

Oct. 24, 1967

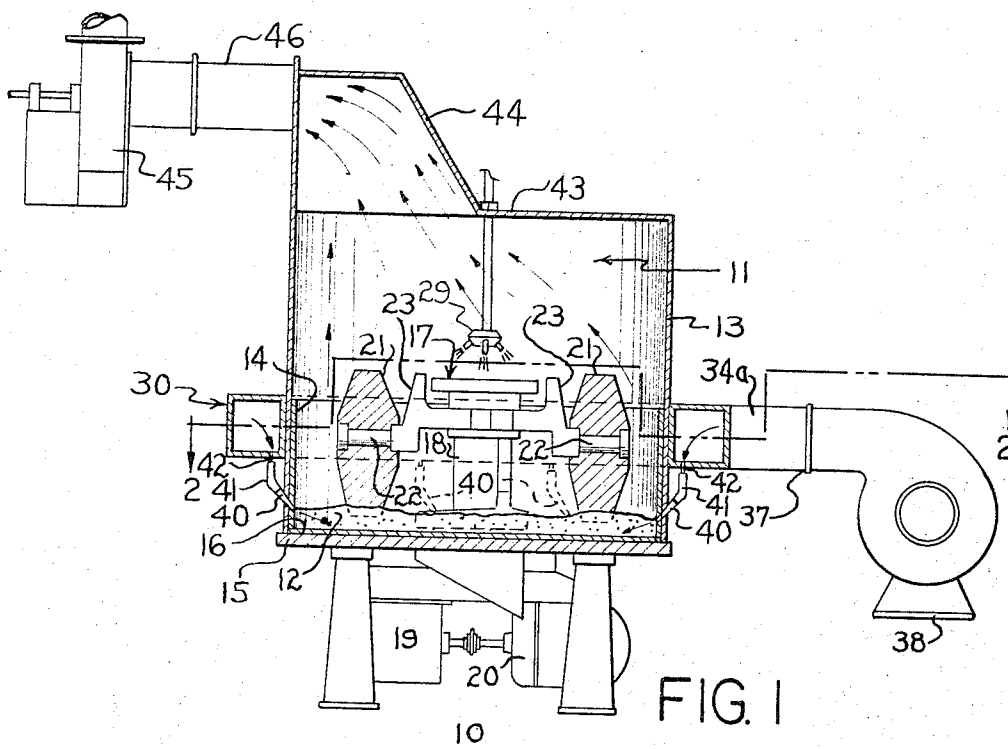
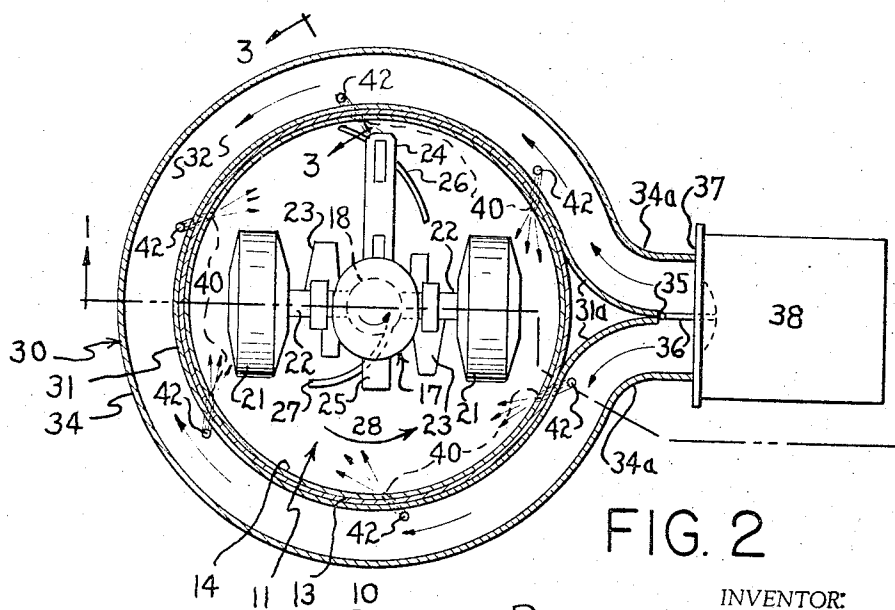
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APPARATUS FOR CONDITIONING PARTICULATE MATERIAL

