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3,003,911

FIBROUS AGGREGATES AND PROCESS AND APPARATUS FOR MAKING THEM

Filed April 7, 1958

4 Sheets-Sheet 1

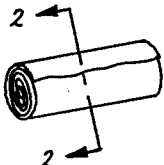


FIG. 1



FIG. 2

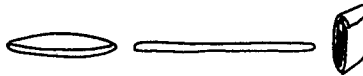


FIG. 3

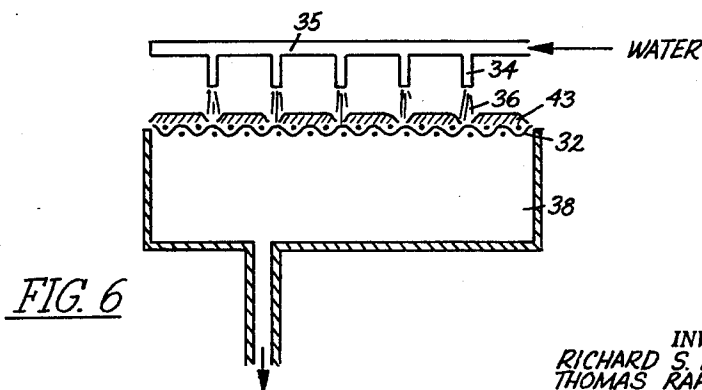
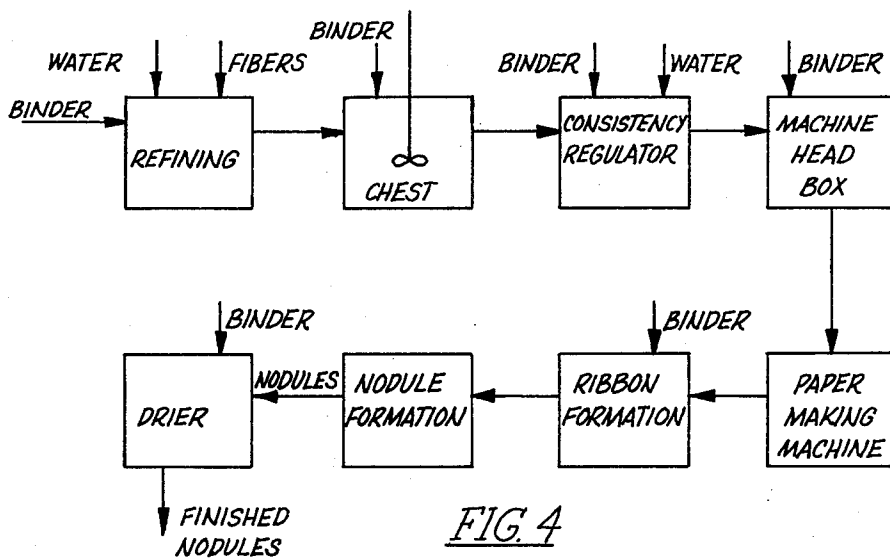


FIG. 6

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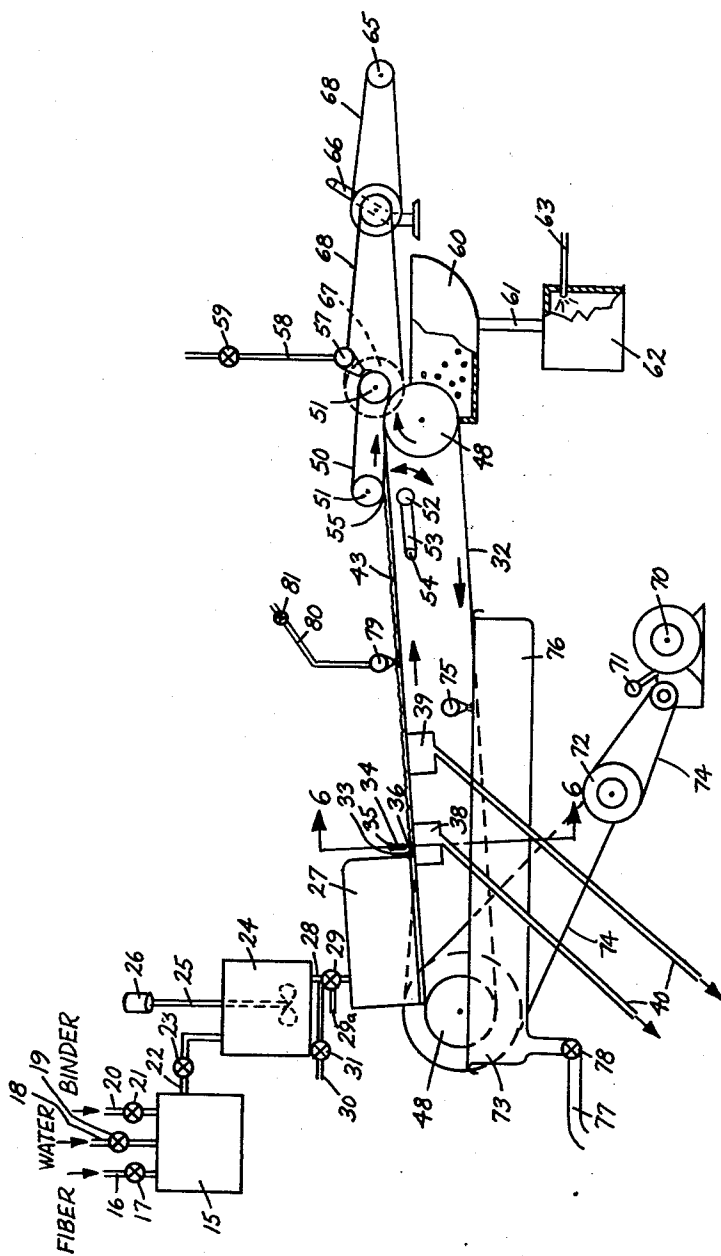


