May 9, 1944. J. H. MORROW 2,348,560

COOLING APPARATUS

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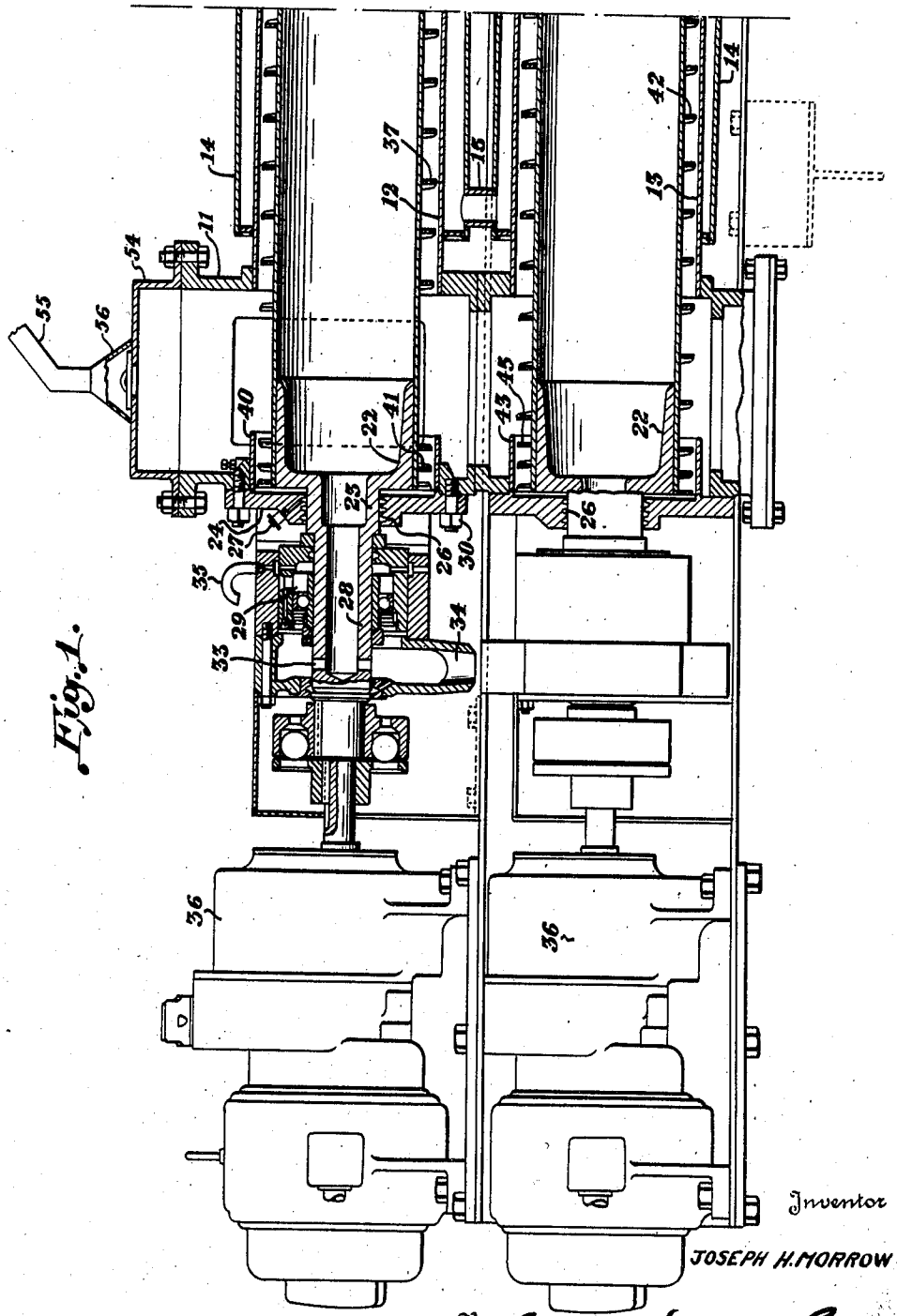


Fig. 1.

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Fig. 1a.