Filed Dec. 7, 1964

4 Sheets-Sheet 1



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4 Sheets-Sheet 3

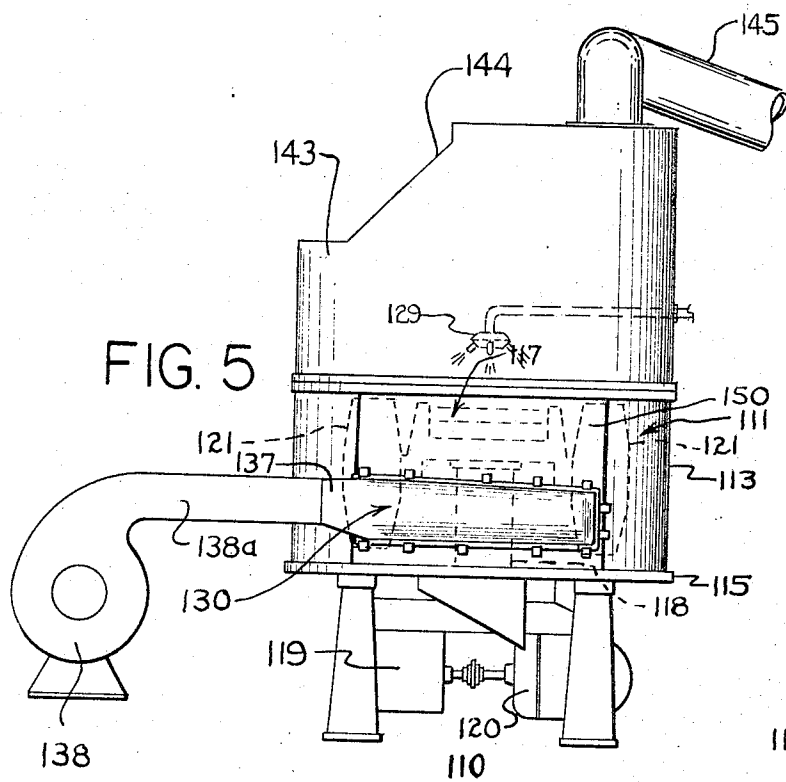
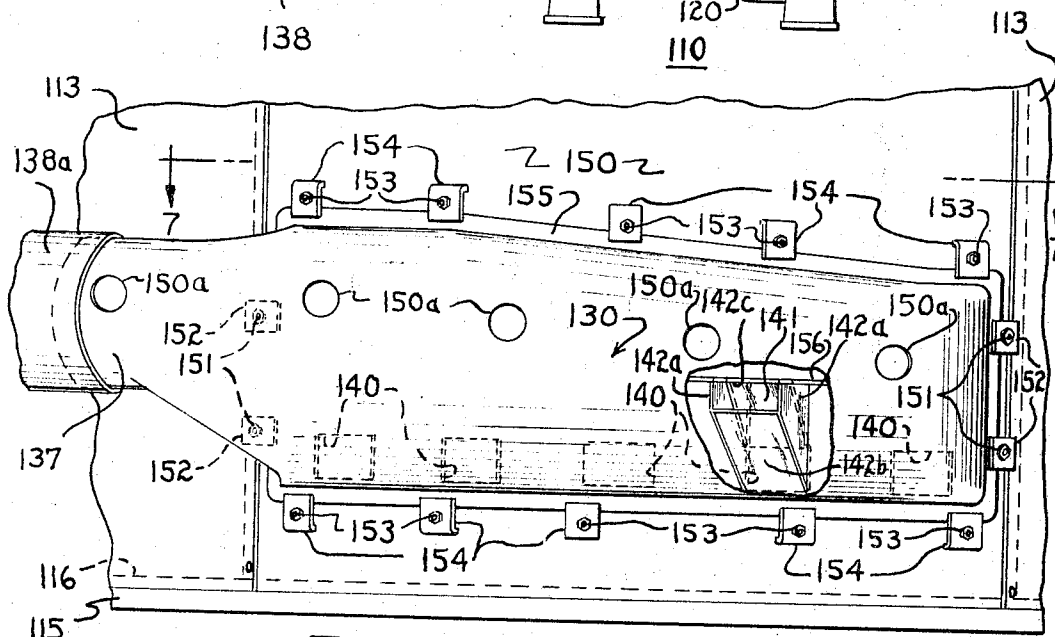