FIG. 5

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4 Sheets-Sheet 3

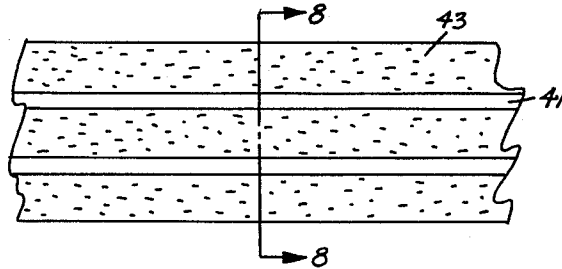


FIG. 7

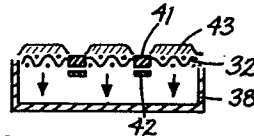


FIG. 8

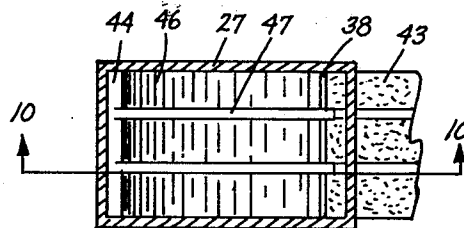


FIG. 9

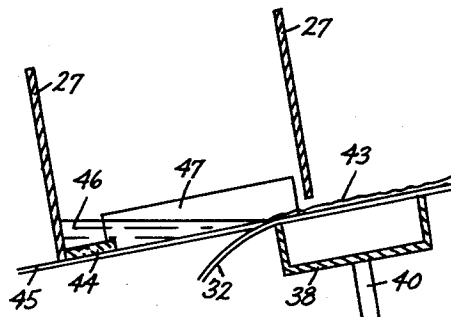


FIG. 10

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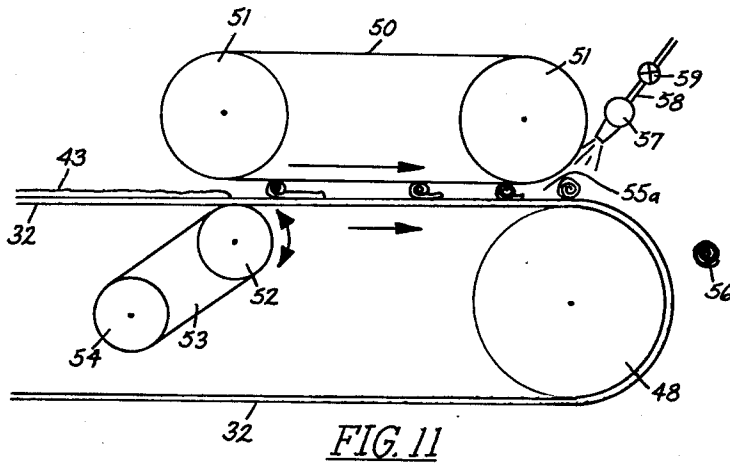


FIG. 11

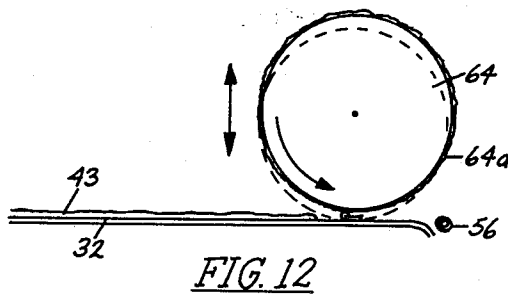


FIG. 12

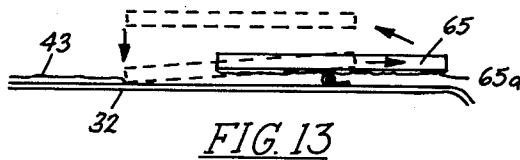


FIG. 13

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FIBROUS AGGREGATES AND PROCESS AND APPARATUS FOR MAKING THEM

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8 Claims. (Cl. 162—100)

This invention relates to the processing of fibers and more particularly to making small fibrous nodules or aggregates of controlled sizes and densities.

In the usual paper making processes the formation of randomly sized and shaped aggregates has been undesirable and many devices have been designed and processes developed to avoid their formation. In other paper-making processes the formation of aggregates has been incidental to the reduction of the cellulosic materials to fiber sizes suitable for paper making and the existence of such aggregates has been fugitive and brought about in the process of disintegration of cellulosic entities. We are not, however, aware of any attempts to make such aggregates or nodules purposely from a wet web, and to form them to specified sizes and in a manner to embody the natural bonding characteristics of fibers or to incorporate binders therein to interbond and form nodules which remain bonded.

Fibrous aggregates of relatively high densities and well-controlled sizes would have many applications among which may be listed use as a molding material which requires only sufficient binder to bond the surfaces, use as a free-flowing, inexpensive filler for plastic molded articles, and carriers for chemicals such as insecticides, internally-taken medicines

It is therefore an object of this invention to provide fibrous aggregates which remain in a sufficiently tightly-bonded nodular form to permit them to be handled and processed without exhibiting any appreciable break-up. It is a further object to form nodules or aggregates of fibrous materials which are of natural, synthetic or mineral origin. Another object is to provide fibrous aggregates which can be made in controlled sizes and densities, and which are formed in a manner to take advantage of the natural interbonding of fibrillated fibers. Another object is to provide fibrous aggregates which do not require any additional binder to keep them in a nodular form, but which may have some binder incorporated in them if desired. Still another object is to provide a process and apparatus for making fibrous aggregates in nodular form, which process and apparatus incorporate means for making nodules of graded sizes and densities. These and other objects will become apparent in the following discussion.

