Jan. 17, 1961 E. R. POWELL 2,968,069

METHOD AND APPARATUS FOR CLEANING AND FELTING FIBROUS MATERIAL

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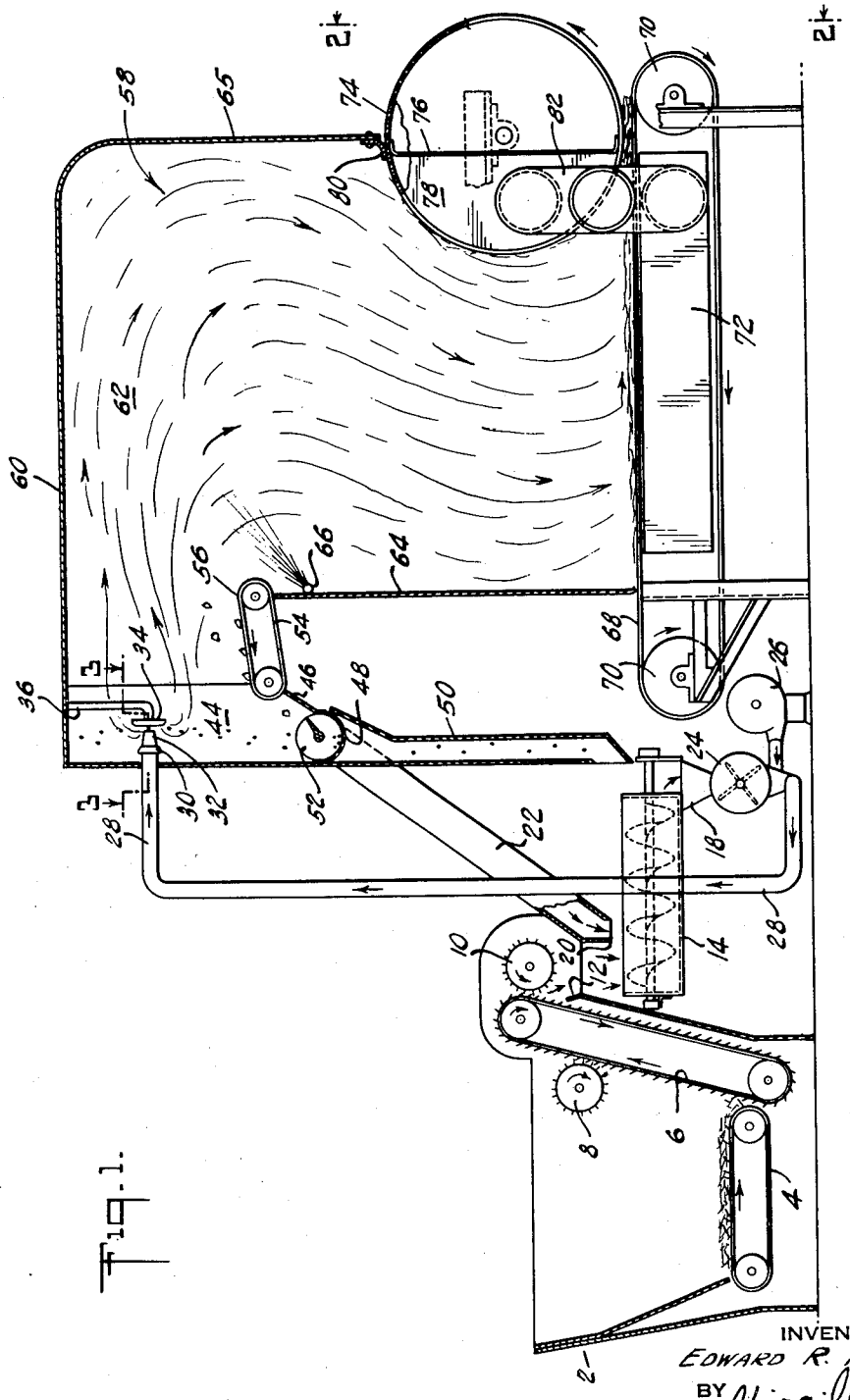


Fig. 1.

