Sept. 29, 1964 J. R. HIGHTOWER 3,150,496

COOLING CONCRETE INGREDIENTS

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FIG. 1

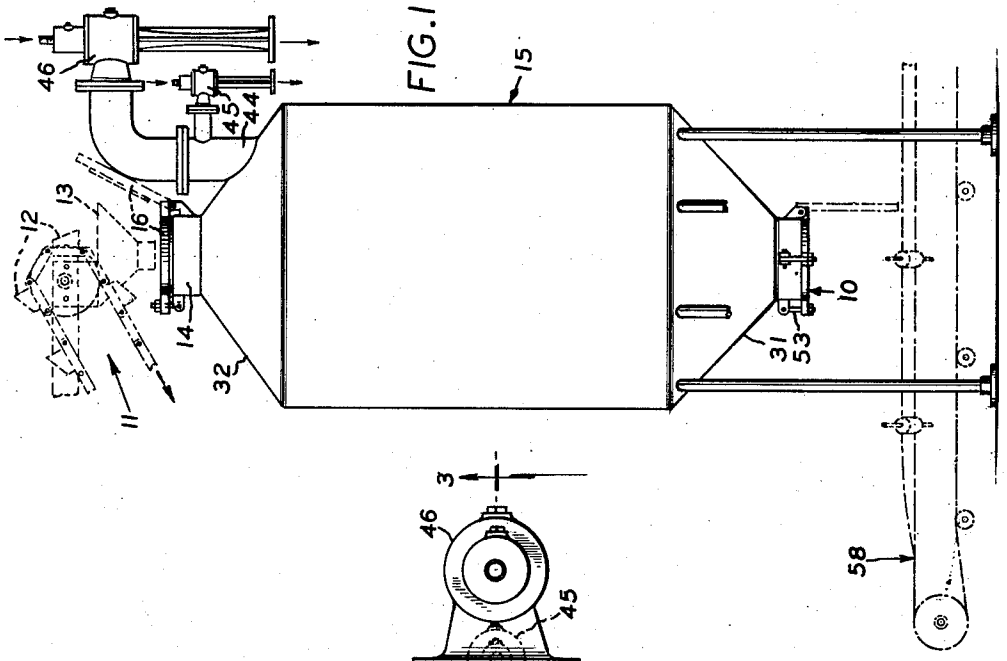
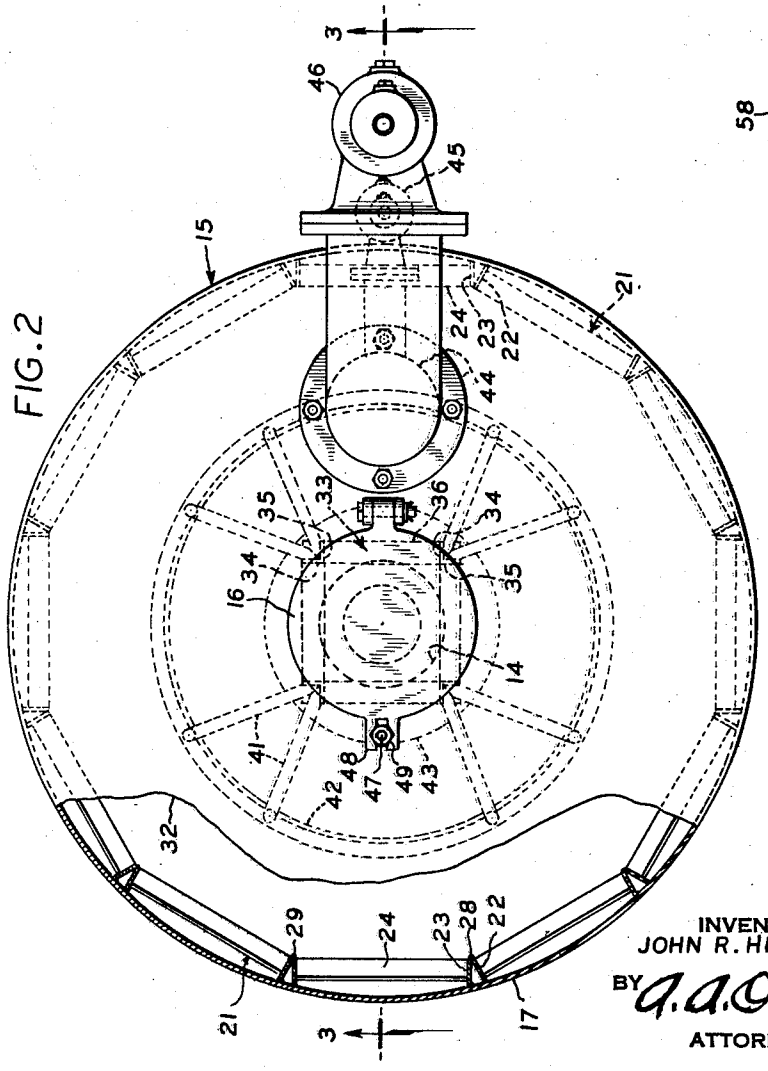


