square inch at the same density.

Example 2

Kiln dried Douglas fir was reduced to fibrous elements using as a rotary cutter a surfacing wheel covered with 20-mesh emery grit having a spacing on the average of 3½ millimeters. There was no prescoring. As in Example 1, the peripheral speed of the cutter was maintained at 2,520 feet per minute and the traversing speed at 656 feet per minute. A uniform, hair-like fibrous element about 0.004 inch thick and 0.004 inch wide which was elongated and tapered at both ends was produced. As opposed to the fibrous elements of Example 1 which were curled, this fiber was substantially straight. When made into board, it had a rupture modulus of 405 pounds per square inch at a density of 0.33.

When the above abrasive cutter was operated at the same peripheral speed and a traversing speed of only 60 feet per minute, short fibrous elements resulted which upon being made up into board by the procedure described above, produced a board having a modulus of rupture of only 245 pounds per square inch at the same density.

Hence by an evaluation of the data presented in the foregoing examples, it is apparent that application of the long, tapered fibrous elements of the present invention to the fabrication of insulating boards has a significant and advantageous effect on the strength of the boards. By their use, boards may be made having rupture moduli nearly double those of boards prepared under identical conditions from conventional fibrous elements. This fact obviously is of the greatest significance in determining the commercial utilization of the boards.

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

1. The method of producing fibrous elements tapered at both ends and cut substantially parallel to the grain of the wood which comprises traversing pieces of wood and a rotary cutter relative to each other at a traversing speed of at least one-fifth of the peripheral speed of the cutter, the direction of the traversal being substantially uniformly against the direction of cutter rotation.

2. The method of producing fibrous elements tapered at both ends and cut substantially parallel to the grain of the wood, and of controlled length and width, which comprises prescoring the surface of the wood at a spacing corresponding to the width of the fibrous elements desired, and traversing the scored wood relative to a rotary cutter at a traversing speed of at least one-fifth the peripheral speed of the cutter, the direction of the traversal being substantially uniformly against the direction of cutter rotation.

3. The method of producing fibrous elements tapered at both ends and of controlled length, width, and thickness which comprises placing a piece of wood on the surface of a supporting structure through which projects the cutting surface of a rotary cutter, adjusting the extent of projection of the cutting surface above the support and thereby determining the thickness of the fibrous elements produced, prescoring a surface of the piece of wood at predetermined intervals and thereby determining the width of the fibrous elements produced, and traversing the scored wood relative to the cutter at a predetermined traversing speed which is not less than about one-fifth of the peripheral speed of the cutter, the direction of the traversal being substantially uniformly against the direction of cutter rotation, thereby controlling the length of the fibrous elements.

4. Apparatus for producing fibrous elements tapered at both ends and cut substantially parallel to the grain of the wood which comprises a rotatably mounted table, a rotary cutter mounted on the table with a surface projecting beyond the surface thereof, means on the table for holding a piece of wood with its surface pressed against the surface of the table, means operatively connected to the rotary cutter for driving the same, means operatively connected to the table for rotating the same, whereby to traverse the wood across the cutter, and means for controlling the speed of the cutter and of the table so that the traversing speed is at least one-fifth the peripheral speed of the cutter.

5. Apparatus for producing fibrous elements tapered at both ends and cut substantially parallel to the grain of the wood which comprises a frame, a table rotatably mounted on the frame, a rotary cutter mounted on the table with its surface projecting beyond the surface thereof, a scoring means mounted on the table with its surface projecting beyond the surface thereof on the same side as the surface of the rotary cutter, means on the table for holding a piece of wood with its surface pressed against the table surface, means operably connected to the rotary cutter for driving the same, means operably connected to the table for rotating the same whereby to traverse the wood first across the scorer and then across the rotating cutter, and means for controlling the speed of the cutter and the table so that the traversing speed is at least one-fifth the peripheral speed of the cutter.

6. The apparatus of claim 5 wherein the wood holding means comprises a hopper superimposed upon the table with its bottom open and adapted to contain a plurality of pieces of wood which rest upon the rotating table and hence contact the scoring means and rotary cutter.

7. Apparatus for producing fibrous elements tapered at both ends and cut substantially parallel to the grain of the wood which comprises a substantially horizontal table, a hopper positioned above the table and opening onto the same, a rotary cutter mounted beneath the table and extending upwardly through an opening in the same, the opening in the table being aligned with the opening in the hopper, a pivotally mounted vertical shaft affixed centrally to the table, motor means connected to the shaft for rotating the same, thereby traversing the rotary cutter with respect to the hopper, a sleeve mounted on the shaft and freely rotatable thereon, gear means interconnecting the sleeve and the rotary cutter, and motor means connected to the sleeve for rotating the same thereby contemporaneously rotating the cutter and reducing to fibrous elements wood contained in the hopper.

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