Jan. 25, 1949. P. E. ISTA 2,460,129

APPARATUS FOR MANUFACTURE OF FIBROUS ARTICLES

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Fig. 1.

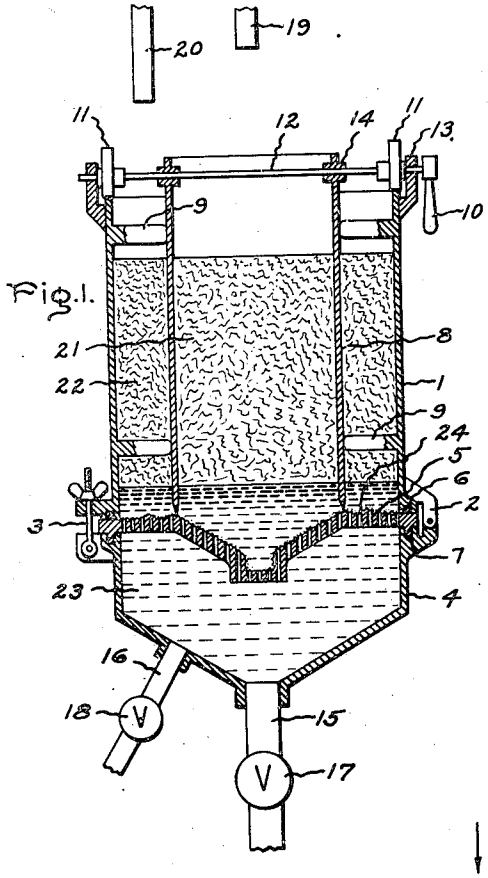


Fig. 2.

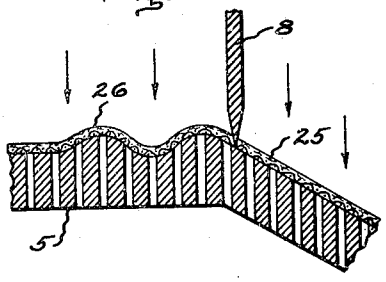


Fig. 3.

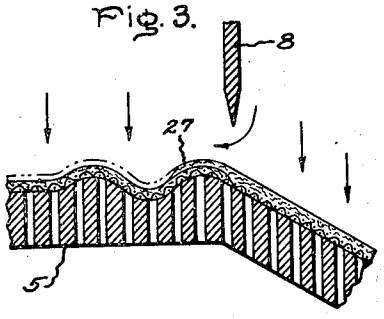


Fig. 4.

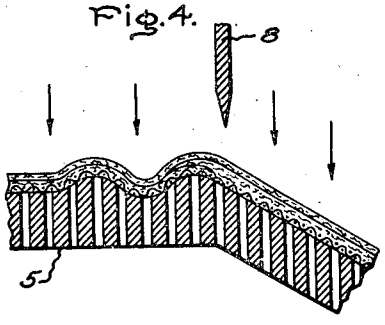
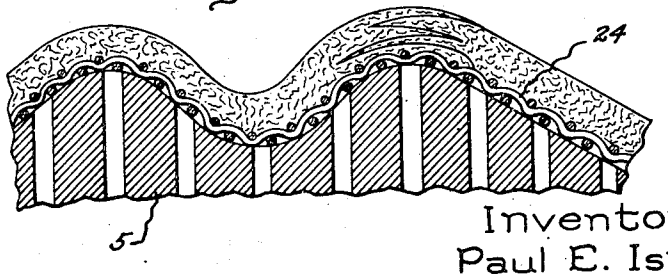


Fig. 5.



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Fig. 6.

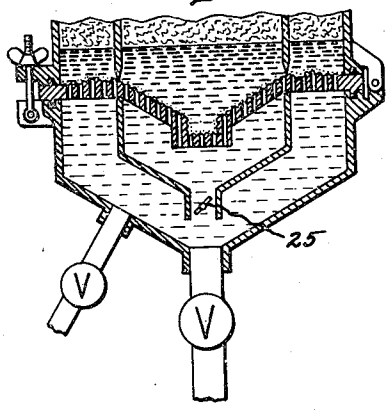


Fig. 7.