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Fig. 2.

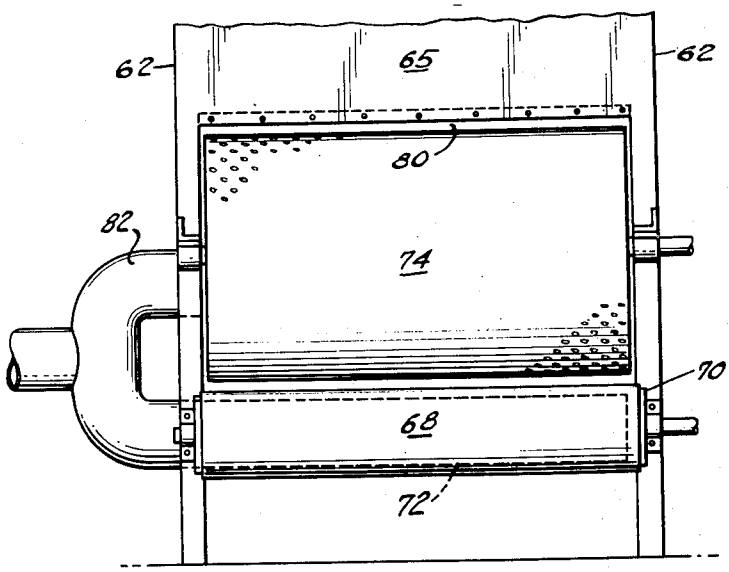
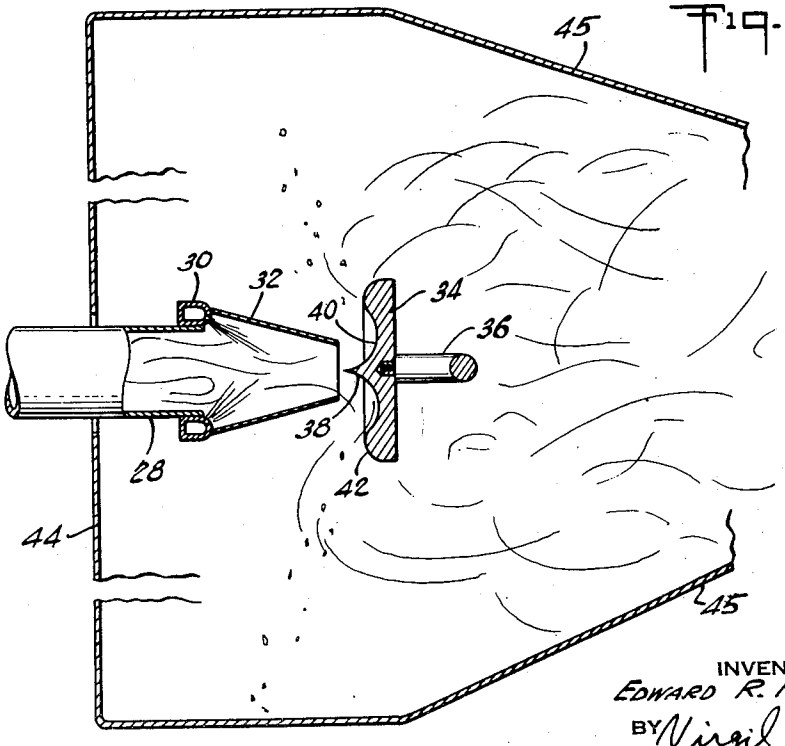


Fig. 3.



