Sept. 26, 1967 J. J. MULLAN ETAL 3,343,933

BINDER DISTRIBUTION METHOD FOR PRODUCING MINERAL WOOL BOARD

Filed May 8, 1964

Fig. 1.

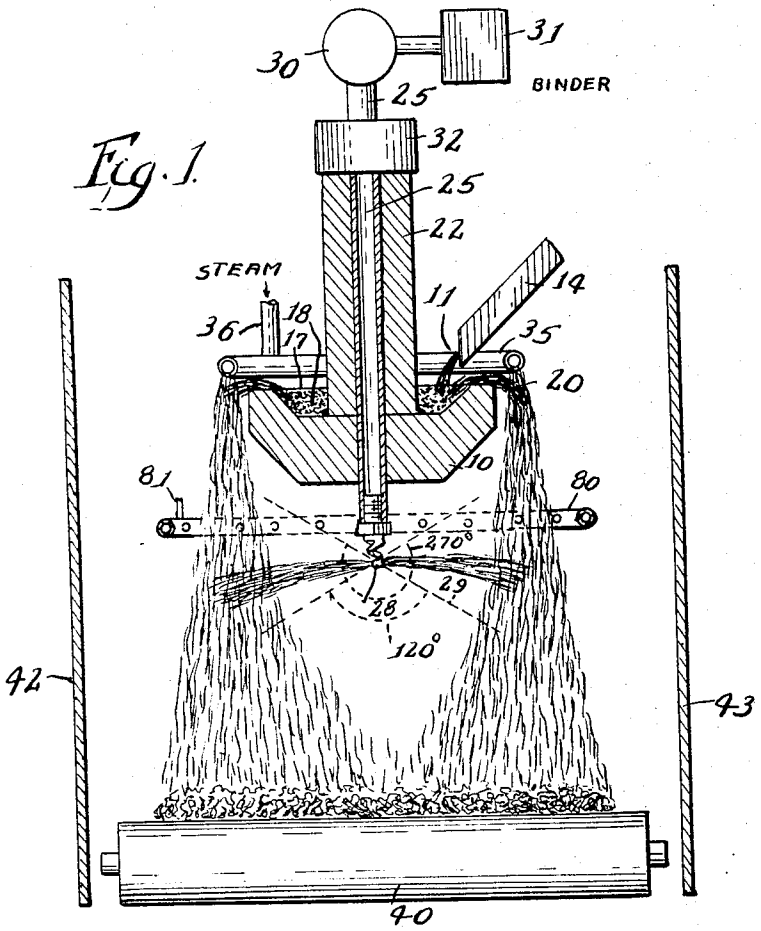
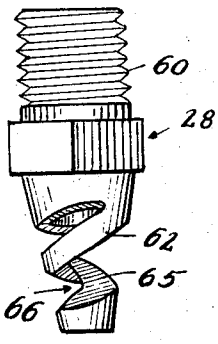



Fig. 3.



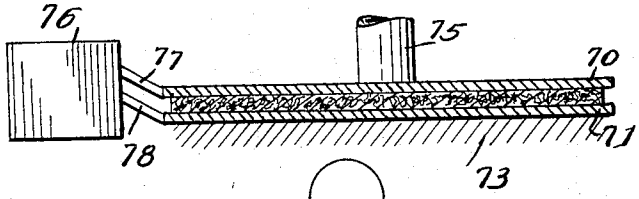
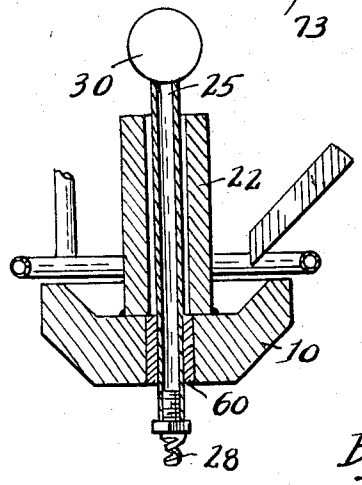




Fig. 2.

Fig. 4.




Inventors.
John J. Mullan.
William H. Prentice
By. James W. Grace
Attorney.