The term fibrous aggregates includes nodules formed of any material which may be made into fibers. Such materials include those of natural origin such as cellulose in many forms, those which are synthesized from organic polymeric materials and generally termed synthetic fibers, and those of a mineral origin, such as glass and asbestos. If the synthetic fiber can be fibrillated, it may be treated as a cellulosic fiber and formed into nodules without the addition of any binder.

The cellulosic materials suitable for the practice of this invention include any of the forms of cellulose normally used in paper making and also contemplate the use of such waste materials as newsprint, rags, etc.

Synthetic resins which can be formed into fibers and hence are suitable for the practice of this invention include the acetates, viscose rayons, nylons, vinyls and their copolymers, acrylics, polyolefins, polyesters, zeins, and the halogenated polyolefins such as Teflon.

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Mineral fibers which can be made into nodules include those which are manufactured, such as glass fibers, and those which occur naturally such as asbestos.

For the sake of simplicity, the fiber processing and formation of aggregates will be discussed in terms of cellulosic fibers, but it is not intended to limit this invention to this type of fiber. Examples are given to illustrate the making of synthetic fiber nodules and nodules from mineral fibers, e.g., glass.

In general, this invention involves the formation of a water stock of the fibers, the introduction of the stock into a head box and thence into a paper-making machine for the formation of a wet sheet or web which is formed into long thin ribbons by any suitable means such as cutting the web by impinging water jets on it. These ribbons of wet paper are then subjected to a scuffing action which rolls lengthwise sections of the ribbons into controlled-sized aggregates. The aggregates are then removed and dried to give the nodules of the invention.

The apparatus used for forming the fibrous aggregates of this invention comprises an endless foraminous belt, means for depositing on said endless belt a wet web of fibrous material, means for forming the wet web into continuous ribbons, means for cutting the ribbons into predetermined lengths, and means for tightly winding the ribbon lengths to form interbonded fibrous aggregates.

The following description is given with reference to the accompanying drawings in which:

FIG. 1 is an enlarged, diagrammatic representation of a single typical fibrous nodule or aggregate made in accordance with the practice of this invention;

FIG. 2 is a cross-sectional representation of the nodule of FIG. 1 across lines 2—2 of FIG. 1;

FIG. 3 illustrates some modifications in the shape of the nodules of this invention;

FIG. 4 is a flow diagram of the process of the formation of the nodules of this invention;

FIG. 5 is a detailed drawing, in side view, of the apparatus used in the formation of the nodules;

FIG. 6 is a cross-section of the apparatus of FIG. 5 taken along lines 6—6;

FIG. 7 is a top plan view of a section of a modified foraminous belt suitable for forming ribbons;

FIG. 8 is a cross-sectional view of the foraminous belt of FIG. 7 taken along lines 8—8 of FIG. 7;

FIG. 9 is a top plan view of a head box modified to form wet web ribbons;

FIG. 10 is a cross-sectional view of the head box of FIG. 9 taken along lines 10—10 of FIG. 9;

FIG. 11 is a detailed drawing of the portion of the apparatus wherein the aggregates are formed; and

FIGS. 12 and 13 illustrate alternate apparatus for forming nodules.

The process of the invention may be more clearly described first with reference to the flow diagram of FIG. 4 and then with reference to the apparatus of FIGS. 5 through 11.

In preparing the fibrous material for use in nodule making the fibers should be refined by any acceptable process such as beating or milling. The length of the fiber should be determined in relation to the size of the nodule to be formed, and the maximum length of fibers in the stock can generally be defined as that which does not exceed the circumference of the final nodule or the length of the nodule. If any great quantity of fibers have lengths in excess of the circumference of the nodule to be formed, it will be difficult to roll the nodule in the tightly formed aggregate necessary; while if any great number of the fibers have lengths greater than the length of the nodule aggregate, they will tend to overlap from one to the other requiring some cutting or other separating of the nodules after formation.

The stock dilutions suitable for laying the wet web from which the nodules are to be formed may be such as to provide a furnish consistency normally employed in paper making. Thus the stock may range from about 0.1 to 1.0% fiber by weight. Higher consistencies, e.g., up to as much as about 3% may be used if very thick nodules are to be formed. Although it is possible to use consistencies of less than 0.1% fiber, it is not economically practical.

The stock, and hence the web to be made therefrom, may be loaded with fillers, opacifiers and the like which are common to paper making to the same extent that any paper making stock is loaded. Thus for example, if extremely white nodules were desired, as much as 5-10% TiO_2 by weight of total fiber may be added, preferably at the end of the beating cycle.

After the fibers have been sufficiently refined so they will form sheets and the furnish reduced to approximately the desired consistency, the water mixture is transferred to a chest where continued agitation is performed to maintain a uniform stock until further processing is carried out. The stock may then be passed through some form of control device to regulate both the flow of the stock and the concentration of the fibers therein. Such a device may be a stock control valve or a consistency regulator. The final stock is then passed into a machine head box and from there into a paper-making machine where the wet sheet is formed in a suitable apparatus such as on a cylinder or in a Fourdrinier machine. The resulting wet sheet is formed into ribbons as it is advanced on a foraminous endless belt, conveniently by the process of impinging a water jet against the wet web, the direction of water flow being at approximately right angles to the plane of the sheet. After the ribbons have been formed, they are carried along to the point of nodule formation.