FIG. 6

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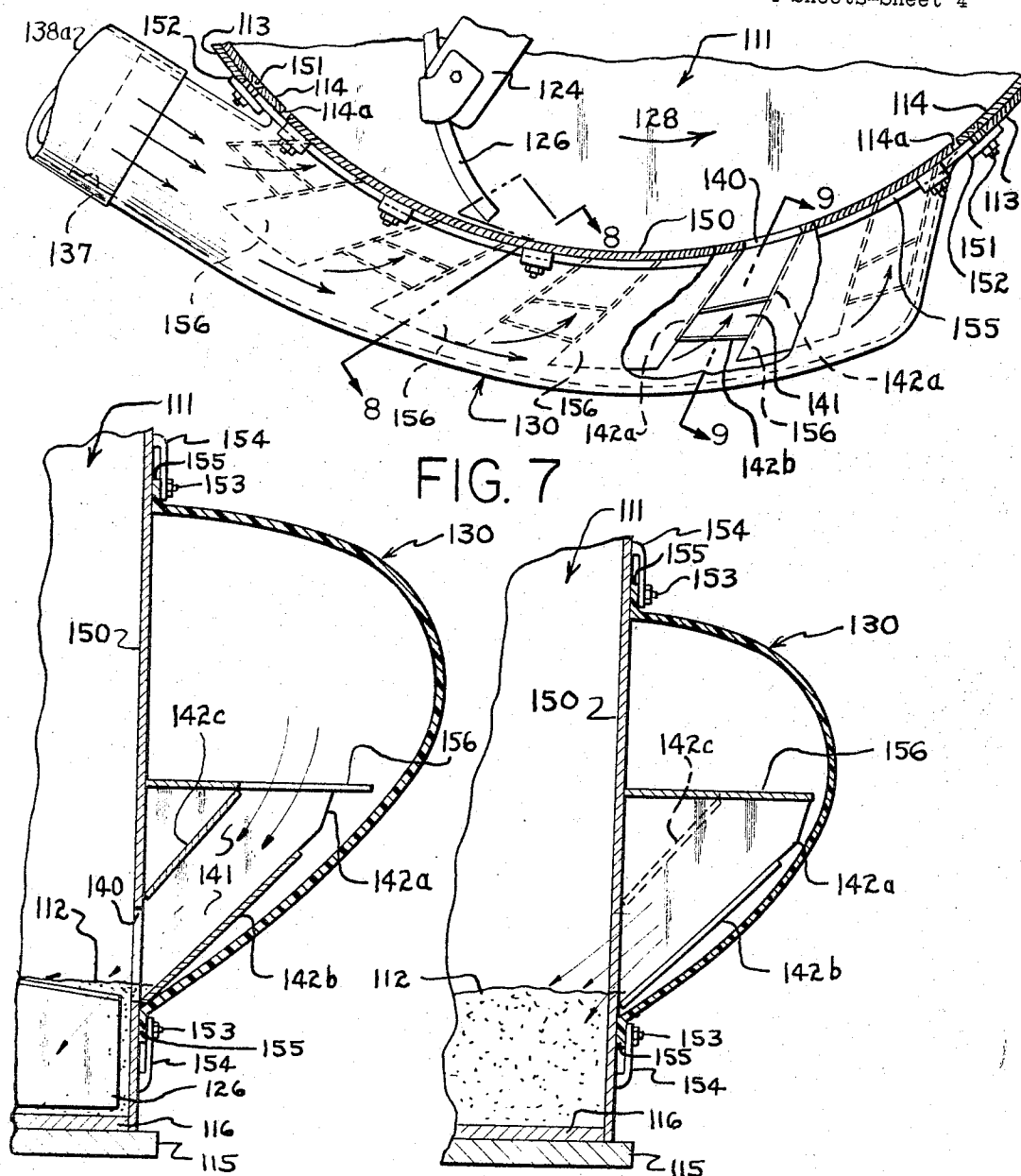


FIG. 8

FIG. 9

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APPARATUS FOR CONDITIONING PARTICULATE MATERIAL

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Filed Dec. 7, 1964, Ser. No. 416,566

5 Claims. (Cl. 259—1.51)

This application is a continuation-in-part of the copending U.S. patent application Ser. No. 148,570, filed Oct. 30, 1961, now abandoned, which application is assigned to the same assignee as the present application.

The present invention relates generally to a new and improved apparatus for conditioning granular material and, more specifically, relates to a new and improved method and apparatus for pulverizing, mixing, and cooling hot foundry sand which is removed from molds during shake-out operations in order to prepare the sand for further use in molding operations. It is to be understood, however, that the apparatus of the present invention is useful in connection with conditioning of materials other than foundry sand.

A prior method and apparatus used for reconditioning spent foundry sand is illustrated and described in U.S. Patent No. 2,593,327, which patent is assigned to the same assignee as the present invention, and the present invention is an improvement over the method and apparatus of this prior patent.

One disadvantage of prior art methods and apparatus for reconditioning foundry sand is the requirement for a large volume of cooling air in order to cool the sand to the desired temperature. Because of the large volume of air used, it was usually necessary to install large, bulky dust collectors in order to prevent the excessive loss of fines. Another disadvantage in the prior art is the relatively low cooling efficiency obtained because only a small portion of the sand surface is exposed to a direct flow of cooling air and the velocity of the air, being relatively low, is consequently not able to sufficiently penetrate the sand mass below the surface thereof.