United States Patent Office 3,343,933 Patented Sept. 26, 1967



3,343,933

# BINDER DISTRIBUTION METHOD FOR PRODUCING MINERAL WOOL BOARD

John J. Mullan, Rolling Meadows, and William H. Prentice, Des Plaines, Ill., assignors, by mesne assignments, to The Celotex Corporation, Chicago, Ill., a corporation of Delaware

Filed May 8, 1964, Ser. No. 365,986
6 Claims. (Cl. 65—3)

This invention pertains to an improved method of making a rigid mineral fiber board and more particularly to an improved method of making a mineral fiber board with more efficient distribution of binder throughout the board.

In the field of residential and commercial building, the heat insulation and acoustical treatment of ceilings and walls have been historically of great importance. Even greater emphasis in comfort and relief from unwanted noise is becoming more and more evident.

The search for more efficient materials to provide an effective answer to this problem has given rise to the manufacture of a rigid mineral fiber board in which the fibers are held together with a resin binder. The mineral fibers are formed by the deposition of molten slag on a spinning rotor and then blasting with steam the streams of molten slag thrown off the periphery of the rotor. The binder is deposited on the individual mineral fibers immediately after they have been formed and while they are in a separated, individualized condition. A blanket of such binder coated fibers is formed on a conveyor and the resultant blanket is cured under heat and pressure to set the binder. The result is a rigid mineral fiber board which can be then finished to form a ceiling panel or tile.

There are, in general, two methods for applying the binder to the mineral fibers. One of these is by centrifugally throwing the binder outwardly into the annulus of loose, separated fibers from a point located centrally of the annulus. This is accomplished by attaching a disc or slinger plate arrangement to the side of the rotor away from the side to which the molten slag is applied and supplying the slinger plate arrangement with binder through a tube extending through the rotor. Patent No. 2,944,284, entitled "Binder Distribution and Atomizing System for Fiberizing Apparatus," and issued to W. T. Tillotson et al., describes such an arrangement.

The disadvantages of such a system are that the binder is dispersed in a manner in which the size of droplets varies over a large range and that the distribution of the binder depends upon the speed of rotation of the rotor since it is centrifugal force which causes the distribution. The ultimate effect of such disadvantages is that the binder distribution is not as efficient as it could be.

A second prior art method of applying the binder to the fibers is shown in U.S. Patent No. 2,707,847, issued to C. A. Anliker and entitled, "Means for Treating Mineral Wool Fibers." The spray apparatus is mounted independently of the rotor and throws the binder in a direction parallel to the flow of formed fibers to be applied at points downstream of the formed fibers. Again, in this patent there is no teaching relative to the importance of the uniformity of the droplet distribution pattern or the size of the droplets.

The efficiency of binder distribution becomes very important because a cost analysis of the rigid board indicates that the binder represents about 79% of the material cost of the rigid board. Where, as in the present instance, millions of square feet of rigid board are sold annually, a saving of over 7% of the binder cost is an important factor in merchandising this product.

It is, therefore, extremely advantageous to apply the binder in as efficient manner as possible. Savings in manufacturing cost of from $1 to $5 per thousand square feet of finished product represents a considerable commercial advantage in such a highly competitive field.



The present invention is directed to a novel method of making a mineral fiber board by spraying binder on mineral fibers, with a uniformity of droplet size, resulting in increased efficiency and improved binder distribution. For optimum efficiency, the size of the droplets of binder deposited on the fibers should be such that at least 90% of the droplets are less than 0.11 and not less than 0.01 inch in diameter. The total amount of binder should be between 2% and 10% depending upon the density of the board and the desired rigidity. The method of forming the fibers, forming an interfelted blanket of the fibers and curing the resin binder under heat and pressure to rigidify the blanket into the finished board are conventional.

It is an object of the present invention to provide an improved method of applying binder to mineral fibers to make a rigid, resin bonded, mineral board.

It is another object of the present invention to provide an improved method of making a rigid, resin bonded, mineral fiber board by controlling the uniformity of droplet size of the applied binder.

It is still another object of the present invention to provide an improved method of making a rigid, resin bonded, mineral fiber board in which the binder may be applied to the fibers either immediately after they are formed or at any point along their path within two feet after they are formed.

Other objects and advantages of the present invention will be apparent from the description of the drawing, in which like numerals indicate like elements, and in which:

FIG. 1 is a schematic view, partly in cross-section, of an apparatus for practicing the invention;

FIGURE 2 is a cross-sectional view of an additional apparatus for practicing the invention;

FIGURE 3 is a side view of a nozzle used in the invention; and

FIGURE 4 is a detailed view of a modification of the apparatus of FIGURE 1.