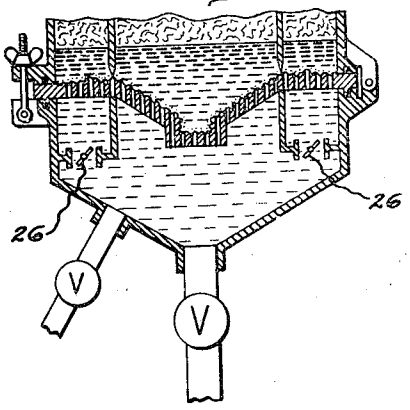


Fig. 8.

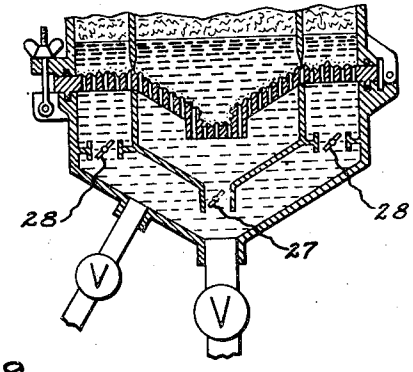


Fig. 9.

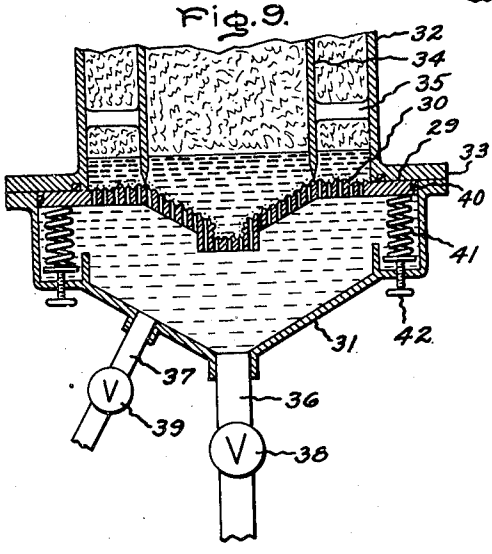
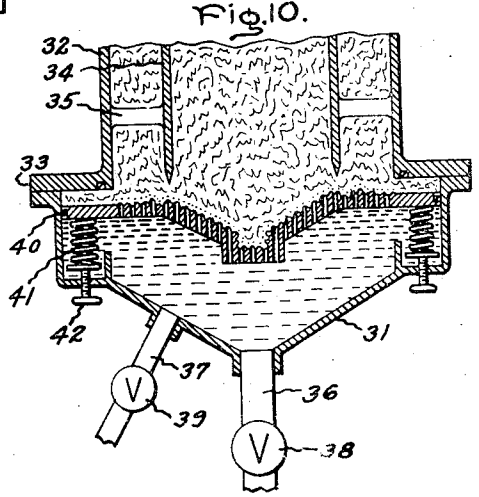


Fig. 10.



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UNITED STATES PATENT OFFICE

2,460,129

APPARATUS FOR MANUFACTURE OF FIBROUS ARTICLES

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2 Claims. (Cl. 92—54)

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This invention relates to a method of making fibrous articles and means for carrying out such method. More particularly, the invention relates to the forming of unitary and integral fibrous articles, different portions of which have different physical characteristics, the variation in properties from one portion to another being sharp and distinct.

It is, of course, well known to make fibrous articles by depositing fibers from a fibrous suspension on a foraminous form by maintaining suction on the opposite side of the form from the fibrous suspension. Furthermore, fibrous articles having various physical properties in different portions of the article have been manufactured by supplying fibers from fibrous suspensions contained in a plurality of baths or chambers, each chamber supplying fibers capable of affording different properties in the different portions of the ultimate fibrous article. According to this latter method the chambers have been separated by walls, the bottom edges of which are permanently spaced a short distance above the surface of the form in order to permit formation of a complete fibrous article as the fibers are deposited. As a result appreciable mixing of the suspensions in the space between the bottom edges of the walls and the surface of the form takes place throughout the forming operation. This procedure causes areas of appreciable width in the article in which the various types of fibers have been deposited from a mixture of the suspensions and, as a result, the delineation of properties from the one portion of the article to another tends to be gradual, lacking the sharpness desirable for many applications.