Therefore, it is an important object of the present invention to provide a new and improved apparatus for conditioning granular material and the like wherein only a relatively low volume flow of cooling air is needed to provide a relatively high rate of cooling of the material.

Another important object of the present invention is to provide a new and improved apparatus for conditioning granular material and the like which avoids the necessity of using a large, bulky collector or, in the alternative, which permits efficient operation with a much smaller, lighter, and less expensive collector while, at the same time, avoiding any substantial loss of the material being cooled.

Yet another object of the present invention is to provide a new and improved apparatus for conditioning granular material and the like which can be easily and inexpensively utilized with existing mixing and pulverizing equipment.

A further object of the present invention is to provide a new and improved apparatus for conditioning granular material and the like which provides a relatively low-volume flow of air at high velocities to obtain a relatively high rate of cooling and which does not require the use of a large collector to prevent the loss of fines.

Another object of the present invention is the provision

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of a new and improved method of conditioning granular material and the like wherein an excess amount of moisture is added to the material and then is rapidly evaporated by means of high-velocity airstreams to provide additional evaporative cooling of the sand.

Yet another object of the present invention is the provision of a new and improved apparatus for conditioning granular material wherein high-velocity, cooling airstreams are introduced directly into a moving mass of the material at or below the upper level thereof to momentarily entrain the particles of material in the airstreams for rapid cooling.

Still another object of the present invention is to provide a new and improved apparatus for conditioning granular material wherein a multiplicity of high-velocity, cooling airstreams are introduced at fixed positions spaced along the periphery of a moving mass of the material as it is being continuously mixed and pulverized.

Another object of the invention is the provision of a new and improved apparatus for conditioning granular material including a mixer with an upstanding wall having a removable section, which section is provided with a plenum chamber and ports or nozzle means therein for directing air in the plenum chamber directly into the material in the mixer through a plurality of high-velocity airstreams to cool the material.

The foregoing and other objects and advantages of the present invention are accomplished by the provision of a new and improved method of conditioning granular material and the like comprising the method of continually pulverizing and mixing a mass of granular material, adding an excess quantity of water to the material, subjecting the moving mass of material to a flow of high-velocity, cool air directed into the material at or below the upper surface thereof to entrain and cool the particles of the granular material in the airstream and provide additional cooling by evaporating the excess moisture and exhausting of the cooling air from the material at velocities substantially below particle entrainment velocity so that the fines and other material will be dropped from entrainment and return to the mass of material.

Other objects and advantages of the present invention are accomplished by the provision of new and improved apparatus for conditioning granular material comprising a mixer having a mixing chamber with upstanding side walls and a rotating mixing head mounted in the chamber for continually mixing and pulverizing the mass of material in the chamber. A plenum chamber is disposed along the sidewall of the chamber and is in communication with the interior thereof through a plurality of ports or nozzles positioned at spaced intervals to introduce high-velocity airstreams from the plenum chamber directly into the moving mass of material in the chamber at or below the upper level thereof. Air is supplied to the plenum chamber from a high pressure blower to maintain the plenum chamber at a pressure suitable to provide the necessary velocity in the airstreams entering the mixing chamber so that the particles of material will be entrained in the airstreams and rapidly cooled as they are mixed and pulverized. In order that the air within the chamber can be exhausted without carrying out more than a minimal quantity of fines, an exhaust hood is provided over the mixing chamber and the hood is connected to an exhaust blower through a duct system of sufficient size so that the velocity of the flow therein is well below

the entrainment velocity of the particles of material and these particles return to the mass of material in the mixer.

In another embodiment of the invention, the mixing chamber is provided with a removable wall section or portion and a plenum chamber is attached thereto. Ports are provided in the wall section and means are provided in the plenum chamber for directing air through the ports into the mass of material in the chamber in high-velocity spaced streams to cool the moving mass of material.

For a better understanding of the invention, reference is made to the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 is a side elevational view with portions in section taken substantially along line 1—1 of FIG. 2 showing one embodiment of apparatus for conditioning granular material constructed in accordance with the present invention;

FIG. 2 is a horizontal sectional view taken substantially along line 2—2 of FIG. 1;

FIG. 3 is a fragmentary vertical sectional view taken substantially along lines 3—3 of FIGS. 2 and 4;

FIG. 3A is a fragmentary sectional view similar to FIG. 3 but illustrating another embodiment of the invention;

FIG. 4 is a horizontal sectional view similar to FIG. 2 but illustrating another embodiment of the invention;

FIG. 5 is a side elevational view similar to FIG. 1 illustrating another embodiment of the apparatus of the present invention;

FIG. 6 is an enlarged fragmentary elevational view of the manifold or plenum chamber of the apparatus of FIG. 5 with portions broken away to show internal details thereof;

FIG. 7 is a horizontal sectional view taken substantially along line 7—7 of FIG. 6;

FIG. 8 is a vertical sectional view taken substantially along the line 8—8 of FIG. 7; and

FIG. 9 is a vertical sectional view taken substantially along the line 9—9 of FIG. 7.