FIG. 2



INVENTOR
JOHN R. HIGHTOWER
BY A. A. Orlinger
ATTORNEY

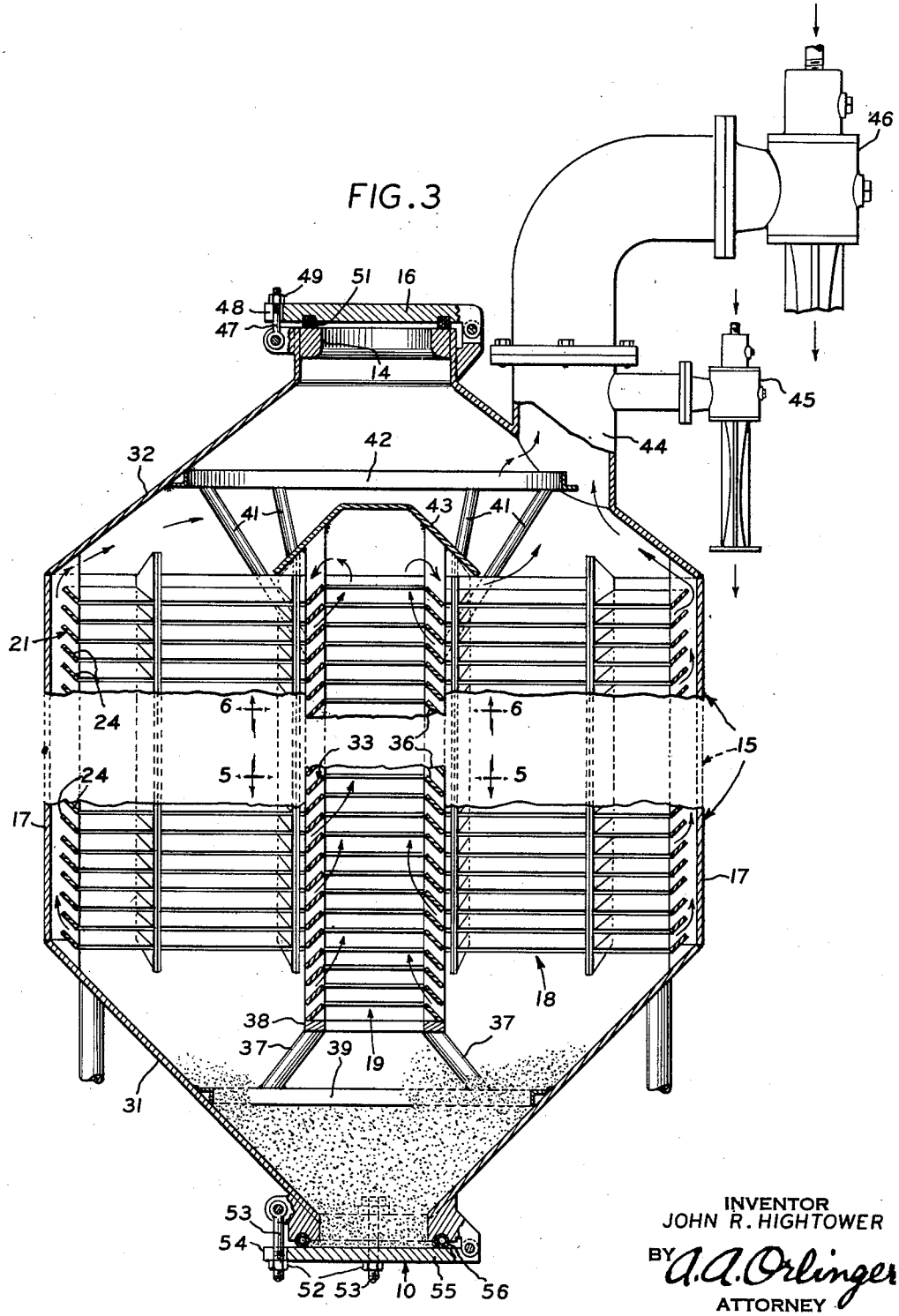
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COOLING CONCRETE INGREDIENTS

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FIG. 3



INVENTOR
JOHN R. HIGHTOWER
BY A. A. Orlinger
ATTORNEY

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FIG. 4

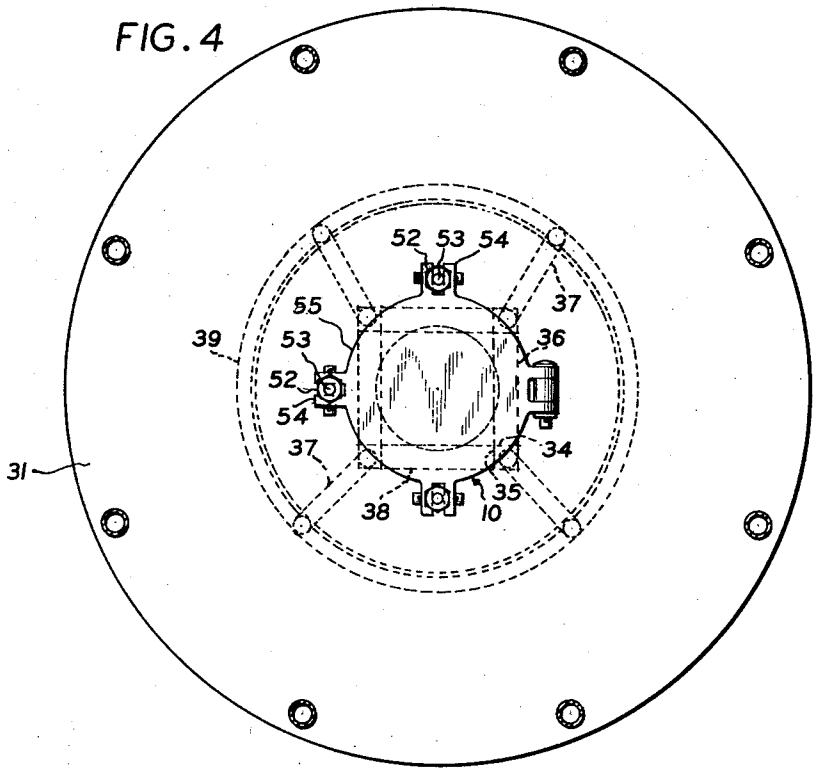
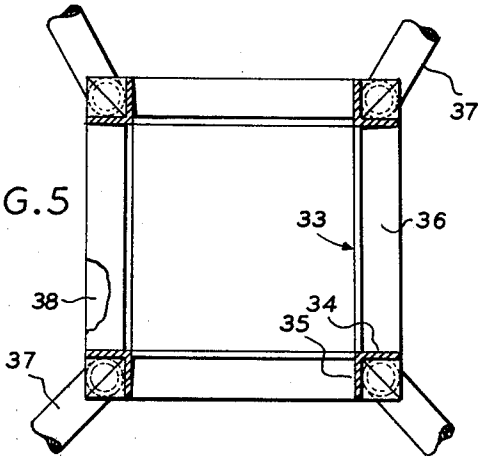