Although it has been found convenient to form the ribbons by cutting the wet sheet with one or more water jets, other means of ribbon formation may be employed. Thus strips may be used on the first suction box or in the foraminous belt to mask certain areas so that the stock flowing therefrom will strike the foraminous belt to form alternating strips of web and blank or open spaces on the belt. The resulting strips or ribbons of wet web tend to be built up higher in the middle portion and result in the formation of tapered nodules. It has been found that this means for making ribbons is more adaptable where thin sheets or webs are to be rolled.

Another way of forming the ribbons necessary for nodule making comprises dividing the head box into a series of small head boxes spaced apart from each other by means of vertical walls or spacers located in the head box. This method is suitable for making relatively large thick ribbons. In addition to the various ways of forming ribbons on the foraminous belt it is possible to maintain the ribbons in a separated condition before nodule formation by providing means for picking up alternate ribbons onto a second foraminous belt and transferring them into a second nodule formation apparatus.

The width of the ribbons formed is of course related to the length of the nodules desired. It has been found impractical to work with ribbons less than $\frac{1}{16}$ inch wide. The maximum ribbon width and hence maximum length of the nodule may depend upon operating conditions, for example, the amount of drying which can be done economically. Otherwise, there is no practical maximum length on the nodule and hence on the ribbon width.

Although it is desirable to form the ribbons so that there is little or no overlapping of fibers from one to another and hence to effect a clean break between the ribbons, it is possible to permit some overlapping if means are provided to break the nodules apart after their formation.

We have found one satisfactory way of forming the nodules from the ribbons is to pass a scuffing belt or a

roughened roller over and in contact with the ribbons as they are removed forwardly on the foraminous belt. Contact between the scuffing belt, or roughened roller, and the foraminous belt is periodically broken, a procedure which serves to cut the ribbons into predetermined lengths and to complete formation of one nodule as formation of another is begun. Thus while the scuffing belt and foraminous belt are rolling a length of ribbon into a nodule, a succeeding length of ribbon is being moved forwardly in between the two belts.

Although the continuously moving scuffing belt has been found to be convenient for nodule formation, other means of rolling the wet web to form aggregates are suitable. Thus the scuffing belt may take the form of a horizontal surface which is periodically moved backward and forward, the forward movement (movement in the same direction as that of the advancing foraminous belt) being the nodule formation movement. Likewise, of course, the nodules can conceivably be rolled by hand or by a hand-operated flat rough surface moved in the manner described above for the mechanically operated flat surface.

After the nodules have been formed, they are expelled from the nodule-forming mechanism and directed into a collector by means of an air knife. The collector may be a drier or the nodules may be further transferred to a drier.

If it is desired to add a binder to enhance the interbonding character of the fibers, it may be added at one of several points of the process. Thus as is shown in FIG. 4 the binder may be added to the fibers before refining in a suitable pretreatment step, it may be added during the refining step, to the chest, or even as late as in the consistency regulator. It may also, of course, be added at several of these points. Binder may also be dusted on the web before or after the ribbons are formed or it may be applied as a coating or saturation bath to the nodules during or after the drying step.

In FIG. 5 there is shown a suitable apparatus for the production of the nodules of this invention. This apparatus comprises a beater 15 with suitable inlets for fibers, line 16 controlled by valve 17; for water, line 18 controlled by valve 19; and for binder, line 20 controlled by valve 21. Line 22, having valve 23, connects beater 15 with chest 24. Chest 24 is equipped with a stirrer 25 driven by motor 26 and is in turn connected to head box 27 by means of line 28 containing valve 29. Line 30, with valve 31, leads into line 28 and may be used to introduce binder into the system at the entrance of regulator valve 29. Line 29a permits additional water to be introduced into head box 27. A foraminous belt 32 such as that suitable for a Fourdrinier machine is supplied for the formation of web 33. Nozzles 34 (FIG. 6) leading off from a water inlet line 35 supply water jets 36 for cutting web 33. Suction boxes 38 and 39 connected by means of lines 40 to a suitable vacuum system (not shown) are supplied to more quickly draw off the water from wet web 33.

Variations in the apparatus for forming the ribbons are shown in FIGS. 7-10. In FIGS. 7 and 8 a section of a modified foraminous belt is shown having lengthwise strips 41 which effectively close the openings of the foraminous belt and prevent a suction from being formed on those portions of the belt defined by the area of the strips. The result is the formation of ribbons 43 as illustrated. Modification of the foraminous belt may be achieved by any suitable means, for example by painting the required strips on with a plastisol which would close the openings of the foraminous belt. As an alternate arrangement, the first suction box 38 may have strips 42 located along its top to block off the suction applied to the foraminous belt, thus achieving the same results. It would not be necessary to use strips on both the foraminous belt and the first suction box.

Another way in which ribbons may be formed is illus-

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trated in FIGS. 9 and 10. In this variation, the head box 27 is modified in a manner to divide it into a series of elongated, adjacent head boxes. A thin strip of rubber 44 is affixed to the after end of head box 27 and affixed to the bottom plate 45 under the level of stock 46. Appended to rubber strip 44 and aligned vertically with respect to bottom plate 45 are dividers 47 which extend forward in head box 27 beyond the level of stock 46 and to at least the point where the after end wall of first suction box 38 contacts foraminous belt 32. The vertical dividers 47 thus divide head box 27 into a number of smaller head boxes and the resulting web formed on foraminous belt 32 emerges from head box 27 as ribbons 43.

Foraminous belt 32 is driven by rollers 48 in the direction indicated by the arrows and is preferably of the endless-belt type.

The nodule-forming apparatus (FIGS. 5, 11-13) consists of a scuffing belt 50 rotating about rollers 51, and an oscillating roller 52 mounted through arm 53 to pivot pin 54 and designed to move up and down as indicated to make and break contact between scuffing belt 50 and foraminous belt 32. The length of contact between scuffing belt 50 and foraminous belt 32 can be adjusted and ends at point 55a from which point the finished nodules 56 emerge.