Referring now to the drawings and especially the embodiments of the invention shown in FIGS. 1 through 4, there is illustrated a mixing and mulling machine 10 of the type in common use in foundries for preparing foundry sand. The machine 10 includes a mixing chamber 11 for containing a mass of sand or other granular material 12 which is to be reconditioned by mixing, pulverization, and cooling.

The chamber 11 includes an upstanding cylindrical sidewall 13 having a replaceable wall liner 14 therein and a bottom 15 having a replaceable wear plate 16 on the upper surface thereof. A rotating mixing head assembly 17 is mounted for rotation in the mixing chamber about a central vertical axis. The mixing head assembly includes a central shaft 18 extending through bottom 15 and wear plate 16 of the mixing chamber and drivingly connected to a gear reducer 19 and electric motor 20 disposed beneath the mixing chamber.

The mixing head assembly 17 includes a pair of heavy mulling wheels 21 mounted on opposite sides of the central shaft 18 to rotate therewith. Each wheel is journaled for free rotation on a radially extending horizontal axle 22 which is movable vertically and is supported on a pivoted support arm 23 of the head assembly. The head assembly also includes a pair of plow support arms 24 and 25 which carry an outer plow 26 and an inner plow 27, respectively. Both of the plows are carried as shown in FIGS. 2 and 4 and have lower edges positioned to move along the wear plate 16. The outer edge of the outer plow 26 moves in close proximity to the wall liner 14 in order to scrape away material tending to collect in the peripheral lower corner of the mixing chamber and the plow is curved inwardly to move the material inwardly into the path of the mulling wheels 21. The inner plow 27

is curved to move material outwardly from the center of the mixing chamber into the path of the mulling wheels.

As the mixing head 17 rotates in the chamber 11, the material 12 in the chamber is moved generally in a circular path as indicated by the arrows 28 in FIGS. 2 and 4. The material adjacent the outer periphery of the chamber is moved inwardly by the outer plow 26 and the material around the center of the chamber is moved outwardly by the inner plow 27 into the path of the mulling wheels 21 which pulverize and break up any lumps or agglomerates in the material. The material encountered by the plows is turned over and scraped off the wear plate 16 as the plows move to further insure good mixing and pulverizing of the circularly moving mass of material.

When the material being prepared is hot foundry sand which has been obtained from mold shake-out operations, it is necessary to cool the material during its conditioning in the mixer and add a bonding agent and water in order to obtain the desired consistency or plasticity of the sand needed for further molding operations. It has been found very advantageous to cool the material as it is being mixed and pulverized in the mixer since the mixing action exposes more surface area of the material for direct contact with the cooling agent. Since the material around the outer portion of the circularly moving mass is moving at a generally higher velocity than the material nearer the center of the mixing chamber, it has been found most advantageous and efficient in cooling to direct high-velocity airstreams inwardly into the moving mass of material from a plurality of positions spaced along the perimeter of the mixing chamber at a level adjacent the upper level of the material.

It has been found that by directing the airstreams inwardly into the moving sand mass at velocities in the order of 6,000 to 10,000 f.p.m., individual particles of sand being turned over by the outer plow will be picked up and momentarily entrained in the airstreams and more efficient cooling can be obtained with a smaller volume of airflow needed. This results in considerable savings on power needed for supplying the necessary volume of air at the requisite velocity. It has also been found that more efficient cooling is obtainable by adding excess water to the material which is evaporated in the high-velocity airstreams and provides additional evaporative cooling of the material. Water is added to the material in the mixing chamber 11 by means of a centrally disposed, fixed spray head 29 having several nozzles to direct a spray of water into the material around the chamber.

In order to supply cooling air for the moving mass of material in the chamber 11, a circular plenum chamber or air manifold 30 is secured around the periphery of the sidewall 13 of the mixing chamber. The manifold 30 may be rectangular in cross section, as shown in FIGS. 3 and 3A, and includes an inner wall 31 abutting the mixing chamber, a lower wall 32 spaced above the level of material 12 in the chamber, a top wall 33, and an outer wall 34.