FIG. 5



INVENTOR
JOHN R. HIGHTOWER
BY A. A. Orlinger
ATTORNEY

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FIG. 6

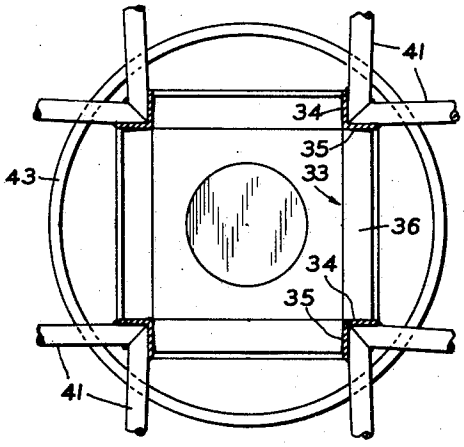
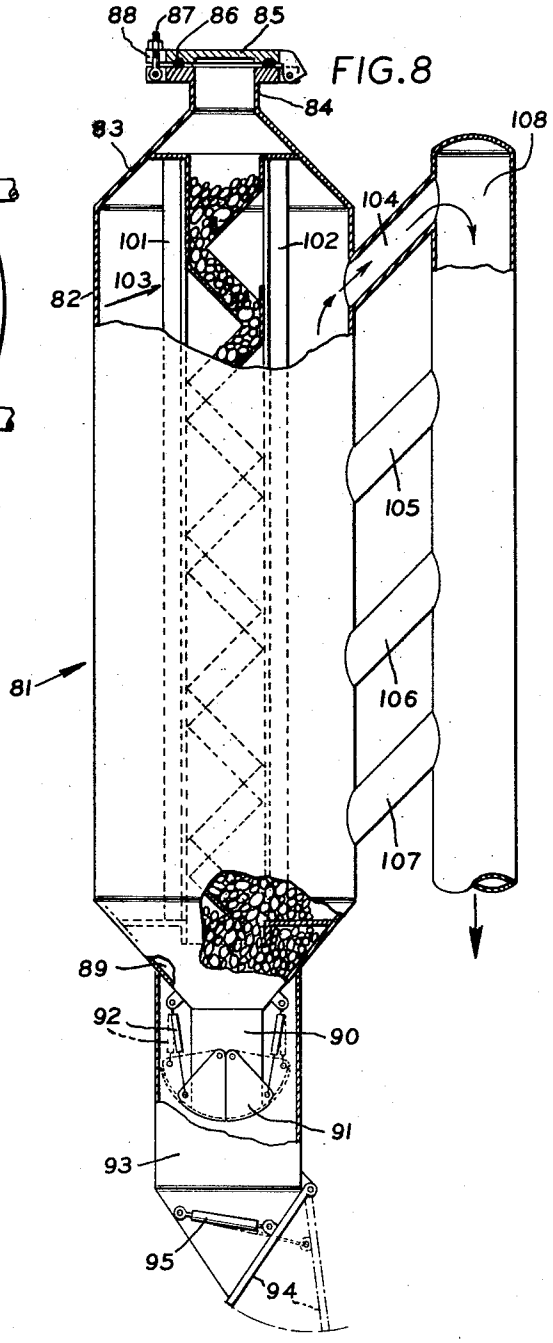


FIG. 8



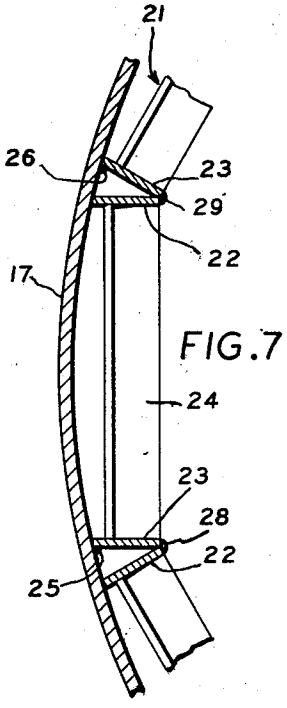


FIG. 7

INVENTOR
JOHN R. HIGHTOWER
BY A. A. Ordinger
ATTORNEY

United States Patent Office 3,150,496 Patented Sept. 29, 1964

3,150,496

COOLING CONCRETE INGREDIENTS

John R. Hightower, 340 Hollowell Ave., Hermosa Beach, Calif., assignor to John R. Hightower, Samuel W. Croll, Jr., James T. Reynolds, and John D. Hightower as joint trustees

Filed June 24, 1958, Ser. No. 744,275
13 Claims. (Cl. 62—64)

This invention is that of a method for separately cooling the coarse aggregates, the fine aggregates, and the sand as well as any mixtures of any of these, that go into concrete. Such ingredients conveniently can be called non-plastic ingredients (i.e. those other than the cement and the water) that go into concrete mixes.