Contact between scuffing belt 52 and foraminous belt 32 may be made and broken by providing means for moving the scuffing belt 50 and its roller 51 vertically up and down instead of moving the foraminous belt vertically by means of the oscillating roller.

Variations in apparatus suitable for forming the nodules are illustrated in FIGS. 12 and 13 wherein a roughened roller 64 (FIG. 12) and a horizontal scuffer 65 (FIG. 13) are substituted for scuffing roll 50 (FIG. 11). The roughened roller 64 is provided with means for rotating it and means for moving it vertically (not shown), the latter movement serving to make and break the contact with the foraminous belt to cut the ribbons into the desired length for nodule formation. The horizontal scuffer 65 is provided with a roughened surface 65a and with means (not shown) for moving in the cycle indicated by the dotted lines. Nodule formation takes place when the horizontal scuffer 65 is in its lower position and moving forward in the direction indicated by the arrow.

An air knife 57 connected by line 58 (containing valve 59) to a compressed air source (not shown) is located at the end of scuffing belt 50. Collector 60 is provided for catching the nodules and drier 62 for removing residual moisture from the nodules. Drier 62 may be equipped with a sprayer 63 for flashing on a binder during the drying operation and may be connected to collector 60 by transfer line 61 if automatic removal of the nodules from collector 60 is desired.

Auxiliary equipment includes a variable-drive mechanism for moving the scuffing belt 50 at the speed desired, and a variable speed drive for driving and controlling the speed of foraminous belt 32. The variable-drive mechanism connected with the scuffing belt 50 may include a motor 65, a regulating device 66, and a drive roll 67, all suitably connected with belts 68. The variable speed drive associated with the foraminous belt 32 may include a motor 70, a regulating device 71, a control device 72 and drive roll 73, with belts 74.

A water spray 75 for cleaning the foraminous belt, a collector 76 for the white water and a line 77 with valve 78 for removing the water from the system are also provided. A spray device 79 suitable for depositing a binder in either a liquid or powder form is provided above the foraminous belt for introducing binder onto the wet web. Binder is brought into the spray device 79 from a source (not shown) by way of feed line 80 controlled by valve 81.

In the operation of the apparatus of FIGS. 5-13, fibers are introduced into beater 15, along with the sufficient quantity of water. There they are refined to the desired

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degree. From the beater 15 they are taken in the form of a water slurry or stock into chest 24. If necessary, additional water is introduced into chest 24 before the stock passes into head box 27 by way of line 28 which contains a stock flow control valve 29. Normally, however, it is preferable to add more water to the head box 27, such as by way of line 29a. From head box 27 the stock is sheeted out as a wet web 33 onto a continuously moving foraminous belt 32, and shortly after the web 33 emerges from head box 27 on foraminous belt 32, it is formed into ribbons by means of water jets 34 which depend from an overhead line 35.

In the apparatus shown in FIG. 6, it has been found preferable to use nozzles having diameters of from about 20 to 40 mills and water pressures of about 90 p.s.i.g. The water stream 36 should be a fine solid stream to achieve optimum cutting of web 33 into ribbons 43. The type of nozzle chosen will depend upon the thickness of web 33 and should be such that a reasonably clean cut of the web 33 is achieved. The distance between the end of nozzles 34 and the web 33 should be maintained at a minimum in order to achieve good ribbon formation. Preferably this distance should not be greater than 1 inch. A first suction box 38 is located under web 33 at the point where water jets 36 strike the web to form it into ribbons 43. A second suction box 39 is located forward of the first to remove an additional quantity of water and maintain the configuration of the ribbons after being formed. Suitable lines such as 40 connect suction boxes 38 and 39 to vacuum apparatus not shown. The ribbons, from which substantially all of the free or excess water has been removed, are advanced by means of the continuous foraminous belt or wire screen 32 to the point of nodule formation.

When ribbons are formed by the use of a modified foraminous belt or modified first suction box 38 (FIGS. 8 and 9), the fibers in the stock as they strike the belt are drawn away by suction action indicated by the arrows from the area of the belt defined by the strips closing the opening, leaving few if any fibers deposited above the strips. Thus the fibers build up in ribbons. In the use of the modified head box of FIGS. 9 and 10, the vertical dividers 47 insure the immediate deposition of the fibers in ribbons and the suction action insures that the fiber deposition is maintained in the form of ribbons.

In the preferred apparatus (FIG. 11) nodules are formed by periodically contacting a canvas scuffing belt 50 with the wet ribbons 43 being carried forward on the continuous foraminous belt 32. The scuffing belt rotates around rollers 51 and in the direction indicated so that the surface of the scuffing belt 50 which contacts the ribbons is moving in the forward direction of the foraminous belt 32. Periodical contact is made between scuffing roll 50 and foraminous belt 32 to cut the ribbons and hence to form individual nodules. This periodic contact is achieved by an oscillating roller 52 which moves up and down to periodically strike foraminous belt 32 and to force it to contact scuffing belt 50 at the point of introduction of ribbons 55. This periodic contacting cuts ribbons 43 into predetermined lengths, these lengths in turn determining the size of the finally formed nodules. This periodic contacting may be achieved also by providing means for moving the scuffing belt 50 and rollers 51 up and down as an alternative to moving foraminous belt 32 up and down.