The inner wall 31 is formed with sections 31a which curve away from the mixing chamber and are joined together at their outer extremities to form a pivot 35 for supporting a splitter damper 36. The outer wall 34 includes outwardly extending sections 34a which form the outer walls of an inlet fitting 37 for the manifold.

Air is supplied to the manifold 30 from one or more high pressure blowers, such as the blower 38 which is connected to the inlet 37 of the plenum chamber. Preferably, outside air is supplied to the inlet side of the blower 38 through suitable air ducts (not shown), which are large enough so that the inlet pressure to the blower is not substantially reduced below atmospheric pressure. It is desirable that the air supplied to the system be low in humidity in order to provide good evaporative cooling in the mixer and the inlet air should also be relatively cool for maximum cooling of the material.

The blower 38 should be capable of delivering the required c.f.m. at pressures ranging from 1/2 to 3 p.s.i. and

it has been found in conditioning foundry sand that a flow of 2 c.f.m. per pound of sand is a good rule of thumb. In one installation, better than average results were obtained using two Clarage fans No. 115 XL delivering 8,000 c.f.m. at 15 inches of water, static pressure, to the manifold. These fans required 30 HP to drive them and the mixer used contained 4,000 lbs. of said.

In order to direct high pressure air from the manifold 30 into the mixing chamber 11, a plurality of jet nozzles 40 is positioned around the periphery of the chamber to direct high velocity airstreams inwardly into the mass of moving material at or just below the upper level of the material, as shown in FIGS. 1, 3, and 3A. The outlets of the nozzles 40 extend through the sidewall 13 of the mixing chamber and wall liner 14, and the nozzle tips are flush with or protrude slightly inward into the chamber from the inner surface of the wall liner. As can be seen from FIGS. 3 and 3A, the level of the nozzles is approximately even with or just above the top edge of the outer plow 26 so that sand turning over the top edge of the plow will be directly exposed to the high-velocity airstreams to obtain maximum penetration of the cooling air.

The nozzles 40 are connected to the manifold 30 through delivery tubes 41 connected to outlet fittings 42 spaced around the bottom wall 32 of the manifold. The nozzles can be positioned to direct the airstreams radially inward into the material, as shown in FIG. 4, or can be positioned as shown in FIG. 2 wherein the airstreams are directed inwardly at an angle of about 30 degrees to the radial in a direction opposed to the circular movement of the material indicated by the arrow 28. In the latter instance, plugging of the nozzles by said moving with the outer plow 26 becomes more of a problem but cooling is improved because of a higher relative velocity between the sand particles and the airstream. Because the nozzles are positioned at a level adjacent the upper edge of the outer plow, however, plugging is not a significant problem and increased cooling efficiency is obtained because of the material being turned over by the plow directly in the path of the airstream.

As shown in FIG. 3A, the nozzles 40 may be horizontally disposed or they can be directed downwardly toward the sand at angles ranging up to approximately 45 degrees, as shown in FIG. 3. In the latter instance, plugging of the nozzles is alleviated without noticeable change in cooling efficiency.

As the cooling airstreams enter the moving mass of material at velocities of 6,000 to 10,000 f.p.m. particles of the material are momentarily entrained in the airstreams and accordingly a maximum of surface area on the particles is available for cooling. The excess moisture carried by the particles is rapidly evaporated, resulting in further cooling of the particles. The mixing chamber 11 is maintained at atmospheric or slightly less than atmospheric pressure and, since the pressure of the air in the manifold is a minimum of $\frac{1}{2}$ p.s.i. static pressure, the air entering the mixing chamber expands and, in doing so, cools the surrounding material additionally because of the adiabatic cooling effect during expansion. Thus, the present invention provides for highly efficient cooling of the material in the mixer as it is being pulverized and mixed. The cooling is most intensive around the periphery of the moving mass of material where the velocity of the material is the greatest and the mixing is most intense because of the greater speed of the outer plow 26. Cooling is accomplished by the entrainment of the particles momentarily in the high-velocity airstreams which are injected directly into the moving mass of material, by adiabatic cooling in the airstreams expanding upon entering the mixing chamber and by evaporative cooling as the excess moisture is evaporated by the high-velocity airstreams. The airstreams are directed into the material adjacent the upper level thereof in order to obtain maximum penetration and this level is approximately even with the upper edge of the outer flow 26 so that the ma-

terial is being turned over as the airstreams hit the material to expose a maximum surface area to the cool air.

By cooling the material as it is being pulverized and mixed in the mixer, less handling is required and, by moving the material to pass in front of the airstreams rather than moving the airstreams around the mixer, many mechanical problems are eliminated. Moreover, more efficient cooling is obtained than would be possible if the material was relatively stationary and not being continually mixed and pulverized during the cooling.

In order to remove the cooling air from the mixer and to maintain the mixing chamber 11 at or below atmospheric pressure so that the air entering the chamber will expand to effect adiabatic cooling of the material, a top cover or exhaust hood 43 is provided to enclose the chamber. The hood includes an enlarged upper collection chamber 44 which is connected to an exhaust fan 45 by means of an exhaust duct 46. The exhaust fan, duct, and collection chamber are dimensioned so that the velocity of the air leaving the mixing chamber is relatively low and is substantially below the entrainment velocity of the sand particles. Accordingly, as the air entering the mixing chamber through the high-velocity nozzle streams moves upwardly toward the top of the chamber, the air velocity is reduced and most of the particles of material carried by the air drop out and settle back into the moving mass of material in the mixer. Hence, only a small quantity of fines is carried out by the exhaust fan and, since the quantity is relatively small, a large dust collector is not needed and in many instances no dust collector is required.

Even if a dust collector is used because of economic considerations, the collector can be relatively small since only a relatively small volume of cooling air is utilized. This is a great advantage compared to previous high-volume cooling systems of the prior art in which a large volume of air is required to obtain the desired cooling.

Referring now to FIGS. 5 through 9, there is illustrated another embodiment of a new and improved apparatus for conditioning granular material in accordance with the present invention referred to generally by the reference number 110. Many components of the system 110 are identical or very similar to components of the previous embodiments, and reference numbers having an additional prefix digit "1" will be used on components of the latter embodiment. For example, the mixing chamber "11" of the previous embodiments will be indicated as "111" in the embodiment of FIGS. 5 through 9.

The apparatus 110 includes a mixing chamber 111 for holding a mass of granular material 112, such as foundry sand, which is to be conditioned. The chamber 111 is formed with an upstanding cylindrical sidewall 113 having a wall liner 114 around the inner surface thereof and a bottom plate 115 with a replaceable wear plate 116 on the upper surface thereof. Referring to FIGS. 5, 6, and 7, a segment of the wall liner 114 has been removed leaving a large opening 114a and a slightly larger segment of the sidewall 114 has been removed in order that a replaceable circular wall segment 150 may be inserted in the opening in line with the wall liner. The wall segment 150 is supported on the bottom 115 as shown in FIGS. 8 and 9 and is held in place by means of bolts 151 and clamping plates 152.

A mixing head 117 is mounted for rotation in the chamber 111 about the central vertical axis thereof and the head is supported by a central shaft connected beneath the chamber to a gear reducer 119 driven by an electric motor 120. The mixing head includes a pair of mulling wheels 121 and their supporting structure and a pair of scrapers or plows and their supporting structure. The outer plow 126 is shown in FIGS. 7 and 8 of the drawings as it is supported by a support arm 124 in a conventional manner. An exhaust hood 143 encloses the top of the mixing chamber 111 and includes a collecting

section 144 which is connected to an exhaust fan (not shown) by an exhaust duct 145.

A plenum chamber or manifold 130 formed of molded plastic material, such as fiber glass or the like, is secured to the removable wall section 150 by means of a plurality of bolts 153 and clamping plates 154 which bear against the outside surface of the wall section and an outer flange 155 formed around the perimeter of the manifold. The manifold 130 is formed with a circular inlet 137 at one end for connection to a high pressure blower 138 through an inlet duct 138a. The blower 138 is similar to the blower 38, previously described, and supplies the required volume of air to the manifold at pressures in the range of $\frac{1}{2}$ to 3 p.s.i.

In order to direct high-velocity airstreams inwardly into the circularly moving mass of material in the mixing chamber 111, the wall segment 150 is provided with a plurality of ports 140 at spaced intervals along a horizontal line. The lower edges of the ports are at a level adjacent the upper surface of the material 112 in the mixing chamber and are approximately even with the top edge of the outer plow 126. Each of the ports 140 is in communication with the interior of the manifold 130 so that air in the manifold will be directed into the mixing chamber through the ports and the ports are dimensioned so that the airstreams passing therethrough will attain velocities of 6,000 to 10,000 f.p.m. at the region of contact with the material.

In order to evenly distribute the air entering the inlet 137 of the manifold between the several ports 140, the manifold is formed with a curved cross section, as shown in FIGS. 8 and 9. The cross section is gradually and continually reduced along the length of the manifold (FIGS. 5 and 6) from the inlet to the closed end to provide equal distribution of airflow through each of the ports at substantially equal velocities.