For a more detailed description of the invention, reference may be had to the accompanying drawing, and in particular to FIGURE 1 which is a schematic view of an apparatus for practicing the invention.

The apparatus of FIGURE 1 comprises a rotor **10** which may be cast of steel or other metal and capable of withstanding the corrosive effect and high temperature of molten slag **11**. The upper face **17** of rotor **10** is cut away to leave a cup-shaped depression **18** for receiving molten slag **11**. The cup-shaped depression **18** extends toward but falls short of the outer periphery of the upper face **17** of rotor **10** leaving a small lip **20** over which the molten slag is centrifugally thrown. Slag **11** is melted in a cupola (not shown) at temperatures of about 2600° F. and applied to rotor **10** over a trough **14**. A hollow shaft **22** is welded or otherwise secured axially to rotor **10** to provide for rotation thereof. Means (not shown) are connected to shaft **22** for rotating the shaft **22** and rotor **10** at rotational speeds of between 1000 and 2500 r.p.m. A hollow tube **25** is inserted through shaft **22** and rotor **10** to emerge at the lower face of rotor **10**. A nozzle **28**, which will be described in greater detail with reference to FIGURE 3, is connected to the lower end of tube **25** by threads or welding. The upper end of tube **25** is connected to a pump **30** which in turn is connected to a supply source **31** of binder. A conventional rotary joint **32** is connected between shaft **22** and the upper section of tube **25** so that the lower end of tube **25** may rotate without rotation of its upper end.

A steam ring **35**, supplied through a pipe **36**, is placed slightly above and spaced outwardly of the periphery of rotor **10**. A series of holes (not shown) are drilled around the under side of steam ring **35** to permit steam under

pressure to blow past the lip **20** of rotor **10** and attenuate the molten slag which is centrifugally thrown off lip **20** into thin streams of molten slag. These molten streams are blasted into fibers by the steam ring and blown downwardly in the form of a hollow cone to become a blanket on a conveyor **40** at the bottom of a collection chamber, illustrated by sidewalls **42** and **43**. The force or energy of the steam emerging from the steam ring **35** gives the individual mineral fibers their maximum velocity in the area of the steam ring.

What has been described thus far with reference to the production of mineral wool fibers is conventional and well-known practice in the mineral wool art. The mineral wool fibers thus produced are made within a short distance below the steam ring.

The droplets of binder are thrown out uniformly into the veil of formed fibers and the energy of the steam blast atomizes the uniform droplets so that the fibers are efficiently coated.

The method of coating the individual mineral wool fibers with a binder in the form of uniform droplets, of which at least 90% have a diameter of less than 0.11 inch and not less than 0.01 inch, comprises the use of a nozzle **28** attached to the end of the binder tube **25**. Nozzle **28** issues a spray of binder in the form of a sheet substantially planar and perpendicular to the lower end of tube **25**. Nozzle **28** must be chosen such that the binder issues in the form of uniform droplets of the form described in order to achieve the unexpected increase in binder efficiency. It has also been found that only slightly less efficient binder distribution is achieved when the binder issues from the nozzle in a cone whose inside angle is 120°, as opposed to the 180° angle of the planar distribution. This arrangement is shown by the dotted line representation **29** at the nozzle **28** of FIGURE 1.

From another viewpoint, the binder should enter the cone of fibers in an area not more than two feet below the steam ring. In addition, the binder may be blown upwardly in the form of a hollow cone such that the area of penetration of the binder into the cone of the fibers is near the lower face of the rotor. In this latter application, the angle of the spray measured from below is about 270°. Between these limits the binder distribution efficiency appears to be optimum for commercial purposes. The distribution of binder in a cone whose inner angle is less than 120° appears to be less efficient because the individual fibers have separated into too large an area to be efficiently coated, and the atomizing energy in the steam veil is largely dissipated at this distance from the steam ring.

A typical nozzle suitable for spraying the binder has been found to be that described in U.S. Patent No. 2,804,-341 issued to John U. Bete and assigned to Bete Fog Nozzle, Inc. These nozzles are sold commercially in various sizes having orifice diameters of between 3/16" and 7/16" being most applicable to the present invention. Reference may be had to FIGURE 3 for a view of a typical nozzle. The nozzle **28** has a threaded base portion **60** and a helical shaped vane **62** extending axially from the threaded base portion **60**. The vane **62** spirals inwardly and its inner wall **65** has an inward axial taper to form a bore **66** in a conical or bullet shape so that the cross-section of the bore is reduced in the direction of flow through the nozzle. In its action, the nozzle causes a uniform sheet of fluid to be peeled off by the vane **62** and atomizes the fluid in the form of droplets.

The nozzles can be selected so as to give a binder spray with a 270° or greater angle measured from below in the pattern of a hollow cone with a spray angle of 120° downwardly with respect to the axis of the nozzle. If desired, the nozzle can be designed to provide any spray angle between these limits.

To determine the distribution of droplets by size from various types of binder applicators, high speed instantaneous photographs of the binder sprays were taken and



analyzed. The following table sets forth the results in tabular form:

TABLE I

| | Number of Droplets of Given Diameter | | |
|---|---|---|---|
| | Slinger Plate | Nozzle TF 20 | Nozzle TF 28 |
| Diameter×10⁻² inches: | | | |
| 1 | 27 | 62 | 50 |
| 2 | 18 | 40 | 54 |
| 3 | 14 | 21 | 28 |
| 4 | 12 | 13 | 19 |
| 5 | 17 | 15 | 31 |
| 6 | 11 | 17 | 10 |
| 7 | 5 | 9 | 13 |
| 8 | 9 | 19 | 9 |
| 9 | 2 | 4 | 5 |
| 10 | 31 | 35 | 11 |
| 11 | 2 | 3 | 3 |
| 12 | 7 | 8 | |
| 13 | 1 | 2 | |
| 14 | 1 | | |
| 15 | 5 | 2 | 7 |
| 16 | | | 1 |
| 17 | 1 | | |
| 18 | 2 | | |
| 19 | | | |
| 20 | 12 | | 3 |
| 21 | | | |
| 22 | 2 | | |
| 23 | 1 | | |
| 24 | | | |
| 25 | 1 | | 2 |
| 26 | | | |
| 27 | | | |
| 28 | | | |
| 29 | | | |
| 30 | 3 | | 2 |
| 31 | | | |
| 32 | 1 | | |
| 33 | | | |
| 34 | | | |
| 35 | 1 | | |

In analyzing Table I it should be noted that the smallest droplet recorded was .01 inch in diameter. In viewing the high speed photographs of the operation it was found that droplets smaller than this size are caught in the turbulence created by the blast of steam and are effectively unusable to coat the fibers. In effect, they do not reach the falling cone of fibers and so are not considered to be of any significant importance in binding the final product. On the other hand, droplets larger than 0.10 inch in diameter tend to put too much binder on individual fibers and thus reduce the efficiency of the binder in terms of the amount of binder used for a given amount of product produced.

For most efficient binder distribution, it has been determined that the optimum droplet size should be such that 90% of the droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter.

In comparing the effectiveness of binder applied to the fibers by the three means set forth in Table I; namely, the slinger plate apparatus, the nozzle TF 20 and the nozzle TF 28, it was found that the efficiency of the binder applied to the fibers was 69.5% for the slinger, 78.5% for the TF 20 nozzle, and 73% for the TF 28 nozzle. Other nozzles having similar droplet size distribution to those of the nozzles set forth in Table I, were found to have efficiencies of about 75%.

The efficiency of binder application was determined on the basis of the final product having the same density, thickness and other like characteristics.

In comparing binder efficiency, it should be remembered that for any given rotor installation there is a maximum amount of mineral wool fibers made during a given time period. The efficiency of the binder is a measure of the amount of binder used to coat the fibers such that a given percentage by weight of the final rigid board is binder. Hence, the greater the binder efficiency, the less binder must be sprayed during a given time period for the maximum amount of wool produced during the period.

If, for example, the binder efficiency is 75% to 85% for one distribution pattern of binder and the binder efficiency is 60% to 70% for a different distribution pattern of binder, then the amount of binder sprayed per given time period will be about 15% less for the more efficient distribution pattern than for the less efficient distribution pattern.

It has been found that the shape of the binder distribution from the nozzle is independent of the rotation of the rotor. That is, the shape of the distribution pattern and the uniformity of droplet size remains the same whether the rotor is rotating or not. To illustrate an alternative arrangement for the nozzle, reference may be had to FIGURE 4, which shows only that portion of FIGURE 1 which pertains to the use of a non-rotating nozzle. In FIGURE 4, the rotor **10** is connected to hollow shaft **22** and binder tube **25** is inserted through hollow shaft **22**. Binder tube **25** is isolated from rotor **10** by a journal bearing **60** so that rotor **10** can rotate independently of tube **25**. Nozzle **28** is connected to the lower end of tube **25** and sprays the binder from pump **30** in the same manner as previously described. Joint **32** is not necessary in this arrangement.