The linear forward speed of the scuffing belt 50 must be greater than that of the endless foraminous belt 32. The ratio of the speed of the scuffing belt to the speed of the endless belt is so adjusted that the strip of ribbon which is cut at the time of contacting will have been completely rolled into a nodule by the time it reaches the end of the overlap of the two belts. Thus the ratio of the speeds of the belts is varied with the size of the nodule desired for any constant length of overlap of the scuffing belt and endless belt. For any given nodule size, the

shorter the contact length, the faster the scuffing belt must move to complete the formation of the nodule. Generally it is convenient to use scuffing belt speed/foraminous belt speed ratios from about 4 to 1 up to 25 to 1, the range between 4 to 1 and 10 to 1 being the preferable range.

In FIGS. 12 and 13 the scuffing belt is replaced by a roller 64 of FIG. 12 (preferably rubber), or by a horizontal scuffer 65 of FIG. 3. The movements of the roller 64 and horizontal scuffer 65 are illustrated in dotted lines. The roller and the horizontal scuffer are provided with roughened surfaces 64a and 65a, respectively.

The scuffing belt 50, roller 64 or horizontal scuffer 65, should have a roughened surface in order that a sufficient grip is obtained by the scuffing surface and the foraminous belt to roll the ribbons tightly into nodules. Thus a relatively rough canvas belt such as illustrated in FIG. 11, rubber roller with a rough surface or a horizontal scuffer with rough surface is suitable for the nodule forming operation. When canvas is used either as a belt or as a surface, it is necessary to use some means for reconditioning the nap on it, such as an air knife 57 (FIG. 11) not only to separate the formed nodules from the canvas, but also to raise the nap of the canvas and to remove any residual slime-like material therefrom before the surface passes into position to form another nodule.

The nodules are expelled at the final point of contact 55a between the scuffing belt 50 and the continuous belt 32 where air knife 57 assists in removing any nodules which might tend to adhere to the scuffing belt. The nodules may be collected in receiver 60 from which they are removed to a drier 63, either manually, or by means of transfer line 61. It may be necessary to tumble them to break any contact between two nodules or to otherwise separate any of those which have been held together by one or more overlapping fibers.

In drier 62 the remaining residual water is removed, usually to the extent required to reduce the moisture content to that which will be in equilibrium with the surrounding atmosphere or to leave a predetermined amount of moisture in the nodules. Heating may be required to activate the binder, such as converting thermosetting resins to their irreversible C-stage, vulcanizing a rubber-type binder or fusing a thermoplastic binder. The temperature and duration of such a heating step will depend upon the amount and type of binder and the amount of moisture to be removed.

The drier 62 may be equipped with a suitable spray device 63 by which a binder in any convenient liquid form may be sprayed or flashed on during the drying process. It may be preferable, under some circumstances, to remove the binder-coated nodules from the drier while they still contain some moisture. For example, a small percentage of moisture may serve as a catalyst in later activating a thermoplastic binder which had been flashed on in the drying step.

Many ways of drying the nodules may be employed. Among such drying methods may be listed air-drying, passing them into a fluidized bed type drier where maximum temperatures are maintained below that at which any appreciable deterioration of the fibers or binder takes place, exposure to a hot-gas stream, and similar drying operations. As an example, if cellulosic nodules having a phenol-formaldehyde binder and averaging in length from about 1/8 inch to one inch and having l/d ratios from about one to about 6 are to be dried, they may be air dried overnight, placed in an air-circulating oven at 200° F. for about 2 hours, passed through a fluidized bed at 300° F. for several seconds or tumbled in an air stream at 350° F. for 20 to 30 minutes.

Auxiliary equipment is supplied to drive the scuffing belt 50 and the foraminous belt 32. Variable speed driving mechanism consisting of motor 65 and its control

mechanism 66 drive the scuffing belt through roll 67 in the direction indicated; while a variable-speed drive consisting of motor 70 and controls 71 and 72 drive the endless foraminous belt 32 through roll 73. Water-spraying device 75 continuously cleans the wire screening of the foraminous belt 32. Water collected in tank 76 is removed by way of line 77. If a binder is to be added to the web, it is fed by line 80 to a suitable application device such as sprayer 79.

In the formation of the nodules of this invention, the amount of stock dilution and the stock flow rate will determine the thickness of the wet web while the width of the ribbon is controlled by the spacing of the water jets or by the other means described for the formation of the ribbons. Ribbon widths may range from about 1/16 of an inch to as long as is practical for handling in the apparatus. It is preferable that the individual ribbons 43, as they are moved forward to the point of nodule formation, be separated to the extent that no further provision must be made for breaking apart the nodules formed. However, there may be some overlapping of individual fibers from nodule to nodule.

The length of the nodule formed, as pointed out above, is a function of the ribbon width while the density is a function of the type of fibers used, the density of the web as it reaches the scuffer and of the pressure applied between the scuffer and foraminous belt. The diameter of the nodule is a function of the rate of pulsation of the oscillating roller or of the make-break contact cycle between the foraminous belt and the scuffer as well as of the rate of ribbon feed to the scuffer and the thickness of the ribbon web. Thus it will be seen that there are provided convenient parameters for controlling both the size and the density of the nodules.

The nodules thus formed may have length to diameter ratios which vary over a wide range, the ratio being usually dependent upon the use to which the nodule is to be put. Diameters ranging from 1/16 to 1/2 inch are feasible while the length to diameter ratios ranging from 0.5 to 5 or greater are possible. It will be appreciated that when l/d ratios are less than one, the nodule takes on a disk form. Where, for example, it is desired to make a free flowing material, l/d ratios are preferably between one and two.

If binders are added prior to actual nodule formation, they may amount to from about 0.5 to 50% of the total weight of the dried nodule. Binders suitable for incorporation into the nodules include those which are normally classified as thermoplastic, thermosetting, and elastomeric. In addition, binders of natural origin such as the proteinaceous materials (glues, casein and the like) may be used.