The method of the invention is useful for cooling such various ingredients (for example, gravel, crushed stone, and other fine or coarse aggregates, including the sand as well). The aggregates can be of all sizes and gradations thereof and also of natural source or otherwise prepared. The method, however, is especially applicable to the smaller gradations of aggregates and the sand.

The invention includes also apparatus that particularly enables the practical cooling of the smaller ingredients such as the sand and gravel, and especially by the novel method of the invention.

The steady increase in the size of structures made from concrete, particularly the extensively massive concrete dams, correspondingly increased the problems as to the danger of expansion and contraction cracks stemming from the heat of hydration and of setting of the cement, evolved throughout the extensive dimensions of these structures, lack of uniformity in placing temperature, and the time required for transfer of the heat from the interior of the mass. Then also, lowering of the placing temperature retards the heat released by hydrating and setting concrete; which extends the period the concrete is workable, a special need in hot summer months.

These situations contributed to the requirement in placing specifications for cooling the concrete mixes to be placed to a temperature sufficiently below the average ambient temperature to assure that the heat liberated in the placed concrete will not raise its temperature to the level where gelatinization can occur and prevent its setting. The various methods tried for such cooling presented their respective disadvantages and shortcomings.

For example, using ice for cooling and at the same time to provide the water needed for the mix was limited not only by the small quantity of ice that could be used because of the required small ratio of water to cement, but also because it prolonged the mixing time to allow the ice to melt, and also by the need to provide the ice usually by an ice-making plant, including a crusher and handling equipment, in addition to their associated cost and maintenance.

Inundation as a cooling method not only was limited to use on the crushed stone and other coarse aggregates, but also required a cooling plant and circulation equipment for the water used as a cooling medium and which could only operate by differences in sensible heat; and also needed a long time lag for drainage off of excess water. It could not be used practically on the smaller ingredients because it would wash away fines and other useful content of them with consequent great loss, and also gave incompleteness and lacked uniformity because of channeling. In addition, it presented problems of controlling the water-cement ratio, changes in proportions of various particle sizes (as a result of abrasion), as well as wear and tear on equipment from it.

Chilled air circulation not only required expensive refrigeration, equipment for moisture separation from the air and for cooling it, but also the expense for equipment maintenance; and also was limited both as to its application, capacity and efficiency, and also by channeling. It could depend essentially only on exchange of sensible heat and then also was confined solely to use on coarse aggregates, because of the extensive resistance to flow through any practical thickness of smaller aggregates and especially through sand.

The strength and durability of concrete produced from prime quality aggregates, sand, cement, and water depends, all other conditions being equal, on the water-cement ratio. The lower the total water included, the stronger the concrete will be, so long as sufficient water is provided to enable the cement to hydrate.

The high water content ordinarily present in sand for concrete, and since sand represents about twenty-five to thirty-five percent by weight of a concrete mix, and thus also holds that same percentage of the total sensible heat of the mix, provokes serious need for a practical method and device for cooling it economically and effectively. A hollow flight screw conveyor, with chilled water at about 40° F. circulated through both the screw and the trough, was tried. However, the poor convection of heat through the sand and poor conduction from it to the metal parts of the conveyor required using a large number of these very costly units. In addition, the extensive abrasion of the screw and the trough by the sand made it almost impossible to keep these units running regularly.

The various disadvantages and shortcomings of the prior methods and apparatus for cooling concrete ingredients are avoided by the method, and also in the use of the apparatus, of the invention. Considered broadly, the method of the invention comprises loading the non-plastic ingredient for concrete to be cooled into a vacuum-tightly closeable vessel communicating with a source for producing subatmospheric pressure in that vessel, and with the particles of the ingredient to be cooled bearing a certain amount of water, and subjecting such water-bearing particles housed in that vessel to subatmospheric pressure sufficient first to cause the air to be removed from about the ingredient to be cooled therein and then to reduce the pressure in the vessel to a level below the vapor pressure of the water on that ingredient, whereby the water on the surfaces of its particles or pieces is caused to evaporate and thereby to extract heat therefrom and from any non-evaporated water and in an amount equal to the latent heat of vaporization of the water being evaporated from their surfaces; and continuing to lower the subatmospheric pressure about the ingredient being cooled until it reaches the desired lower temperature.

The amount of water held by the ingredient to be cooled, when it is loaded into the cooling vessel that is to be closed vacuum-tight, is to be at least sufficient to permit enough water to be evaporated from the surfaces of the particles or pieces of that ingredient for them to be cooled to the desired temperature, for example, about 40° F. With the average sand used for concrete mixes, the sand to be cooled should contain a starting minimum of about two percent of moisture to enable reaching about that low temperature. In some cases, its starting moisture content may be as low as about one percent, and in some instances even as low as eight-tenths of a percent so long as it is sufficient to enable the desired lower temperature to be reached. An advantageous maximum starting moisture content for sand is one that will let it contain a residual moisture content of about eight percent when the desired lower temperature of the sand (including its non-evaporated water) is reached.

The apparatus of the invention, advantageously applicable to the chilling of the smaller ingredients such as

sand and gravel, comprises an outer vacuum-tight shell (briefly called the "chilling silo") having a feed inlet in its upper end and a discharge outlet at its lower end. Both the feed inlet and the discharge outlet are designed to enable them to be vacuum-tightly closed. Extending outwardly from the upper end of the silo and communicating with its interior is a vacuum-tight exhaust conduit leading to suitable exhausting means for producing subatmospheric pressures in the interior of the silo.