Each of the ports is provided with a downwardly extending air scoop 141 to smoothly transition the horizontal flow of air in the upper part of the manifold into a downwardly directed stream to the port. Each air scoop has an open upper end and is formed by a pair of side plates 142a, a sloped bottom plate 142b, and a sloped top plate 142c. As can be seen in FIG. 7, the side plates 142a are positioned to extend in a direction slanted toward the inlet 137 in order to smoothly direct the airflow from the inlet into the ports. Also, the side plates forming each air scoop 141 converge toward each other as they approach the port to increase the velocity of the air stream in the air scoop as it approaches the port.

The sloped top and bottom plates of each air scoop also converge toward each other as they approach the port so that the cross section of each air scoop is gradually reduced in area from the open inlet end to the port end. The air passing through each air scoop is gradually accelerated as it passes down the scoop and out through the port so that the velocity of the streams leaving the ports will be in the 6,000 to 10,000 c.f.m. range. Adjacent air scoops 141 are interconnected by a series of horizontal baffle plates 156 which help direct the air flowing horizontally in the manifold into the upper portion thereof. The baffles thus reduce turbulence in the manifold and strengthen the air scoops 141 by tying them together.

It should be noted that the air scoops 141 slope downwardly and, hence, direct the high-velocity airstreams downwardly into the material in the mixer in a manner similar to the downwardly directed nozzles 40 in the embodiment of FIG. 3. This construction virtually eliminates port plugging problems and aids the efficiency of the cooling as previously described. It should also be noted from FIGS. 5 and 6 that the inlet 137 is aligned horizontally with the upper portion of the manifold in order that the main portion of the air will flow along the upper portion of the manifold and only a small portion of the air will flow around the outside of the air scoops 141

in the lower portion of the manifold. The outside wall of the manifold is provided with a plurality of cleanout openings 150a which are covered by removable plugs or caps (not shown) so that the interior of the manifold or the individual air scoops may be cleaned if necessary.

Since the manifold 130, air scoops 141, and associated baffle plates 156 are all attached to the removable wall section 150, the entire assembly can be readily removed from the sidewall of the mixing chamber and replaced with another assembly or merely a curved wall section if no cooling of the material in the mixing chamber is desired. Also, another assembly can be located on the opposite side of the mixing chamber if desired. The shaping of the manifold, the air scoops, and baffle plates provides for efficient airflow in the manifold with a consequent reduction in losses because of eddy flows, and the use of ports in the mixing chamber sidewall rather than nozzles virtually eliminates any plugging problems.

While several particular embodiments of the present invention have been illustrated and described in detail, it should be understood that the invention is not limited thereto since modifications may be made by one skilled in the art, and it is therefore contemplated that the claims herein shall cover any such modifications that fall within the true scope and spirit of the invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. Apparatus for conditioning particulate material, such as foundry sand and the like, comprising an enclosed mixing chamber for containing a batch of said material, said chamber including a bottom wall, an upstanding peripheral sidewall, and a top wall, a mixing head in said chamber mounted for rotation about an axis upstanding from said bottom wall for moving said material in a circular orbit around said chamber to mix and agitate the same, an elongated gaseous fluid supply manifold secured to the exterior of said sidewall, said manifold extending generally parallel of said bottom wall and having an interior peripheral edge conforming to and adapted to seal against the exterior surface of said sidewall, fan means connected to one end of said manifold for delivering gaseous fluid under pressure to the interior thereof, a plurality of inlet opening defining means in said sidewall at circumferentially spaced locations therein in communication between the interior of said chamber and the interior of said manifold, a plurality of fluid delivery conduits connected to the interior of said manifold, each having an exit end in communication with one of said inlet opening defining means in said sidewall and an open inlet end in communication with the interior of said manifold for delivering a high velocity flow of gaseous fluid directly into the material in said mixing chamber, and exhaust fan means in communication with said mixing chamber above said inlet opening defining means in said sidewall for exhausting gaseous fluid from said chamber at velocities substantially less than the velocity of said fluid flowing into said material through said inlet opening defining means in said sidewall.

2. The apparatus of claim 1 wherein said fluid delivery conduits slope upwardly and outwardly of said inlet opening defining means in said sidewall for directing the gaseous fluid downwardly and inwardly into the mass of material in said chamber.

3. The apparatus of claim 1 wherein said fluid delivery conduits include converging wall portions extending from their open inlet ends to their exit ends for increasing the velocity of the gaseous fluid flowing into said mixing chamber from said manifold.

4. The apparatus of claim 1 wherein said mixing chamber sidewall includes a removable wall section, said manifold being secured to said wall section and said inlet opening defining means positioned in said wall section adjacent and along a lower portion thereof.

5. The apparatus of claim 3 including elongated baffle means in said manifold dividing said manifold into

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upper and lower portions, said open inlet ends of said delivery conduits being secured to said baffle means.

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