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METHOD AND APPARATUS FOR CLEANING AND FELTING FIBROUS MATERIAL

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13 Claims. (Cl. 19—156)

The present invention relates to a method and apparatus for opening, cleaning and felting fibrous material, and is particularly concerned with removal of unfiberized particles from fibrous material such as mineral wool. The term "mineral wool" as used herein is intended to include fibrous materials formed from rock, slag, glass, mixtures thereof and like raw materials, and while in principle the invention will be found useful in processing any mineral wool, the specific embodiment disclosed in this application is particularly useful with relatively coarse fiber of the type normally employed in home and less critical industrial insulations. The invention also may be found particularly useful with the tougher fibers formed from relatively viscous melts.

Mineral wool for home insulating purposes is conventionally produced either by blowing a molten stream into fiber or by discharging molten material from the peripheral surface of spinning rotors in the form of fiber. With either process, production rates are normally between 3,000 and 5,000 lbs. per hour for each production unit, and products so produced contain fiber of varying lengths and diameters, tufts or clumps of fiber of varying degrees of entanglement and a considerable amount of unfiberized material known as "shot." The shot, in many products of this type, may vary in size from 20 mesh and larger to 325 mesh and smaller and be present in amounts between 40 and 70% by weight of the product. While loose shot and shot held within relatively open tufts or clumps of fiber can many times be removed merely by shaking and screening the product, it has been found difficult, particularly with the longer fiber produced by spinning, to remove shot from tufts or clumps in which the fiber is entangled to a relatively high degree. The particular problem to which the present invention is directed is opening entangled masses of fibrous material such as conventional mineral wools, separating shot from the fiber and forming the open and cleaned fiber into a felt, i.e., into a mat, batt, blanket or board of fiber.

Known methods and apparatus for separating solids of different weights have not been found practicable in opening and cleaning fibrous materials such as mineral wool of the home insulation grade because such methods and apparatus (1) either fail to reduce significantly the overall shot content of the fibrous material or, where shot reduction is attained, shorten the fiber to a powder-like state by repeated, relatively severe mechanical action; (2) attain only such limited processing rates in comparison with fiber-production rates that the overall process of fiberization, cleaning and felting cannot be made continuous; or (3) remove shot from fiber in such a way that the opened, cleaned fiber cannot conveniently be continuously collected in felt form.

Accordingly, a primary object of the present invention is to reduce the overall shot content of conventional mineral wools to as low as about 10%, while preserving sufficient fiber length to produce strong, relatively resilient felts.

A further object of the present invention is to provide

a method and apparatus through which conventional mineral wools may be opened, cleaned and felted at rates equal to their production rates.

A still further object of the present invention is to provide a method and apparatus for opening and cleaning fibrous material such as mineral wool at high production rates and continuously forming such material into felts.

The invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the following detailed description of a preferred embodiment of the invention and to the accompanying drawing in which:

Fig. 1 is a longitudinal sectional view of the apparatus of the invention;

Fig. 2 is a partial elevation of the apparatus of Fig. 1 as viewed from the right; and,

Fig. 3 is a partial sectional view of the cleaning device of the apparatus of Fig. 1 as viewed from above.

Referring to the drawings and particularly to Fig. 1, the apparatus disclosed consists of three basic components, namely, an arrangement for feeding fibrous material into a fluid stream, shown at the left of Fig. 1, a device for opening and cleaning the fibrous material, located in the upper central portion of the figure, and a device for forming the fibrous material into a felt, shown at the right. The feeding equipment includes a hopper **2** having a conveyor belt **4** in the lower portion thereof, the upper reach of which extends horizontally to the right and ends at a point adjacent the upper reach of a spiked conveyor **6**. The spikes on the upper reach of spiked conveyor **6** extend in a generally upward direction which is the direction of movement of the upper reach, whereas the spikes on the lower reach of conveyor **6** extend generally downwardly. Doffer rolls **8** and **10** are positioned adjacent the upper and lower reaches, respectively, of the conveyor **6**. Below the roll **10** there is provided a chute **12**, beneath which is located a trough **14** provided with a screw conveyor **16** terminating adjacent another chute **18**. Also located above trough **14** is the exit end **20** of a trunk **22** leading from a recycling apparatus, later to be described. Chute **18** communicates with a feed valve **24** which in turn communicates with the discharge trunk of a fan, diagrammatically illustrated at **26**. Trunk **28** constitutes the feed means for the fiber opener and cleaner.