Such binders may be conveniently introduced in the form of water solutions or dispersions if mixed in before the web is formed, the form of the binder depending upon the nature of the binder. If the binder is added to the web after it is formed, it may also be introduced in the form of finely divided powder. For example, if the binder is to be introduced before web formation, a water solution of an A-stage thermosetting resin may be used; while if the resin is a B-stage thermosetting resin or a thermoplastic resin water dispersions will normally be added. In the case of elastomeric binders, they will preferably be added in the form of a latex.

The final nodules during or after drying may also be treated on the surface with a binder by any suitable technique known in the art such as spraying on, dry mixing, and the like, and this invention contemplates the formation of nodules which are at least partially surface-coated with a binder. The maximum quantity of binder applied after nodule formation will preferably be equivalent to not more than 25% by weight of the coated nodule. Such a coated nodule may be subsequently employed as a molding compound with or without additional resins.

Enlarged and somewhat diagrammatic representation

of the nodules formed by the process of this invention are shown in FIGS. 1 through 3. FIG. 1 illustrates how the nodule is formed by tightly rolling the wet ribbon into a discrete roll in such a manner that full use is made of any natural interbonding characteristics of the fiber and of any binder which may have been added. FIG. 2 is a cross-section of the nodule of FIG. 1 while FIG. 3 illustrates several different variations in shape which are possible to form in the practice of this invention.

The nodules of this invention may of course be formed from webs containing a mixture of fibers. For example, a mixture of cellulosic and acrylic fibers may be processed to form a web and nodules made therefrom.

The final nodules may be described as fibrous aggregates in the form of a tightly wound, convoluted fibrous web, the successive layers of the convoluted web being sufficiently bonded to adjacent layers to maintain the aggregate in tightly woven form. As discussed above and shown in the examples below, the necessary bonding may be achieved by the natural interbonding of fibrils, by the addition of a binder, or a combination of both of these.

The formation of nodules in accordance with the teaching of this invention may be further illustrated by the following examples in which cellulosic fibers with no binder, synthetic acrylic fibers with and without a binder and glass fibers with a binder are used to form nodules.

Example I

Waste newsprint and sufficient water to give a 2% consistency of cellulosic fibers were placed in a valley-type beater and refined by beating for one-half hour. The dispersion was transferred in a chest and sufficient water added to give a stock consistency of 0.5%. The stock was then introduced by way of a consistency regulator into a head box, without any further adjustment in consistency, and sheeted out on a foraminous belt (such as in FIG. 5) moving at the rate of 12.5 feet/minute. As the wet web moved out of the head box, water jets under 90 p.s.i.g. were impinged upon it to form ribbons approximately $\frac{1}{2}$ inch wide and $\frac{1}{16}$ inch apart. The ribbons reaching the point of contact between a canvas scuffing belt and the foraminous belt were cut into lengths of approximately $\frac{3}{4}$ inch. The ratio of scuffing belt speed to that of the foraminous belt was kept at 6/1. The nodules were permitted to air dry over night. The finished nodules averaged about $\frac{1}{2}$ inch long and about $\frac{1}{8}$ inch in diameter and had a bulk density of 0.1 gm./cc. After a prolonged period of storing they were still tightly rolled and they consistently maintained their original character.

Example II

A quantity of the nodules prepared in Example I was coated by tumbling them with a powdered phenol-formaldehyde resin. The binder pick-up averaged about 5% of the total weight of the nodules. The nodules were free-flowing and made excellent filler material for molded plastic articles.

A second quantity of the nodules of Example I was coated with a water solution of phenol-formaldehyde resin in the process of drying as indicated in FIG. 5. The total binder pick-up averaged about 20% of the final weight of the nodules. These nodules were satisfactory for molding material requiring heat activation of the binder (up to about 300° F.) in the molding process.

Example III

The procedure of Example I was repeated using synthetic acrylic fibers about 9 microns in diameter and cut to $\frac{3}{8}$ inch lengths as the charge. All conditions were the same except that the stock was refined one hour in the beater. The size of the nodules and the bulk density were the same as obtained with the newsprint charge.

Example IV

The procedure of Example I was repeated using $\frac{3}{8}$ inch glass fibers having an average diameter of 9 microns as the charge. The size and bulk density of the resulting nodules were generally the same but the nodules had less cohesive strength than those prepared from cellulose or the acrylic fibers. The glass nodules did, however, have sufficient strength for limited handling.

Example V

The procedure of Example III was followed except that sufficient starch solution was sprayed onto the wet ribbons before nodule formation to yield a dried product containing about 2% starch. The nodules produced using this starch binder had greater cohesive strength than those of Example III.

Example VI

A water stock was made up as in Example I except that glass fibers having an average diameter of 9 microns were substituted for the cellulosic fibers. A nitrile rubber latex (approximately 40% solids content) was added to the head box in sufficient quantity to produce final nodules having a binder concentration of about 15% by weight. The stock was then sheeted out, ribbons formed and nodules made in the manner described in Example I. The dried nodules were somewhat longer than those made in Example I and although they could be pulled apart lengthwise, they were sufficiently bonded to be handled without breaking and possessed better cohesive strength than the nodules formed in Example IV.

Among the many important uses for the nodules of this invention, are their use as a plastic molding material and as a carrier for various chemical compositions which are to be released or leached out at a controlled rate under specified predetermined circumstances. In order to further illustrate the importance of these nodules and how they may be used, the following examples are given:

Example VII

Nodules were prepared as in Example II and sufficient urea-formaldehyde binder in the form of a B-stage water dispersion was sprayed on to impregnate and coat the nodules. The final binder content amounted to about 25% of the final weight of the nodules. After drying, the nodules were suitable for use as a molding material. A quantity of them was placed in a small cubicle mold and a pressure of about 2000 p.s.i. was applied while the mold was heated to about 325° F. After cooling the molded article was removed and found to be a relatively dense, well-shaped cube having good structural strength.