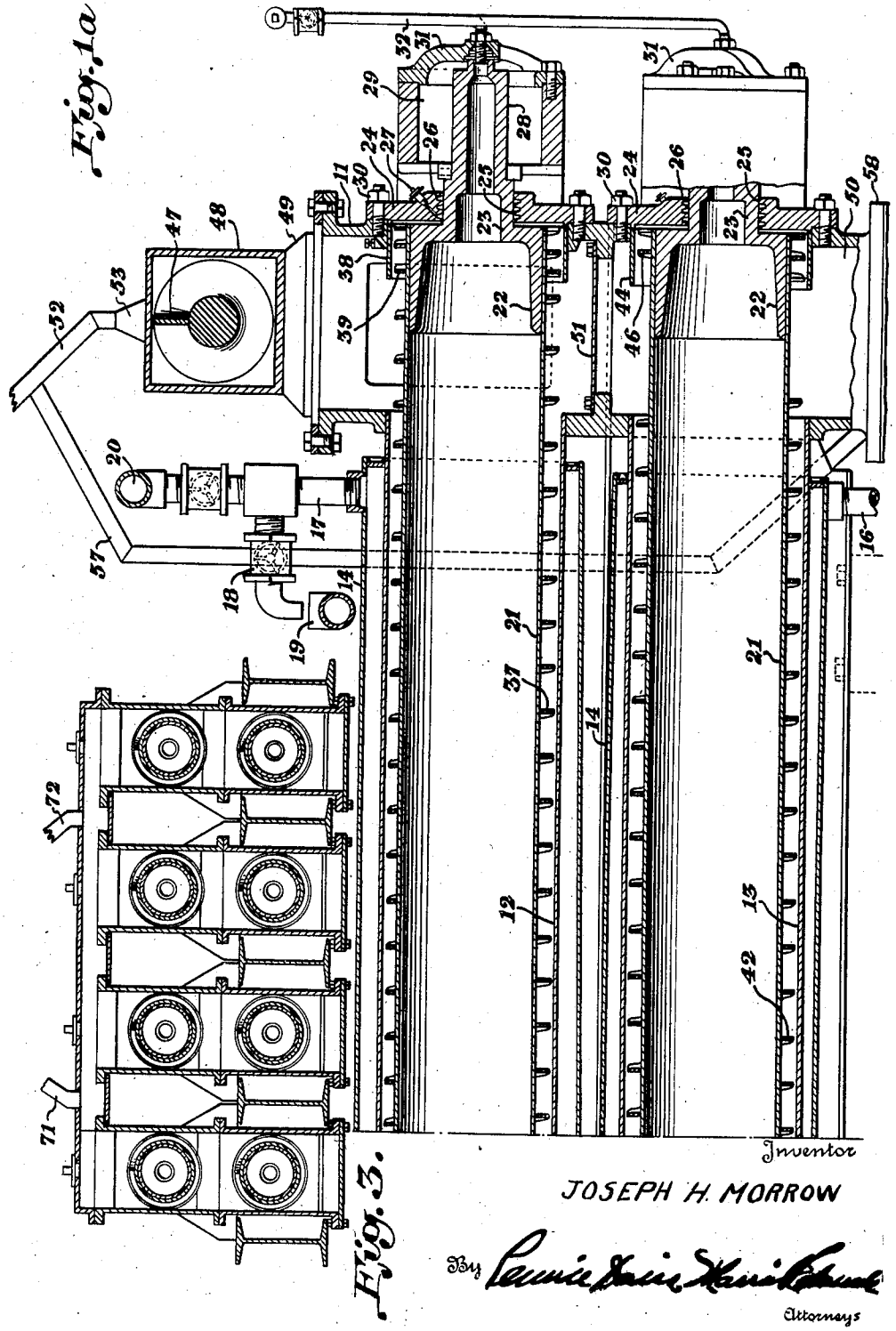


Fig. 3.

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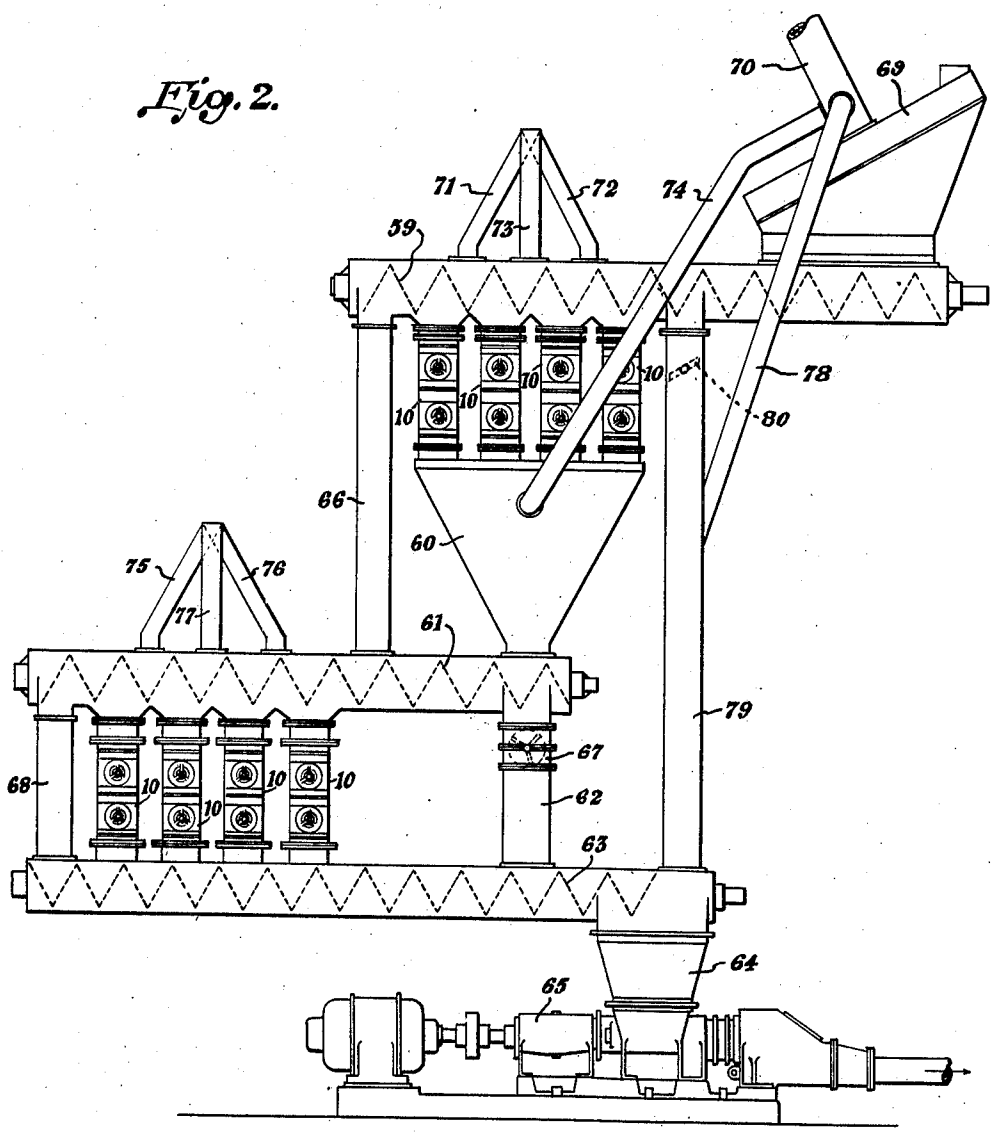
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Original Filed July 3, 1941 3 Sheets-Sheet 3

Fig. 2.



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Patented May 9, 1944 2,348,560

UNITED STATES PATENT OFFICE

2,348,560

COOLING APPARATUS

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Original application July 3, 1941, Serial No. 401,053. Divided and this application March 2, 1944, Serial No. 524,757

6 Claims. (Cl. 34—180)

This invention relates to the treatment of pulverulent, granulated and crushed material in order to reduce the temperature. More particularly, the invention is concerned with a novel apparatus for extracting the heat from such materials in a manner so that the material flows continuously between cooling surfaces in a uniform stream. The new apparatus is of general utility in cooling of materials of the class described, as will be readily apparent, but, for purposes of explanation, their use in connection with the cooling of freshly ground cement clinker only will be described.

During the finish grinding of clinker in the manufacture of cement, the temperature of the material rises appreciably, depending upon the characteristics of the clinker and the fineness to which the finished product is ground, or both, and depending upon the method of grinding, especially open or closed circuit. The temperature of these various types of products as they are discharged from the mill range from about 210 degrees F. to 300 degrees F. Some recent specifications which must be met by the manufacturer require that the cement must be ground to a much higher surface area, which sharply increases the temperature, the specifications also requiring that the cement be at a temperature of not more than 125° F. in some cases, and in order to meet this requirement it is necessary that the cement be delivered to the storage silos at a temperature not greatly exceeding the specification. In one commercial installation, reduction of the temperature of the freshly ground cement to not over 140 degrees F. enabled the manufacturer to meet a 125° F. specification. The handling and shipment of the cement from the storage silos to the job results in sufficient additional cooling to meet this requirement.

In the cooling of cement and the cooling of other materials of the class described, in which the manufacture thereof is usually a continuous process, it is essential that the cooling of the material to the desired reduced temperature take place at the same or greater rate than it is discharged from the apparatus immediately in advance. In the event that the material is stored prior to cooling, the requirement that the cooling to the desired temperature take place at least at a rate equal to the feed means is necessary for economical operation. Failure of the cooler to handle the material uniformly and at the required rate leads to objectionable results. Thus, in the case of cooling cement as it is discharged from the finish mills, if the flow of material from the mill is not reduced to the desired temperature in passing through the cooler it must be rehandled so as to pass again through the cooler, or other means must be used to further reduce the temperature. If the flow of material through the cooler is erratic, so as to result in failure to handle the mill discharge, such operation necessitates additional handling of the material and at times may require the stopping of the grinding mill until the material previously discharged can be cooled.

The problem thus presented is the efficient and economical removal of heat from material of the class described in a manner to discharge the material at a uniform rate.

It has been the practice heretofore to reduce the temperature of the finished cement in a number of ways such as spraying the finished grinding mills, by water jacketing cement transport lines, by recirculating the cement in storage silos or by a combination of these methods, but such methods are inefficient, and even when used in combination, have proved to be inadequate.

Various types of coolers are available in the prior art in which the material is advanced between concentric water cooled surfaces and such apparatuses have proved to be successful when the material treated is in a liquid form or in a perfectly dry form. However, in the treatment of finely ground material, such as finished cement, which contains a certain amount of moisture such apparatuses have proved to be unsatisfactory due to the condensation of the moisture present when the temperature is lowered. The condensed moisture accumulates in the cooler and after short period of operation the material flow becomes erratic, due to the formation of semiplastic or set cement masses which insulate the cooling surfaces so as to cause inefficient heat transfer and eventually cause such resistance to further movement of the material as to completely stop operation.

One source of the moisture present in finished cement is from the gypsum which is ground in with the clinker for the purposes of regulating the setting time of the cement when it is used. As previously stated, the temperature rises appreciably during finish grinding and especially if the cement is ground in open circuit, this temperature may exceed 240 degrees F. The gypsum is calcined to the hemi-hydrate at about 240 degrees F., this reaction temperature varying with the degree of purity of the gypsum rock. Under such conditions about 1½ mol. of water are released by the gypsum during the grinding process and most of this water is retained in the stream of material as it discharges from the mill.

Another source of moisture in the finished cement results from the practice in a number of plants of spraying the hot clinker discharge from the kiln with water to assist in its cooling. The greater portion of the water applied to the clinker for this purpose is converted to steam and passes away in the atmosphere, but usually a small percentage is retained within the clinker. In many plants, clinker is stored in the open where further moisture is contributed by the effect of weather.

The present invention is, accordingly directed to a method of treating pulverulent, granular and crushed material so as to extract heat therefrom and remove moisture, so that the material is cooled efficiently and discharged continuously in its reduced temperature condition at a uniform and uninterrupted rate, and to an apparatus whereby the new method may be advantageously and economically performed.

In the practice of the invention a continuous stream of material to be treated is passed to an enclosed circuit in which the material is continuously formed at a substantially thin bed between heat extracting surfaces, the bed being advanced and the particles thereof agitated to contact with the heat extracting surfaces, while maintaining the complete circuit under a uniform partial vacuum.

An apparatus in which the new method may be economically performed comprises in general one or more cooler batteries with each cooler battery having one or more cooler units. Each cooler unit comprises a pair of headers in which two vertically spaced barrels are supported with one barrel directly over the other. Each barrel is provided with a water jacketed casing, and a hollow shaft, concentric with the casing and of slightly less diameter and having screw flights thereon, operates to move the material through the casing. Water is circulated continuously through the water jackets and hollow shafts to absorb the heat from the material. The upper casing at one end communicates through the header with a feed manifold which may be used to supply the material to a number of adjacent units. The upper casing, at the end remote from the feed manifold, communicates directly through a header with the lower casing, and material passing through the upper casing in one direction enters the lower casing and travels in the opposite direction. The material discharges from the lower casing directly below the header inlet and enters a hopper which receives the discharge of all the lower casings in the battery, when more than one unit is used. The material from the hopper may be directed to a second battery of coolers or to storage or the like.

The hollow shafts are provided with trunnions at each end which are journalled in the headers and at one end extend through the headers for connection to individual motors, the lower shaft of each unit preferably being driven at a higher rate of speed than the upper to prevent clogging in the header.

The casings are maintained under a partial vacuum and in order that the pressure conditions will not develop to interfere with the uniform flow of material a duct communicating with the vacuum source is connected adjacent the ends of each casing. In this manner, the water vapors resulting from the reduction of temperature which usually collect at the discharge end of each casing are quickly removed from the system. This effectively insures against the formation of the layers of set cement which otherwise form on the cooling surfaces due to condensation of the moisture.

For a better understanding of the invention, reference is made to the accompanying drawings, illustrating apparatus suitable for the practice of the new method. In the drawings

Fig. 1 is an elevation partly in section of the drive end portion of a complete cooler unit.

Fig. 1*a* is a continuation of Fig. 1 showing the feed end of the unit.

Fig. 2 is a front elevation of one form of a complete cooling system.

Fig. 3 is a sectional view taken at the discharge end of one battery of cooler units shown in Fig. 2.

Referring now to the drawings, the apparatus will be seen to comprise individual cooling units 10 which may be used singly or in combination in a manner later to be described, the number of units used depending upon the capacity and degree of cooling desired.

As each cooling unit is the same, only one will be described and will be seen to comprise front and rear hollow headers or housings 11, open at each end, and having vertically spaced openings in their inner side walls with one opening directly above the other. A pair of parallel casings 12 and 13 communicate with the interior of the headers through the spaced openings and are supported thereby.

Each casing carries an individual water jacket 14 which extends substantially the length of the casing exposed between the front and rear headers. The upper and lower water jackets are connected at one end through a communicating passage 15 whereby cooling water supplied to the lower jacket from pipe 16 travels first through the lower jacket and then through the upper jacket to pipe 17. With the flow of water in the direction from the lower jacket to the upper jacket, pipe 17 is connected through valve 18 to a suitable drain 19. In the event it is desired to reverse the flow of water through the jackets, the valve to the drain 19 is closed and water supply line 20 connected to pipe 17, in which event, the water supply to the lower jacket is cut off and pipe 16 connected to a suitable drain in a manner similar to that shown and connected to the upper jacket.

Within each casing there is provided a hollow shaft 21 of slightly less diameter than the casing and mounted concentrically therewith. Hollow trunnions 22 carried at the ends of each of the shafts are provided with reduced portions 23 which extend through openings in the outer sides of the headers. The openings in the outer sides of the headers are substantially larger than the greatest diameter of the shaft in order that the shaft may be removed for repair or cleaning, and detachable retaining plates 24 serve to seal these large openings. Each plate 24 is provided with an opening 25 through which the reduced portion 23 of the trunnion passes. Grease grooves 26 are provided in the surfaces defining the openings 25 and may be filled with grease through a suitable nipple 27 to prevent leakage of material at these points.

Adjacent to and beyond the reduced portion 23 the hollow trunnions are further reduced in diameter, as at 28, and bearings 29 carried by the detachable plates 24 support the trunnions at this point. Thus it will be seen that by this construction the bolts 30 holding the plates 24 in

place may be removed and the plates **24** and bearings **29** slipped from the trunnions and the hollow shafts removed from the casings.

Caps **31** secured in a suitable manner to the bearing housings, at the forward end of the cooler unit, seal the hollow trunnions at this end, and water supply lines **32** connect to the interior of the shafts through the center of each cap.

The cooling water entering the hollow trunnions at this point flows through the trunnions into the hollow shafts and thence into the hollow trunnions at the opposite end of the unit. At a point beyond the supporting bearings for these latter trunnions discharge openings **33** are provided through which the cooling water flows to a discharge outlet **34**. The discharge from the upper cooler flows to the discharge outlet of the lower cooler and the combined flow may be disposed of in a suitable manner.

It has been discovered that upon rotation of the shaft in the bearings **29** that a partial vacuum is developed due to the action of the grease. This creation of vacuum has no effect at the forward end of the unit, but at the rear end it has a tendency to draw water from the discharge outlet into the bearing. An air vent **35** provided in each rear bearing successfully prevents this destructive action.

The trunnions at the rear end of the unit beyond the discharge openings are extended in a solid form for connection to individual drive means **36**. In order that the material will be removed quickly as it discharges from the upper screw the drive for the lower shaft is geared to rotate this shaft at a slightly greater speed than the upper shaft.

The upper shaft is provided with screw flights **37** of uniform pitch which extend from adjacent the outer wall of the front header to within the hollow portion of the rear header whereby material entering the front header is advanced along the shaft in a steady bed between the shaft and casing and is discharged to the lower screw through the rear header. A guard **38** attached to the outer wall of the front header and surrounding the shaft and flights diverts the incoming material from the end of the shaft where it passes through the plate **24** and double screw flights **39** on the shaft within the guard **38** further assisting in keeping the material from this opening. A similar guard **40** attached to the outer wall of the rear header and double flights **41** serves the same purpose at the rear end of the upper screw.

The lower screw is constructed similar to the upper screw, the only difference being that this screw is turned end for end in order that the flights **42** advance the material through the lower casing in the opposite direction. Guards **43** and **44** and double flights **45** and **46** at the rear and front end respectively of the lower screw serve to prevent leakage at these ends.

The material to be treated is fed to the upper open end of the front header by a screw **47** which operates in a housing **48** to advance a continuous supply of material. A connection **49** between the housing **48** and the header directs the material to the upper screw.

As will be apparent, the front and rear headers are identical and to prevent the material entering the front header from passing directly through to the discharge opening **50** a closure plate **51** is provided midway of the header.

The interior of the entire cooling unit is maintained under a uniform reduced pressure. A duct **52** enlarged at **53** connects the feed housing to a source of vacuum (not shown). A cover **54** closes the open upper end of the rear header and a duct **55** having an enlarged portion **56** also connects the interior of the unit at this point to the vacuum source. A third duct **57** connects the discharge hopper **58** which receives the material from the outlet **50**, after a complete run through both casings, to the duct **52** thereby connecting the unit at this point to the vacuum source. It will be clear that by connecting the unit at the entrance, at the discharge end of the upper shaft, and at the discharge end of the lower shaft with the vacuum source that the pressure will be maintained substantially equal over the entire system, thereby precluding a flow of air in a direction opposite to the flow of material which would substantially affect the discharge rate.

The apparatus thus far described constitutes a complete cooling unit and may be used alone for the treatment of materials of the class described, and its operation is as follows.

The valves controlling the water flow are regulated to cause a flow of cooling water through the water jackets **14** and hollow shafts **21**, and the motors **36** connected to their source of power to cause rotation of the shafts, with the lower shaft being rotated at a slightly greater speed than the upper shaft to insure against clogging of the material in the hollow rear header. The feed screw is then operated to deliver the hot material to the upper portion of the front header and as the material builds up on the division plate **51** and surrounds the shaft it is advanced along between the upper shaft and casing in a thin circular bed.

The material as it is advanced contacts the casing and a portion of its heat is absorbed by the cooling water in the jacket. As the outer diameters of the screw flights are slightly less in diameter than the casing, a film of material between the screw and casing causes the rate of heat transfer to be less at this point as compared with the transfer of heat to the water circulating through the shaft. The material as it is advanced by the screws transfers a large proportion of its heat to the water within the shaft, the screw acting as a cooling fin for the transfer of heat to the water. The rapid rotation of the shaft causes the coldest and heaviest water to contact the walls of the shaft to further increase the efficiency of the cooling along the exposed shaft area between the flights.

Any water vapor present as the material is fed to the front header is removed through the duct **52** and as the partially cooled material discharges from the upper screw through the rear header to the lower screw, the water vapors present at this point are removed.

The material entering the lower casing is further cooled in the same manner as is the upper casing and the discharge end of this shaft is also connected to the source of vacuum in order to remove any water vapor present.

Due to the equalized reduced pressure maintained throughout the system the material flows freely and uniformly and is discharged to the hopper **58** in a substantially dry condition.

In Figures 2 and 3 a complete cooling system is shown in which upper and lower batteries of four cooler units are used.

In the practice of the invention in a system of this type the hot material is advanced by screw

59 to each of the cooler units 10 in the upper unit. In the event that the cooling units of the upper battery are capable of handling the entire feed, the material, after passing through the units is discharged to the hopper 60, from which it may be either distributed by the distributing crew 61 to the lower battery of cooling units for additional cooling or may be passed directly through the discharge duct 62 to the screw 63 which advances it to the hopper 64 of a Fuller-Kinyon pump denoted generally at 65, which is adapted to cause the treated material to flow to the desired storage silo or packing house.

In the event that the feed rate is greater than can be handled by the upper battery of cooler units, the excess material passes to the discharge duct 66 to be distributed by the screw 61 to the lower battery of cooler units. Under such operating conditions the cooled material from the discharge hopper 60 may be passed directly through the discharge conduit 62 to screw 63 and thence to the conveying system, or the valve 67 may be closed and this cooled material advanced by the screw 61 along with the overflow from discharge duct 66 to the lower battery of cooling units. The excess material which cannot be handled by the lower battery of cooling units is advanced to the discharge duct 68 which directs this excess to the screw 63 which advances this excess and uncooled material along under the discharge outlets of the second battery of coolers where it is mixed with the material passing through these cooler units, It will thus be seen that the material to be treated can be double-cooled by passing through the two batteries of cooling units in series, or the maximum quantity capable of being handled by both batteries of cooling units may be passed through the cooling units once and delivered to the conveying system.

The entire system of both batteries of cooling units is maintained at a uniform reduced pressure to cause uniform flow of the material and to remove moisture as it appears during the reduction of temperature throughout the system. To obtain this uniform reduced pressure, the Hum-mer screen 69 through which the material passes to the feed screw 59 is connected through a duct 70 to a source of vacuum (not shown). This results in a uniform reduced pressure through the screen and feed screw 59 to the front ends of each of the cooler units in the upper battery. A pair of diverging ducts 71, 72 communicating with the discharge ends of the upper screws in this upper battery, are connected to the source of vacuum through the duct 73 which communicates with the feed screw 59.

A duct 74 connected to the source of vacuum through the duct 70 communicates with the discharge hopper 60 to place the discharge ends of the lower casings of the upper battery under partial vacuum. This duct 74 also places the screw 61 under partial vacuum and through this screw the feed ends of the upper casings of the lower battery are connected to the source of reduced pressure. A pair of diverging ducts 75 and 76 similar to those in the upper battery connect the discharge ends of the upper casings in the lower battery to the feed screw 61 through the single duct 77.

A second duct 78 leading from the main source of vacuum connects to the by-pass 79 to place the lower screw 63 and the discharge ends of the lower casings of the lower battery under the reduced pressure. Leakage of air through the Fuller-Kinyon pump to the hopper 64 is immediately removed through the by-pass 79 and duct 78, thereby insuring that the rate of feed in the system is not disturbed, and also that the heat carried by this leakage is not transferred to the material.

The by-pass 79 has a valve 80 therein for controlling the flow of material through the by-pass. When all of the material is to be passed through one or both of the cooling units the valve 80 will be closed. However, if it is desired to by-pass some or all of the material direct from the conveyor 59 to the hopper of the Fuller-Kinyon pump 65 the valve will be opened an appropriate amount.

The piping for the water connection to the water jackets and hollow shafts have not been shown in the system illustrated in Fig. 3, but it will be obvious that this piping arrangement will be the same as shown in Figs. 1 and 1*a*.

This application is a division of my application for Cooling apparatus, Serial No. 401,053, filed July 3, 1941.

I claim:

1. An apparatus for treating pulverulent, granular and crushed material comprising a first series of material-treating units, means for feeding material to be treated to the units of said first series, a second series of material-treating units, feed means for feeding material to be treated to said second series of units, a receiver for material treated in said first series of units, a receiver for material treated in the second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material receiver for the first series of units with the feed means for the second series of units, and means for closing one of said passages to cause the material from the receiver for the first series of units to pass through the other of said passages.

2. An apparatus for treating pulverulent, granular and crushed material comprising a longitudinally extending conveyor for material to be treated, a first series of material-treating units, each unit of said series having a separate material inlet communicating with the conveyor and adapted to receive material to be treated therefrom, the material inlets to the material-treating units of said series being in alignment and spaced longitudinally along the conveyor so that as long as the amount of material fed by the conveyor is in excess of the capacity of the treating units of said series the excess of material will pass successively over the inlets to the units of the series and beyond, a discharge conduit from the conveyor beyond the last inlet to a material-treating unit through which such excess of material may be discharged from the conveyor, a second series of material-treating units, a material-feed means for the second series of units, said discharge conduit from the feed conveyor for the first series of units being connected to the material-feed means for the second series of units, a receiver for material treated in said first series of units, a receiver for material treated in said second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material re-

ceiver for the first series of units with the feed means for the second series of units, and valve means for closing one of said passages to cause the material from the receiver for the first series of units to pass through the other of said passages.

3. An apparatus for treating pulverulent, granular and crushed material comprising a first series of material-treating units, means for feeding material to be treated to the units of said first series, a second series of material-treating units, feed means for feeding material to be treated to said second series of units, a receiver for material treated in said first series of units, a receiver for material treated in the second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material receiver for the first series of units with the feed means for the second series of units, and a by-pass for material from the feed means for the first series of units, in advance of said first series of units, to the material receiver for said second series of units.

4. An apparatus for treating pulverulent, granular and crushed material comprising a first series of material-treating units, means for feeding material to be treated to the units of said first series, a second series of material-treating units, feed means for feeding material to be treated to said second series of units, a receiver for material treated in said first series of units, a receiver for material treated in the second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material receiver for the first series of units with the feed means for the second series of units, a passage connecting the feed means for the first series of units, in advance of said first series of units, with the material receiver for said second series of units, and valve means for controlling the flow of material through said last-mentioned passage.

5. An apparatus for treating pulverulent, granular and crushed material comprising a first series of material-treating units, means for feeding material to be treated to the units of said first series, a second series of material-treating units, feed means for feeding material to be treated to said second series of units, a receiver for material treated in said first series of units, a receiver for material treated in the second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material receiver for the first series of units with the feed means for the second series of units, means for closing one of said passages to cause the material from the receiver for the first series of units to pass through the other of said passages, a passage connecting the feed means for the first series of units, in advance of said first series of units, with the material receiver for said second series of units, and valve means for controlling the flow of material through said last-mentioned passage.

6. An apparatus for treating pulverulent, granular and crushed material comprising a longitudinally extending conveyor for material to be treated, a first series of material-treating units, each unit of said series having a separate material inlet communicating with the conveyor and adapted to receive material to be treated therefrom, the material inlets to the material-treating units of said series being in alignment and spaced longitudinally along the conveyor so that as long as the amount of material fed by the conveyor is in excess of the capacity of the treating units of said series the excess of material will pass successively over the inlets to the units of the series and beyond, a discharge conduit from the conveyor beyond the last inlet to a material-treating unit through which such excess of material may be discharged from the conveyor, a second series of material-treating units, material-feed means for the second series of units, said discharge conduit from the feed conveyor for the first series of units being connected to the material-feed means for the second series of units, a receiver for material treated in said first series of units, a receiver for material treated in said second series of units, a passage connecting the material receiver for the first series of units with the material receiver for the second series of units, a passage connecting the material receiver for the first series of units with the feed means for the second series of units, valve means for closing one of said passages to cause the material from the receiver for the first series of units to pass through the other of said passages, a passage connecting the feed means for the first series of units, in advance of said first series of units, with the material receiver for said second series of units, and valve means for controlling the flow of material through said last-mentioned passage.

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