Supported within the silo is an open-ended, apertured surface exposer for holding the charge of the concrete ingredient to be chilled therein so as to expose during the chilling interval a relatively much greater surface of it than if it were filled solidly across the entire interior of the silo, and thereby at the same time to permit exceedingly easy egress of air and vapors from within the charge of the ingredient.

A decidedly advantageous embodiment of the surface-exposer comprises two vertical, concentric louvered cylinders. The louver-bars of the outer one of them are spaced away from the inside wall of the silo, to provide an annular passageway for air and vapors withdrawn from within the surface-exposer. The inner, louvered cylinder is centrally disposed within the silo as a central passageway or chimney for air and vapor to travel centrally upwardly to the top of the silo to the exhaust conduit. The louver-bars of these two cylinders are horizontal in length and in width incline downwardly inwardly to the interior of the charge supporting zone enclosed by them.

The invention, both as to method and the apparatus, is understood more fully from the following description of the apparatus illustrated in the accompanying drawings wherein

FIG. 1 is a vertical elevation of a presently preferred specific embodiment of the apparatus of the invention;

FIG. 2 is a plan view with part of the top broken away to show the relationship of louver-bars of the outer louvered cylinder to the inside wall of the silo;

FIG. 3 is a vertically foreshortened section along the axis of the silo and line 3—3 of FIG. 2, looking in the direction of the arrows, and showing in full elevation the exhaust conduit connected to evacuating means;

FIG. 4 is a bottom plan view, looking upwardly from underneath the closed silo;

FIG. 5 is a fragmentary section looking downwardly into the inner louvered cylinder or chimney flue, along the line 5—5 of FIG. 3;

FIG. 6 is a fragmentary view, along the line 6—6 of FIG. 3, looking upwardly into the central flue and the distributor or diverter hood;

FIG. 7 is a fragmentary transverse section horizontally across part of the silo shell and of the outer one of the louvered cylinders; and

FIG. 8 is a front elevation, with parts in broken vertical section, of an apparatus for conducting the method of the invention with coarse aggregates (i.e. crushed stone and other aggregates over three-eighths inch diameter).

The apparatus of FIGURES 1 through 7, being primarily essentially applicable to the smaller ingredients, such as sand and gravel, conveniently can be described as used with sand, although not intended to be restricted to use with it alone.

Referring to FIGURES 1, 2 and 3, with the discharge outlet closed by its discharge closure 10, sand to be chilled is elevated from its storage pile or other supply (not shown) by a convenient elevator such as the bucket elevator 11 (shown in phantom) and at its upper end discharged from the there inverted buckets 12 to drop through the feed hopper or chute 13 (in phantom) to be fed into the open top end 14 of the silo 15 when the top closure or cap 16 is in its open position (as seen in phantom).

Housed within the enclosing wall shell 17 of silo 15

is the open-ended, apertured surface-exposer having its outer louvered cylinder 18 encircling the louvered flue 19. The outer louvered cylinder 18 has a plurality of ladder-like segments 21 (FIGS. 2, 3 and 7), twelve of them in this embodiment. Each segment 21 has two parallel vertical louver-supports 22 and 23, and extending horizontally between them and vertically spaced apart from one another a series of louver-bars 24. The outer ends of each louver-bar 24 are secured, preferably by welding, to its respectively opposed pair of louver-supports 22 and 23.

To firmly hold the outer louvered-cylinder, the outer edge of each alternate louver-support (i.e. each support 23) is secured, preferably by welding, to the inner wall of the shell 17, as seen at joints 25 and 26 (FIG. 7). Then the circle of segments 21 is strengthened as a unit by joining together the inner vertical ends of each pair of adjoining louver-supports 22 and 23, preferably by welding, as at 28 and 29, etc.

The lower end of each of the louver-supports 22 and 23, rests on, and is supported by, the upper end of the inverted frusto-conical bottom 31 of the silo, and preferably is secured to it, conveniently by welding. Correspondingly, the upper end of each louver-support 22 and 23 abuts against, and conveniently is secured preferably by welding to, the lower end of the frusto-conical top 32 of the silo.

Similarly, central flue 19 consists of a plurality of ladder-like segments 33 (FIGS. 2 through 6), conveniently four in this embodiment. Just as in segments 21, each segment 33 has two parallel vertical louver-supports 34 and 35 with a series of vertically spaced apart horizontal louver-bars 36 extending between, and similarly secured to, the louver-supports 34 and 35. Conveniently, the adjoining louver-supports 34 and 35 of each pair of them can be one of the two flanges of an angle iron. Thereby the welding of the outer ends of the louver-bars 36 to opposed parallel louver-supports 34 and 35 secures the four segments 33 into a firm unit.

Then central flue 19 is securely supported centrally within silo 15 by a number of lower braces 37 that have their upper ends secured to the open base 38 and their lower ends secured to brace-support-ring 39, and then by a number of hangers 41 that have their upper ends secured to hanger-ring 42 attached to top 32 and having their lower ends anchored to louver-supports 34 and 35.

Louver-bars 24 of the outer louvered-cylinder and louver-bars 36 of the central flue, both along their width, incline downwardly inwardly to the interior of the charge supporting zone enclosed within them.

Supported above the central flue is an inverted dish-shaped diverter or distributor 43 to serve to prevent freshly charged sand from falling into the flue and rather to direct it into the charge supporting zone.

Extending outwardly upwardly from top 32, and communicating with the interior of the silo, is the gas and vapor exhaust conduit 44 leading to suitable exhausting means, in this case the primer steam ejector 45 and the booster steam ejector 46.

The distance vertically between louver-bars, their radial-width, and their inwardly downward inclination are so related that the angle of piling of such sand that can rest on the inner portions of these bars is so steep that none of the sand charge reaches the outer rim of the louver-bar.