In many applications it is desirable to be able to incorporate chemical compositions such as pesticides, insecticides, fertilizers, soil conditioners, and the like in an inert carrier so that the chemical compositions may be released or leached out gradually through solvent action at a controlled rate. The most commonly used carriers are certain types of earths and clays. Since these carriers have either acidic or alkaline natures, they offer the possibility of exerting adverse effects on the chemical compositions to be carried. The nodules of this invention, on the other hand, provide an inert carrier which does not possess properties detrimental in any way to the compositions to be carried. Moreover, if cellulosic nodules are used for carrying soil conditioning compositions, they would exhibit no adverse phytotoxic characteristics and might even be beneficial insofar as soil conditioning is concerned.

The compositions to be carried by the nodules may be incorporated into the nodules in several different forms and at several different points in the nodule manufacture. If the composition to be carried by the nodule is to be introduced in the process before the web is sheeted out, e.g., added to the slurry in the same manner as a beater addition resin is added, then the composition is preferably

introduced as an emulsion or dispersion. Although a solution of the composition to be carried may be used, it is not too practical since much of it will be lost in the white water.

The composition to be carried may be sprinkled on as a dust before the ribbons are formed into nodules such as by spray device 79 (FIG. 5), or the composition may be sprayed on in the form of a solution, dispersion or emulsion at this same point. If it is in liquid form, it may also be deposited on the nodules after they have been rolled and dried as by sprayer 63 (FIG. 5). Finally, it is possible to impregnate the dried nodules by dipping them in a liquid composition and redrying them. In this process care must be taken not to unwind the nodules. This method of impregnating the nodules is preferably used when a wet strength binder has been incorporated in the web.

Examples VIII and IX are given to illustrate how two compositions may be introduced into the nodules of this invention serving as carriers for these compositions.

Example VIII

A dry 5-10-10 commercially available chemical fertilizer was dusted on the wet ribbons before they were formed into nodules (see FIG. 5). The amount of fertilizer incorporated into the nodules amounted to about 15% by weight of the total dry nodule. The nodules were formed and processed in the manner described in Example I. The nodules containing the fertilizer were suitable for distribution on soil in the same manner as clays carrying fertilizer.

Example IX

A water emulsion of chlordan insecticide was made and sprayed on the finished dry nodules by a device such as spray 63 of FIG. 5. The emulsion composition and rate of spraying were adjusted so that the concentration of the chlordan in the nodules amounted to about 5% by weight of the dried nodule. These chlordan-carrying nodules were suitable for use in the same manner as the clay-carrying insecticides.

It will be seen from the above description that this invention provides a novel form of fibrous aggregate and discloses processes and apparatus for the formation of such aggregates. The nodule aggregates may be formed from cellulosic materials, from synthetic resin fibers, or from fibers of a mineral nature. The nodules thus formed are tightly and permanently bonded either through natural fibril interbonding or by means of a binder which may also be used to impart desired specific characteristics to the nodules. The size and the density of these nodules may be controlled to give them a wide range of applications and to open up new uses for fibrous materials.

We claim:

1. Process of forming fibrous aggregates in the form of tightly wound, convoluted fibrous layers, comprising the steps of forming a water stock of fibers, laying said stock on a moving foraminous member to form a wet web, forming said wet web into ribbons, and rolling up predetermined lengths of said ribbons before any appreciable amount of water remaining in said ribbons is removed thereby to form said aggregates.

2. Process in accordance with claim 1 wherein the step of forming set wet web into ribbons comprises impinging a stream of water against said wet web to cut said web into ribbons.

3. Process in accordance with claim 1 wherein the step of forming said aggregates comprises rolling said length of ribbon between said moving foraminous member and a roughened surface moving in the same direction as said foraminous member and at a speed at least four times that of the speed of said foraminous member.

4. Process in accordance with claim 1 further characterized by the step of introducing a binder into said stock.

5. Process in accordance with claim 1 further characterized by the step of depositing a binder on said wet web subsequent to ribbon formation and prior to aggregate formation.

6. Process in accordance with claim 1 further characterized by the step of coating said aggregate with a binder subsequent to aggregate formation.

7. A fibrous aggregate in the form of tightly wound, convoluted fibrous layers, each of said layers being sufficiently bonded to layers adjacent thereto at least partially through the interbonding of fibrils associated with the surface fibers of said fibrous layers to maintain said aggregate in tightly wound form, said aggregate being formed by the process comprising the steps of forming a water stock of fibers, laying said stock on a moving foraminous member to form a wet web, forming said wet web into ribbons, and rolling up predetermined lengths of said ribbons before any appreciable amount of water remaining in said ribbons is removed thereby to form said aggregates.

8. Apparatus for forming aggregates, comprising foraminous conveying means, means for depositing from a water slurry a wet web of fibrous material on said foraminous conveying means, means for directing streams of water under pressure onto said wet web and adapted to cut said wet web into ribbons, and winding means adapted to wind predetermined lengths of said ribbons of said wet web to form said fibrous aggregate, said winding means comprising a roughened surface spaced above said foraminous conveying means and sufficiently close thereto to tightly roll said ribbons into aggregate, said roughened surface being provided with first moving means adapted to make periodic contact with said foraminous conveying means to cut said ribbons, and with second moving means adapted to move said roughened surface in the same direction as said foraminous conveying means at linear speeds greater than the linear speed of said foraminous conveying means.

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