In certain applications, for example, in the manufacture of fibrous, diaphragmatic sound-producing articles it is desirable to have certain portions of the article of a dense and relatively rigid nature and other portions of a more flexible nature. For example, in the forming of the diaphragmatic sound-producing articles, and especially in the manufacture of those types of sound-producing articles which operate as microphones as well as loud speakers, it has been found that the fidelity of sound transmission is better when the cone is relatively rigid and the rim portion or edge of the cone from which the cone is suspended, is of maximum flexibility or suppleness. In order to obtain a fiber structure which will possess the above properties, it is essential that the gradation of properties from those inherent in the material of the cone portion to those of the rim portion be as sharply defined as possible. It is thus necessary to reduce to a minimum the amount of mixing of fibers permitted between the suspensions supplying the cone portion and rim portion of the form.

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It is, therefore, an object of this invention to provide a process for producing fibrous articles having different portions of different physical characteristics in which the gradation of properties from one portion of the article to another is sharp and distinct. This objective is accomplished according to the invention by depositing and integrating fibers on a foraminous form from a plurality of columns of fibrous suspensions. Each of the columns is separated from the adjacent columns by walls, the edges of which at various stages during the forming operation are either against the surface of the form or are spaced to a predetermined degree from the surface of the form so as to limit mixing of the various fibrous suspensions. A zone of reduced pressure is maintained on the opposite side of the form from the fibrous suspensions causing the suspending liquid to be pulled through the form, leaving the fibers deposited and integrated on the form. In this manner, integration of the various portions of the fibrous articles may be obtained without the extensive mixing of the fibrous suspensions prior to the deposition of the fibers, which mixing has been characteristic of processes heretofore employed. The nature of the deposition of fibers at the boundaries of the various portions will hereinafter be described in detail.

A further object of the invention is a forming means by which the above method may be expeditiously carried out on a commercial basis. One device which I have found to be effective comprises a foraminous form, chambers associated with different portions of the form which contain the fibrous suspensions supplied to the different portions of the mold, and a means for separating the edges of the walls of these chambers from the surface of the form to the degree and at the times desired in carrying out the forming operation. This separation of the edges of the walls of the chambers can be accomplished by various means. For example, the chamber walls may be raised or lowered by mechanical or other means, maintaining the form in a fixed position in the meanwhile.

Another modification includes chambers which remain stationary during the forming process and a form which is resiliently mounted and which is moved away from the lower edges of the chambers as the forming operation proceeds. In this latter device various means of moving the form away from the edges of the chamber walls may be employed. For example, the variations in the pressure differential over the foraminous form may be used advantageously to move the form as the fibers are deposited and integrated thereon.

The features of the invention desired to be protected herein are pointed out in the appended

claims. The invention itself, together with its further objects and advantages, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which Fig. 1 is a view in partial section of one modification of my device for forming a fibrous article; Fig. 2 is an enlarged sectional view of the portion of a foraminous form at one of the points at which a wall separating two columns of fibrous suspensions is against the form; Fig. 3 shows the same portion of the form with the wall spaced from the form; Figs. 4 and 5 illustrate sectional views of the same portion of the form as the process proceeds; Figs. 6, 7 and 8 are sectional views of the lower portion of devices which are further modifications of the device shown in Fig. 1 in which means are provided for separately controlling the degree of reduced pressure in various portions of the zone under the foraminous form; Fig. 9 is a sectional view of the lower portion of a device which is still another modification of the invention; Fig. 10 is a further illustration of the device shown in Fig. 9 with the form in a different position.