The distance between the two concentric louvered-cylinders is such as to avoid too great a pressure drop from any point midway between them to their louvers. The greater the pressure drop, the longer is the time required for the vacuum to be drawn to reach the desired lower temperature uniformly throughout the sand. For an overall operating cycle of about one hour or so, it ordinarily would be desirable not to have such a pressure drop greater than a couple of millimeters of mercury.

In general, a suitable spacing arrangement is one

wherein the maximum distance of travel of vapor through the voids of sand is about thirty inches or so. The exposed sand surface of the louvers and the top of the sand charge-supporting zone ordinarily should be about one square foot of exposed area for about two cubic feet of sand.

The sand dropping from the elevator into the open top **14** of the silo is diverted from falling into the central flue by deflector-distributor **43** and falls through the charge-supporting zone into the bottom cone **31** and builds up from there to fill the charge-supporting zone (between the outer louvered-cylinder and the central flue). It is undersirable to feed sand into the charge-supporting zone to a height above the top-most louver-bar.

After sufficient sand has been charged into the silo, the elevator is stopped. To cap **16** is closed and locked by engaging the eye-bolt **47** in the yoke **48** of the cap and turning the locking nut **49** down sufficiently for a vacuum-tight closing by compression of the compressible gasket **51** of cap **16** against the top end **14**.

The primer steam ejector **45** then is started and operated long enough to withdraw the air from above the sand, from the annular space between the outer louvered cylinder and shell **17**, from the flue, and from the voids within the sand. That occurs within a few or several minutes; and the subatmospheric pressure then is at about three inches absolute. Then the booster steam ejector **46** is started and the evacuation is continued to lower the pressure to the vapor pressure of water of the temperature of the sand, for example, to one inch absolute for sand at about 79° F. That then causes water in the sand to evaporate, thereby extracting heat from the sand particles and non-evaporated water left on it by an amount equal to the latent heat of vaporization of the water evaporated, and in turn thereby cooling the sand and the residual water.

The rate of lowering the absolute pressure is controlled to avoid strong enough currents to stir up undersirable sand dust and also to avoid local freezing that would interfere with withdrawal of air and water vapor. The steam ejector operation is continued long enough to bring the absolute pressure low enough to enough the evaporation of water to chill the sand to the desired final low temperature. For example, in about fifty-five minutes the sand can be cooled to about 40° F. at an absolute pressure of about one quarter inch of mercury.

The evacuation then is discontinued. The vacuum is broken, for example, by opening a valve in a leak line (not shown) above the sand. The bottom of the silo then is opened by turning the nuts **52** on the eye-bolts **53** sufficiently to enable them to be swung out of the yokes **54** in discharge cover **55** (incidentally, that releases the pressure on O-ring **56** which served to provide the vacuum-tight closure during the vacuum operation). The cooled sand then discharges on to suitable means, such as the dished-top flight belt conveyor **58** (shown in phantom), to a suitable place of storage or for use.

During the evacuating operation, the pathway of the air entrapped within the sand or gravel passes through the louvers into the annular space between the outer louvered-cylinder and the shell wall and also into the central flue and from both those passageways into the conical top **32** and from there into vacuum conduit **44**, as indicated generally by the arrows.

The operation of the method of the invention, for example, in the embodiment of apparatus of the invention shown in FIGS. 1 through 7, is illustrated, but not limited, by the following specific example of cooling of a batch of sand:

One hundred and five thousand pounds of river sand (occupying 1050 cubic feet) containing between six to eight percent of water are charged into a silo of ten feet six inches inside diameter, having a fourteen foot high outer louvered-cylinder with twelve segments, and a sixteen foot seven inches high four-sided louvered central flue with opposing sides at about eighteen inches apart, supported about four and one-half feet above the lower end of the bottom cone.

With the starting temperature of the sand charge at 80° F., operation of the primer steam ejector in five minutes reduced the pressure in the silo to three inches (Hg) absolute. Then with operation of the booster steam ejector, the pressure dropped soon thereafter to two inches absolute and somewhat later to one inch, and after fifty-five minutes to one-quarter of an inch absolute, with the sand temperature reduced to 40° F., when the evacuation was discontinued. The thus chilled sand showed a moisture loss of about one percent of the wet sand. The overall cooling cycle was an hour.

The apparatus illustrated in FIGURES 1 through 7 is not restricted to use merely on sand for concrete for it also can serve with gravel used in concrete, as well as sand and gravel used for other purposes or even pellets of catalyst used in various catalytic operations. It can readily handle such materials up to sizes that pass through three-eighths inch mesh screens or even slightly larger.

However, the method of the invention can be applied to even much larger pieces such as coarse aggregates (e.g. from all held on three-eighths inch mesh up to six inches) used in concrete. Such coarse material can be cooled by the method of the invention in apparatus of the type illustrated in FIG. 8.

Its silo **81** includes its vertical cylindrical shell **82** with a top cone **83** and inlet neck **84** having a cap **85** bearing an O-ring gasket **86**, and closed by locking the eye-bolt **87** in the yoke **88**. Below shell **82** the silo has an inverted frusto-conical bottom **89** with its bottom outlet **90** closed by an ordinary clam shell gate **91** operated by pneumatic arms **92**.

Since a clam-shell gate is not readily vacuum-tightly closed, bottom outlet **90** is enclosed in a vacuum housing **93** that is vacuum-tightly closed by its swingable flap gate **94** with suitable compressible gasket (not shown), and operated by the pneumatic arm **95**.