If desired, the rotor may be water-cooled in the conventional manner.

The manufacture of the rigid board may be completed from the blanket stage shown in FIGURE 1, by means of a pair of platens **70** and **71** shown in FIGURE 2. The bottom platen **71** may be fixed on a solid foundation **73** while the upper platen **70** may be moved up and down by a ram **75** to compress the blanket to its desired final thickness. A source of steam **76** is connected over flexible tubing **77** and **78** to the platens **70** and **71** to provide for heating the platens so as to cure the resin binder.

The binder may be a thermoplastic or thermosetting resin depending upon the characteristics desired in the final product. A suitable thermosetting resin may be, for example, an aqueous solution of phenol formaldehyde. While the term binder has been used throughout this application, other liquid materials may be sprayed in a like manner. This spray method is also applicable for sizing the fiber, and introducing various materials in slurry form.

Since the most efficient use of the binder occurs because of the uniformity of the droplet size between diameters of about 0.01 inch and 0.10 inch, it is apparent that the binder need not be sprayed from inside the descending cone of fibers. As an alternative arrangement, an outside spray ring **80** supplied through tube **81** shown in FIGURE 1, may be as effectively used, provided only that the same uniformity of droplet size distribution be achieved.

It should be clear that the present invention is directed to the application of binder to individual mineral wool fibers wherein the binder is atomized such that more than 90% of the droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter. The method for achieving this uniform distribution of droplet size is independent of mechanical means used to achieve this distribution. Thus, while various commercially available nozzles have been discussed and described, these are done so only to set forth a practical apparatus for achieving the desired results. Any mechanical means which can produce such a size distribution of binder droplet may be used.

While particular embodiments of the present invention have been herein shown and described, other modifications and changes will occur to those skilled in the art and it is intended to cover such modifications and changes in the accompanying claims:

We claim:

**1.** The method of coating mineral fibers with binder comprising the steps of:

forming individual mineral fibers from molten slag;

atomizing a binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter, and coating said fibers with said atomized binder.

**2.** The method of coating mineral fibers with a binder comprising the steps of:

forming individual mineral fibers from molten slag in the form of an expanding cone;

atomizing said binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter,

applying said atomized binder to said fibers from a point along the central axis of said cone in the form of a conical spray having an angle of between about 120° and 270° to contact said fibers while they are in an area of maximum forward velocity.

**3.** The method of coating mineral fibers with a binder comprising the steps of:

forming individual mineral fibers from molten slag in the form of an expanding cone;

atomizing said binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter,

and applying said atomized binder to said fibers from a point along the central axis of said cone and in a plane substantially perpendicular to said axis to contact said fibers while they are in an area of maximum forward velocity.

**4.** The method of coating mineral fibers with a binder comprising the steps of:

forming individual mineral fibers from molten slag in the form of an expanding cone;

atomizing said binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter,

applying said atomized binder to said fibers from a point along the central axis of said cone in the form of a conical spray to contact said fibers at a distance of between one inch and two feet from the point at which said fibers are formed.

**5.** The method of coating mineral fibers with a binder comprising the steps of:

forming individual mineral fibers from molten slag in the form of an expanding cone;

atomizing said binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter,

applying said atomized binder to said fibers from points located outside said expanding cone.

**6.** The method of making a resin bonded mineral fiber board comprising the steps of:

forming individual mineral fibers;

atomizing a resin binder to form fine droplets such that more than 90% of said droplets are smaller than 0.11 inch in diameter and not less than 0.01 inch in diameter;

coating said fibers with said binder;

forming an interfelted blanket of said coated fibers,

and curing said binder under heat and pressure to rigidify said blanket.

**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,931,422 | 4/1960 | Long | 65—3 |
| 2,944,284 | 7/1960 | Tillotson et al. | 65—14 X |
| 3,021,563 | 2/1962 | Slayter et al. | 65—3 |

DONALL H. SYLVESTER, *Primary Examiner.*

S. LEON BASHORE, *Examiner.*

R. L. LINDSAY, *Assistant Examiner.*