Referring more in detail to the drawings, the device illustrated by Fig. 1 is of the type in which the foraminous form, here shown as a form for a diaphragmatic sound-producing device, is maintained in a stationary position during the operation of the device and the inner chamber wall is movable. In the figure the outer cylindrical wall or tank 1 is removably secured by means of a hinge 2 and latch mechanism 3 to the vacuum or reduced pressure tank or chamber 4. The foraminous form 5 covered by a perforated sheet of metal or screen 24 is held between the lower edge of the outer cylindrical wall and the upper edge of the vacuum tank and is gasketed by means of gasket rings 6 and 7 to prevent passage of liquid from the tank above the form to the vacuum tank below the form around the circumference of the form. A movable inner cylindrical wall 8 is located inside of and in concentric relationship with the outer cylindrical wall. This movable wall is maintained in position with respect to the outer wall by means of spacing elements 9. Thus the inner and outer cylindrical walls form a central cylindrical chamber and an annular chamber for holding and supplying dissimilar fibrous suspensions 21 and 22 to the form. Wall 8 may be moved in a vertical direction by various means. However, for purposes of illustration, a crank 10 operating cams 11 through shaft 12 is shown as the operating means. The shaft 12 rotates in bearings 13 slidably secured to the outer tank 1 and bearings 14 in inner tank walls 8. The cams 11 ride on the edges of outer tank 1. Suction line 15 and water inlet line 16 controlled by valves 17 and 18, respectively, are connected to the vacuum tank 4. Fibrous suspension is admitted to inner tank 8 by means of pipe 19 and to the annular space between the inner and outer tanks by means of pipe 20.

Employing the above described device, the forming process is carried out in the following manner: The suction valve 17 is closed and the water inlet valve 18 is opened for a sufficient time to admit water to the vacuum tank and the chambers or tanks above the form 5 to a level slightly above the form. The lower edge of the internal cylinder is then placed against the form by means of the crank and cam mechanism so as to isolate the inner chamber from

the outer annular chamber and the fibrous suspensions are admitted to the respective chambers through pipes 19 and 20. The columns of fibrous suspensions are supported on the surface of the water 23 which has previously been admitted to the chambers, as shown in Fig. 1. The suction valve 17 is opened while the lower edge of wall 8 is in contact with the form and water is drawn from the suction chamber and the chambers above the form until the lower level of the fibrous suspensions reach the surface of the form. As liquid continues to be withdrawn from the system the fibers suspended in the baths 21 and 22 are deposited and integrated on the surface of the form, the suspending medium passing on through the form and out through the suction outlet.

The effectiveness of the method of this invention as carried out by the device described in the foregoing will be more clearly understood by reference to Figs. 2, 3, 4 and 5 which show an enlarged sectional view of a portion of the form at a point where the movable cylinder wall separates the fibrous suspensions.

At the beginning of the forming operation a very thin layer of fibers 25 and 26 settles on both the central conical section of the form and on the rim portion. After a predetermined time the cylinder wall 8 is raised slightly and a small amount of the fibrous suspension from bath 21 moves under the edge of the wall toward the rim portion, as shown at 27 in Fig. 3, because of the fact that the fibers deposited from bath 21 are finer and tend more rapidly to build up resistance to flow of liquid than do the coarser fibers deposited from bath 22 on the rim portion. As soon as the rates of flow through the two portions of the cone equalize, the fibers of bath 22 are again deposited on the entire width of the rim portion and the fibers of bath 21 are deposited on the cone portion as shown in Fig. 4. This process of alternate deposition of fibers from the two baths continues as the wall 8 is raised, with the result illustrated in section in Fig. 5, until the operation is complete.

When the fibrous article has been built up to the desired thickness, the upper portion of the device, including both of the cylinder walls and the lifting mechanism for the inner cylinder are removed from their position on the form and the vacuum tank by loosening the latch mechanism 3 and swinging the upper portion away from the form by means of hinge 2.

The devices illustrated in Figs. 6, 7 and 8 operate in a manner similar to that just described for Fig. 1 except that more accurate control of the vacuum produced in the zone of reduced pressure under various portions of the form may be obtained by means of valves 25, 26, 27 and 28. This is accomplished in the device shown in Fig. 6 by means of the valve 25 controlling the rate of flow of water from the reduced pressure zone under the conical section of the form, and in the device shown in Fig. 7 by means of the valves 26 controlling the rate of flow from the zone under the rim portion of the form. Fig. 8 illustrates a still further modification in which the suction on both portions of the form can be separately controlled by means of the valve 27 controlling the flow from the central portion and the valves 28 controlling the flow from the rim portion.

Figures 9 and 10 illustrate a sectional view of a still further modification of the device of the invention. This device includes a foraminous form 29 covered by a perforated sheet of metal

or screen 30 which is arranged to move vertically in the upper or cylindrical portion of the vacuum chamber or tank 31 and an outer cylindrical tank 32 which is situated above the form and removably secured by means of flange 33 at the bottom of the tank to the vacuum tank below the form. An inner cylinder 34 in fixed relationship to the outer cylinder 32 and spaced therefrom by spacer members 35 is also located above the form in concentric relationship to the cylinder 32. A suction line 36 and a water inlet line 37 controlled, respectively, by valves 38 and 39 are connected to the vacuum chamber 31. A gasket ring 40 situated in a recess around the circumference of the form abuts against the inner wall of the cylindrical portion of the vacuum tank in such a manner as to prevent the fibrous suspensions from escaping around the edges of the form during the operation of the device.

Various means may be employed for moving the form in the vacuum chamber during operation. One means which has been found to work successfully utilizes the variation in pressure differentials between the fiber suspension chambers over the form and the vacuum tank to produce movement of the form. A resilient mounting means is provided around the circumference of the vacuum tank which normally biases the form against the lower edges of the cylinders 32 and 34. A number of springs 41, the tension of which may be varied by means of adjusting screws 42, are illustrated as the resilient mounting means in Figs. 9 and 10. However, instead of springs, other flexible devices such as rubber wedges, hydraulic cylinders, or flexible pneumatic devices might also be employed. The force required to move the form against the resilient means may be determined from the operating characteristics desired.

The initial steps in the operation of the device shown in Figs. 9 and 10 including the charging of the fibrous suspensions into the cylinders above the form are identical to those set forth in connection with the device illustrated in Fig. 1. At the beginning of the operation the metal screen supported by the form is in contact with the lower edges of cylinders 32 and 34 so that the fibrous suspensions in the two chambers are isolated from each other. As the vacuum is brought to bear on the fibrous suspensions and fibers are deposited on the form, the form is drawn downward and gradually moves away from the edges of the cylinder walls until the form attains its final position as shown in Fig. 10.

The movement of the mold, which is slow at the beginning of the operation, is accelerated as more fibers are deposited on the form, because of the increasing resistance which the fibers offer to the passage of the liquid through the form and the resulting increased pressure differential over the form. It may easily be seen that a suitable adjustment of the elasticity of the springs 41 makes it possible to control the velocity and the elongation of the displacement which is imparted to the mold. The deposition and integration of the fibers and the periodic extension of fiber depositions from one chamber, under the edge of the wall of the inner cylinder, onto the portion of the form under the other chamber takes place in the same manner as that described in connection with the operation of the device illustrated in Fig. 1.

The foregoing description of the method and device of this invention relates to the manufacture of diaphragmatic sound-producing devices. However, it is to be understood that numerous other applications of the process and device are within the scope of this invention. For example, in the field of heat insulation, fibrous molded elements having different heat insulation characteristics depending upon the properties of their constituent portions can be realized. As a further example of the possibilities of this invention molded packing elements having different physical characteristics in different portions of the elements may be manufactured. Thus, it is possible to produce unitary elements, portions of which are soft and flexible for containing the items to be packaged or packed and other portions which are relatively strong and rigid to serve as a protective framework. Furthermore, it is possible to produce sheaths or envelopes having a portion easy to remove by tearing and another portion of relatively high strength and resistance to tearing. A still further application of this invention is in the manufacture of tropical helmets in which the crown portion of the helmet must be light and permeable and the rim portion rigid and strong.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A device for making a fibrous article comprising a foraminous form, chambers situated above said form for holding and supplying fibers to different portions of said form, said portions being defined by the lower edges of the walls of said chamber, means situated below said form for maintaining a zone of reduced pressure at the lower side thereof and pressure sensitive means for separating said form and said edges, said separating means comprising a pressure-responsive resilient spring mount for said form which is reactive to changes in pressure below said form.

2. In a device for making a fibrous sound-producing article, a foraminous form, chambers situated above said form for holding and supplying fibers to different portions of said form, said chambers being defined by the lower edges of cylindrical walls concentrically arranged, means situated below said form for maintaining a zone of reduced pressure at the lower side thereof, whereby fibers are attracted to and integrated on the upper surface of the form, said form being normally biased against the lower edges of said cylindrical walls by means of a resilient pressure-sensitive spring mounting for said form which is movable downward when said pressure is reduced.

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