Carried on usual-type verticals **101** and **102** and supported concentrically by adequate brackets and braces (not completely shown) within silo **81** is an ordinary rock ladder designated **103** (as a whole). At desirable elevations from one side of shell **82**, and communicating with its interior, vacuum conduits **104**, **105**, **106** and **107** extend to, and communicate with the interior of, vacuum manifold **108**.

The latter, conveniently at its bottom, connects to suitable exhausting equipment, such as steam ejectors, similar to those of FIG. 3, or mechanical vacuum pump, and the like. As an added precaution, if desired, a vacuum line (not shown) can join the interior of housing **93** with that of manifold **108**.

In operation with the apparatus shown in FIG. 8, with clam shell gate **91** closed and top cap **85** open, coarse aggregates such as crushed stone, raised to the top from its stock-pile, by suitable elevator (slat or bucket), into the top of silo **81**, drops down the successive flights of rock ladder **103** into bottom outlet **90**. It builds up from there to fill conical bottom **89** and thereafter, by overflowing from each successively higher flight of the rock ladder, to fill the silo.

Top cap **85** then is vacuum-tightly closed and so also is flap gate **94**. Evacuation of the air surrounding the coarse aggregates in the silo then is conducted in manner similar to the evacuation operation described above with the apparatus of FIGS. 1 through 7.

However, with coarser material like the coarse aggregates, there is no concern about raising any sand dust or blowing sand around in the silo. Then also, because of the larger size of the voids within coarse aggregates, there is little concern about drop in pressure from the innermost parts of the charge.

Apparatus of the type shown in FIG. 8 is considerably

flexible in size. For example, it can be constructed with a silo sixty-four feet high by eleven feet in inside diameter, and using a vacuum manifold or header three and one-half feet in diameter. Those dimensions for the cooling silo are not necessarily maximum.

While eight percent is the preferable maximum water content for ideal operating conditions, a little above that is readily workable, with sand. However, it is undesirable to charge sand containing too much above eight percent of moisture for then with sand having a large proportion of fines (i.e. smaller than 100 mesh and closer to 200 mesh), so that the sand has a minimum of voids, the tendency to packing of the sand increases. That then at least will decrease the rate of travel of entrapped air from the innermost voids in the sand charge, correspondingly delay evaporation of water from those areas, and also delay the cooling there.

Where the initial moisture content of the ingredient or component to be cooled, e.g. the sand or gravel, greatly exceeds eight percent, then any undesirable excess can be removed usually by mere drain-drying and/or exposure to the atmosphere, before feeding it to the cooling equipment.

In any operation wherein it may not be objectionable, it may be possible to add gravel to such excessively wet sand, and desirably in the ratio in which they are used in the concrete mix. Ordinarily the large aggregates present no excess moisture problem, because of the readiness with which excess moisture can drain off of particles or pieces of a large aggregate.

Generally, the minimum effective starting moisture or water content that should be present is determined from a consideration of the temperature which the component to be cooled has at the start of the operation, the final temperature to which it is to be cooled, and its specific heat. Thus, there will need to be present at the start at least that amount of water that could be evaporated by the amount of heat that the component must give up or lose in being cooled from its starting temperature to the selected lower temperature to which it is to be cooled.

In general, it appears that the raising and blowing around of small size material (e.g. the sand component for concrete) in the chilling silo can be avoided by seeing to it that the pressure at the surface of the material does not exceed the pressure at any point within the charge of sand by sixteen millimeters at the starting and priming (e.g. at 80° F.) and does not exceed it by one millimeter at the end of the run (e.g. at 40° F.).

In the operation described in the illustrative example, the capacity of the steam jet ejectors should be such as to remove water vapor at the rate of at least eighteen hundred pounds per hour at the 80° F. starting temperature. The vapor removal at the end of the operation (40° F; one-quarter inch Hg) is about seven hundred and fifty pounds per hour. As already indicated, in that embodiment as in any other embraced by the method of the invention, any other suitable evacuating equipment can be used.

Louvers such as those already described have thus far been found most advantageous as apertures in the surface-exposer or charge-supporter of the embodiment shown in FIGS. 1 through 8. However, any other type of apertures that allow escape of entrained air and water vapor (resulting from the evaporation) and without spilling over of the sand or gravel into the chimney flue or annular gas and vapor conduit (between the outer apertured cylinder and the inside wall of the shell) can be used. For example, open-topped pockets that project into the open chimney and others likewise into the open annulus, can be used.

While the practice of the method of the invention with apparatus such as that of the embodiment shown in FIGS. 1 through 7 or that shown in FIG. 8 appears to be by a batch operation, the method also can be carried out as a continuous process.

For example, the sand or gravel can be fed continuously into a zone where it accumulates to a height sufficient to provide a vacuum-tight head of substantially stationary sand, and leave relatively continuously from the bottom of such zone to a lower zone maintained at subatmospheric pressure and from it to a further zone maintained at sufficiently lower absolute pressure to attain the selected level of cooling; and therebelow accumulate in sufficient depth to provide at least a sufficient height to serve as a barometric sand leg or vacuum seal; from the bottom of which cooled sand is continuously removed at a required rate.

While the invention as to the method as well as the apparatus has been explained by detailed description of certain specific embodiments, it is understood that various modifications as to form and size and conditions as to any of its elements, and modifications and substitutions, may be made in any aspects of the method or the apparatus within the scope of the appended claims which are intended to cover also equivalents of any of the herein described specific embodiments of the invention.