The fiber opener and cleaner (see Fig. 3) includes an annular jet ring **30** to which a fluid under pressure is supplied through any conventional means, not shown, for the purpose of discharging from the ring a fluid stream. The fluid may be either steam or air or any other suitable gaseous medium. The jet ring **30** is mounted around the discharge end of trunk **28** and is preferably provided with a surrounding funnel-shaped baffle **32** for giving direction to the fluid stream discharged. Positioned coaxially with the trunk **28**, jet ring **30**, and baffle **32**, is a target **34** mounted on suitable strut means **36**. The target shown includes a central portion **38** projecting toward the baffle **32**, this central portion being surrounded by a grooved area **40**. While the central portion of the target may have a great variety of shapes, it is definitely considered preferable that the edge portions **42** be rounded, as illustrated. The jet **30** and target **34** are mounted in a chamber **44**, preferably somewhat wider in the region laterally of the jet and target, as seen in Fig. 3, than in the regions to the right of the target.

Referring again to Fig. 1, at the bottom of the chamber **44** there is provided a wall **46** ending in a screen **48** beneath which there is provided a chute **50**. Mounted for rotation above the screen **48** is a screw conveyor **52** arranged to discharge into the trunk **22** opening into trough **14**. At the upper end of wall **46** and extend-

ing out of the chamber 44 is a conveyor 54, the upper reach of which is arranged to travel toward chamber 44 and screw conveyor 52. In the main, the conveyor 54 is located in the entrance of a collection chamber 58, communicating with chamber 44, the end 56 of conveyor 54 constituting a threshold for the chamber 58.

Collection chamber 58 is arranged with its top wall 60 formed as an extension of the top wall of chamber 44 and with its side walls 62 (one such wall being shown in Fig. 1) connected to converging walls 45 (see Fig. 3) of chamber 44. In the rear wall 64 of collection chamber 58, below the threshold 56, there is mounted a nozzle means 66 through which a binder material may be sprayed upwardly and outwardly into chamber 58. Extending across the bottom of the chamber 58 is a conveyor 68 mounted for rotation on rollers 70, supported in the conventional manner and driven by any convenient means, not shown, in a direction such that the upper reach of the conveyor moves to the right. Mounted beneath the upper reach of conveyor 68 is a suction box 72. Mounted for rotation in front wall 65 of chamber 58, and driven in a counter-clockwise direction by any convenient means, not shown, is a foraminous drum 74. Internally of the drum there is provided a fixed wall 76 extending axially of the drum and cooperating with fixed segmental walls 78 (only one such wall shown in Fig. 1) adjacent the ends of the drum to provide a suction box inside the portion of the drum extending inside collection chamber 58. A sealing strip 80 may be provided at the lower end of wall 65 for cooperation with drum 74. Trunk means 82 is provided for connecting the suction boxes 72 and 78 to an exhaust fan, not shown.

In operation, fiber to be opened, cleaned and refelted may be dumped into the hopper 2 in batches, or may be fed continuously from a fiberizing unit. Material received in hopper 2 is carried by conveyor 4 into the path of spiked conveyor 6 where the material is engaged by the spikes and carried upwardly, excess material being doffed by doffer roll 8. Material remaining on conveyor 6 is carried over the upper end thereof and doffed from the lower reach of the conveyor by doffer roll 10. Material discharged by conveyor 6 falls through chute 12 into trough 14 and is fed by screw conveyor into chute 18. Material falling through chute 18 is metered through valve 24 into trunk 28, through which it is fed by means of fan 26 into the fluid stream issuing from jet ring 30. The primary functions of the feeding apparatus are to initially reduce the fibrous clumps to a size which will not clog the trunk and to provide for a more or less uniform or metered flow of material. Any conventional fiber feeding apparatus which will accomplish these ends may, of course, be employed.

The fibrous material fed into the fluid stream issuing from jet ring 30 becomes suspended in the stream which is directed, through the aid of conical baffle 32, against, over and beyond (to the right of in Fig. 3) the target 34. The velocity of the fluid stream issuing from jet ring 30 is arranged to be such that at least some of the fibrous material is directed against the target with sufficient force to break attached shot from fiber and to open clumps of fiber. The combined effect of this relatively high velocity of the fluid stream and the suction within conveyor means 68 and 74, is to cause the fluid stream to pass over and beyond the target and, in effect, to create a rapidly moving fluid barrier around the target. With proper stream velocity shot and some relatively unopened clumps of fiber are projected laterally from the target with sufficient momentum to pierce the fluid barrier around the target, i.e., to be projected through and out of the stream, whereas the opened fiber (which term should be understood to include lighter, more open tufts) does not attain sufficient momentum to pierce the barrier and is carried beyond the target. While heavy, highly entangled clumps or nodules of fiber tend to act as shot, and light, open tufts tend to act as fiber, a substantial quantity of clumps of intermediate weight and degree of entanglement will act in part as fiber and in part as shot. These intermediate but relatively unopened clumps tend to be carried beyond the target with the opened fiber, but then tend to drop from the fluid stream, in the manner of shot, in the regions immediately beyond the target. With proper suction in the collection chamber 58, opened fiber will remain suspended in the stream and be carried into the chamber. Thus, shot projected from the target, and relatively unopened clumps initially acting as shot, pierce the barrier about in the plane af target 34, strike the walls of chamber 44, and fall downwardly on screen 48; relatively unopened clumps of intermediate weight and entanglement which initially tend to act as fiber are carried beyond the target, at which point they tend to act as shot and drop from the stream onto conveyor 54, to be discharged therefrom onto screen 48; and open fiber remains suspended in the stream, to be carried into chamber 58. The action of screw conveyor 52 is such that clumps of fiber are delivered into trunk 22 and discharged into trough 14 for refeeding through trunk 28, whereas shot is passed through screen 48 and chute 50 to a shot-removal means, not shown.

The horizontal cross-sectional area of chamber 58 at the level of entrance of the fluid stream is so related to the vertical cross-sectional area of chamber 44 that the velocity of the fluid stream is gradually reduced after entering chamber 58. By reason of this progressive reduction of velocity, the lighter, more open components of the cleaned material suspended in the fluid stream tend to be carried in the suspension longer and become predominant in the areas adjacent wall 65, whereas the heavier, more entangled components tend to fall from the suspension sooner and predominate in the areas adjacent wall 64. By reason of suction beneath conveyor means 68 and 74, fibrous material is collected on the conveyor means with the lighter, more open components predominating in the felt collected on drum 74, and the heavier more entagled components predominating in the felt collected on conveyor 68. The distance between the lower portion of drum 74 and the upper reach of conveyor 68 is arranged so that the felts on the respective conveyor means are combined into a single felt between the conveyor means. An atomized liquid binder may be applied to the fibers by means 66, or a powdered binder may have been incorporated in the material at some location in the feed system as, for example, in trough 14, and by curing the binder in a conventional oven for this purpose the fibers and felts are bound together to form a unitary product.

In one apparatus constructed in accordance with the present invention the trunk 28 consisted of a 5" duct and the jet ring 30 and baffle 32 were correspondingly dimensioned. The jet ring 30 was supplied with air at between 40–60 p.s.i. and the jet openings were so arranged as to direct a fluid stream axially of the ring against the converging funnel 32, the minimum diameter of which was 4". The target 34 consisted of a flat circular plate having a rounded edge, the plate being positioned several inches from the small end of baffle 32 and about 3' from threshold 56. Chamber 44 was about 4' in length (direction of stream flow), 3½ to 4½' in width and 2–3' in height, whereas chamber 58 was about 6' long, 3' wide and 10' in height. Suction behind conveyors 68 and 74 was maintained at about ½ inch of water. When this apparatus was operated in the general manner described above, it was found that up to from 6,000 to 9,000 lbs. of fibrous material per hour (including about 1 part new feed and from 1–2 parts refeed) could be fed through the jet ring 30 to the target, although the highest quality commercial products appeared to result with new feed rates of around 2,000 lbs. per hr. or slightly less. Of course, greater processing rates (with a single apparatus)

may be obtained by arranging a plurality of jet and target units in side by side relation in a slightly wider chamber **44**, in which case a plurality of trunks **28** would be arranged to communicate with valve **24**. With two jet and target units in an apparatus of the above type, top quality products could be produced with new feed rates in excess of 3,000 lbs. per hr.

While none of the dimensions, pressures, etc. recited above are considered critical, it will be apparent to those skilled in this art that several factors affect the operation of the above-described apparatus. Decreasing fluid pressure to jet ring **30** tends to result in a decrease in fiber cleaning, whereas increasing this pressure tends to result in increased severity of cleaning action along with such an increase in stream velocity that unopened clumps of fiber are carried over threshold **56**. Decreasing the distance from target **30** to threshold **56** also tends to result in carrying unopened clumps over the threshold, whereas increasing this distance tends to result in some light tufts falling on conveyor **54** and being unnecessarily refed to the cleaning device. Decreasing the feed rate in general results in an increase in cleaning efficiency but a decrease in production and the overall efficiency of the apparatus, whereas increasing the feed rate tends to result in smaller proportions of material fed being cleaned and increases in material refed and unopened clumps included in the final product. Changes in the amount of suction behind the conveyor means in the collection chamber **58** affect primarily only the felting of the product, although insufficient suction would disturb the flow of the fluid stream. It is believed apparent that optimum operating conditions for each of the factors just described depends entirely upon the end product desired. Thus, where it is desired only to remove coarse shot such as 30–100 mesh, and larger, the fluid pressure and feed rates may be increased to result in very high processing rates. With new feed rates in the neighborhood of 3,000 lbs. per hr., a single jet ring and target unit may be capable of removing all but about 2% of this coarse shot. Where large amounts of finer shot are to be removed, it appears that lower feed rates and pressures must be employed with apparatus of the type described above. With relatively low production rates, total shot contents as low as 8% have been obtained, with substantially no coarse shot.

The present invention provides a method and apparatus through which cleaner fiber may be obtained at greater rates than was heretofore possible. Conventional mineral wools may now be continuously processed in a single apparatus at rates substantially equalling their production (fiberization) rates to produce commercially new products having as low as 2% shot of 100 mesh size, or larger, with total shot contents of around 25% and lower. For any given ultimate shot content, the processing rate with the method and apparatus of this invention is higher than the processing rate for any known method or apparatus for the same purpose. These high processing rates are attained without too marked degradation in fiber length whereby clean, tough, resilient felts may be produced. Contributing factors to these results are the fluid barrier feature of the cleaning action, the collecting and refeeding of insufficiently opened and cleaned clumps, and the separation of lighter and heavier components of the cleaned material preparatory to felting.

Having thus described my invention in rather full detail, it will be understood that these details need not be strictly adhered to and that various changes and modifications may suggest themselves to one skilled in the art, all falling within the scope of the invention as defined by the subjoined claims.

What I claim is:

1. A method of opening, cleaning and felting a fibrous material such as mineral wool comprising subjecting the material to an opening and cleaning action, separately collecting relatively unopened clumps of fiber and relatively open fiber felting the relatively open fiber and resubjecting the relatively unopened clumps to the opening and cleaning action.

2. A a method of opening, cleaning and felting a fibrous material such as mineral wool comprising continuously suspending the material in a fluid stream, continuously subjecting material suspended in the stream to an opening and cleaning action, continuously collecting relatively unopened clumps of fiber from the stream after the opening and cleaning action, maintaining relatively open fiber suspended in the stream after collection of relatively unopened clumps, and continuously resuspending the collected relatively unopened fiber in said stream for resubjection to the opening and cleaning action.

3. A method for opening and cleaning a fibrous material containing fibers and unwanted particles comprising, suspending said fibrous material in a fluid stream, directing said fluid stream against a target having a face portion and a peripheral edge to open and clean said fibrous material, passing said fluid stream around said entire peripheral edge of said target and beyond said target, separating said fiber from said unwanted particles by projecting said unwanted particles through and out of said fluid stream and carrying the opened and cleaned fibers around and beyond said peripheral edge of said target with said fluid stream, and collecting said opened and cleaned fibers from said fluid stream.

4. The method of claim 3 including the step of collecting relatively unopened clumps of fiber separate from relatively opened fiber, and resuspending such clumps in the stream ahead of the target.

5. The method of claim 3, including the step of continuously collecting fiber from the stream beyond the target in the form of a felt.

6. The method of claim 5, including the steps of collecting predominantly lighter and more open fiber in one felt and predominantly heavier and more entangled fiber in a second felt, and then combining the two felts into a single felt.

7. Apparatus for opening and cleaning a fibrous material containing fibers and unwanted particles comprising, means for discharging a fluid stream, means for suspending said fibrous material in said fluid stream, a target having a face portion and a peripheral edge positioned in the path of said fluid stream to intercept said fibrous material, means for directing said fluid stream against said face portion of said target to separate said fibrous material into fibers and unwanted particles, said face portion directing said unwanted particles through and out of said fluid stream, means for directing said fluid stream around said entire peripheral edge and beyond said target so that said fluid stream carries therewith the opened and cleaned fibers, and means for collecting said opened and cleaned fiber from said fluid stream.

8. The apparatus of claim 7, said target having a generally circular cross section and being positioned centrally of said stream and including curved surfaces for intercepting the shot and fiber.

9. The apparatus of claim 7, including means for collecting relatively unopened clumps of fiber separate from relatively opened fiber and for resuspending such clumps in the stream ahead of the target.

10. The apparatus of claim 7, including a vertically extending collection chamber positioned beyond the target to receive said stream through an opening in a wall thereof, said fiber collection means being located in said chamber below said opening and comprising foraminous conveyor means.

11. The apparatus of claim 10, wherein said conveyor means includes a belt-like conveyor extending across the bottom of the chamber and a drum-like conveyor mounted in a wall of the chamber remote from the fiber entrance opening, the lower portion of said drum being arranged in spaced, but adjacent parallel relation with

the portion of the belt-like conveyor extending under the wall in which the drum is mounted.

12. An apparatus for opening, cleaning and felting a fibrous material such as mineral wool comprising an opening and cleaning means, a fibrous material feeding means for feeding material to the opening and cleaning means, an opened fiber collecting means, and means positioned between said opening and cleaning means and said collecting means to receive unopened fibrous material and deliver it to said feeding means.

13. An apparatus for separating shot from fiber in a fibrous material such as mineral wool comprising means for suspending said fibrous material in a fluid stream, a converging nozzle for discharging said fluid stream in a predetermined localized path, a target positioned in said predetermined localized path to intercept said shot and fiber, means inducing said fluid stream to continue its flow beyond said target to a fiber collection zone, said converging nozzle being in close proximity to said target, said converging nozzle directing said fluid stream against, over and beyond said target with sufficient velocity to carry fiber beyond said target into the induced flow stream and deflect shot laterally from said target through and out of said stream, and fiber collection means in the path of said stream beyond said target.

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