What I claimed is:

1. The method of cooling an ingredient used in making concrete, prior to admixing it into the initial overall mix, selected from the class consisting of the aggregates and sand, and to a temperature above 0° C. but significantly below the ambient temperature, which method comprises adding to such ingredient whatever amount of water is needed for it to have a moisture content at least sufficient to enable evaporating from the surface of its particles an amount of water the latent heat of vaporization of which equals the amount of sensible heat that would be given up by evaporation from the ingredient for it to be cooled from its initial temperature to the desired final temperature for said ingredient; loading a charge of such ingredient having such moisture content into a vacuum-tightly closeable zone; subjecting said charge of ingredient in the vacuum-tight zone to subatmospheric pressure initially to remove air from that zone and from within the charge of the ingredient; and continuing to reduce the absolute pressure in that zone to remove such air and also to produce a pressure level at least as low as the vapor pressure of water at the lower temperature to which it is desired to cool the charge, and at the same time to remove vapor produced as a result of the evaporation of moisture under the reduced pressure, and doing so until such evaporation has reduced the temperature of the charge to that to which it is desired to cool said charge.

2. The method of cooling an ingredient used in making concrete, as claimed in claim 1 which also comprises providing in the vacuum-tight zone and outside of the body of said charge therein and other than its top and bottom surfaces, at least one path whereby gas and vapors can leave the body of the charge of ingredient being subjected to the reduced pressure in said vacuum-tight zone.

3. The method of cooling as claimed in claim 2, which also comprises providing such at least one other path at a location somewhere along the height of the body of the charge.

4. The method as claimed in claim 3, which also comprises providing a plurality of such paths located along the height of the body of the charge.

5. The method of cooling as claimed in claim 4, which also comprises providing at least some of the plurality of such paths at different elevations along the height of the body of the charge.

6. The method of cooling as claimed in claim 5, wherein the ingredient of concrete being cooled is at least one of the aggregates used as a component for concrete.

7. The method of cooling as claimed in claim 3, which also comprises providing one such other path vertically and from the interior of the body of the charge.

8. The method of cooling as claimed in claim 3, which also comprises providing at least one such other path along at least part of the vertical peripheral boundary around the outside of the body of the charge.

9. The method as claimed in claim 8, which also com-

prises providing one such other path vertically and from the interior of the body of the charge and one other such path annularly vertically along the outside of the body of the charge; and wherein the ingredient of concrete being cooled is a member of the class consisting of sand and gravel.

10. The method of cooling an ingredient for concrete, as claimed in claim 1, wherein, when the water-content of said ingredient is too low for the latent heat of vaporization of that quantity of water to extract enough heat from the charge of said ingredient to cool it from its starting temperature to the final required temperature under the reduced pressure in said vacuum-tight zone, before subjecting said ingredient to the reduced pressure there is distributed in it an additional quantity of water, the latent heat of vaporization of which is sufficient to remove from said ingredient under the applied reduced pressure enough additional sensible heat to cool the ingredient to the required final temperature.

11. The method of cooling an ingredient for concrete, as claimed in claim 2, wherein the ingredient is sand and the charge is so held within said zone in relation to its top and bottom surface and its surface exposed to said at least one path other than said top and bottom, that the maximum distance of travel of water vapor through said charge of the sand is about thirty inches.

12. The method of cooling the sand ingredient for concrete, as claimed in claim 2, wherein the total surface of the body of the sand charge exposed to any continuous body of vapor about the top and bottom surfaces of the charge and the surface exposed to said at least one path other than the said top and bottom, amounts to about one square foot of such exposed area for about every two cubic feet of sand.

13. In the method of preparing concrete to be placed at a temperature below the ambient temperature about the location where it is to be placed, the combination of steps which comprises cooling an ingredient selected from the class consisting of the aggregates and sand, and to a temperature above 0° C. but significantly below said ambient temperature, prior to mixing the various necessary ingredients into the initial concrete mix, by adding to such ingredient whatever amount of water is needed for it to have a moisture content at least sufficient to enable evaporating from the surface of its particles an amount of water the latent heat of vaporization of which equals the amount of sensible heat that would be given up by evaporation from the ingredient for it to be cooled from its initial temperature to the desired final temperature for said ingredient; loading a charge of such ingredient having such moisture content into a vacuum-tighly closeable zone; subjecting said charge of ingredient in the vaccum-tight zone to subatmospheric pressure initially to remove air from that zone and from within the charge of the ingredient; and continuing to reduce the absolute pressure in that zone to remove such air and also to produce a pressure level at least as low as the vapor pressure of water at the lower temperature to which it is desired to cool the charge, and at the same time to remove vapor produced as a result of the evaporation of moisture under the reduced pressure, and doing so until such evaporation has reduced the temperature of the charge to that to which it is desired to cool said charge.

References Cited in the file of this patent

UNITED STATES PATENTS

1,207,763	Jaeger	Dec. 12, 1916
2,083,863	Pfeiffer	June 15, 1937
2,245,664	Gronert	June 17, 1941
2,278,701	Karr	Apr. 7, 1942
2,283,319	Dienst	May 19, 1942
2,621,492	Beardsley et al.	Dec. 16, 1952
2,671,057	McClure	Mar. 2, 1954
2,808,657	Osborne et al.	Oct. 8, 1957

FOREIGN PATENTS

35,730	Denmark	Feb. 26, 1926
471,452	Germany	Feb. 12, 1929

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,150,496 September 29, 1964

John R. Hightower

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 11, for "surface exposer" read -- surface-exposer --; column 5, line 17, for "To" read -- Top --; line 30, for "of", second occurrence, read -- at --; same column 5, line 43, for "enough", second occurrence, read -- enable --; column 8, line 49, after "claim 1" insert a comma; column 10, line 12, for "vacuum-tighly" read -- vacuum-tightly --.

Signed and sealed this 22nd day of February 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents