Sept. 11, 1962 H. KNAUST 3,052,988

APPARATUS FOR COOLING ORE SINTER AND SINTER MATERIAL

Filed May 31, 1960 5 Sheets-Sheet 1

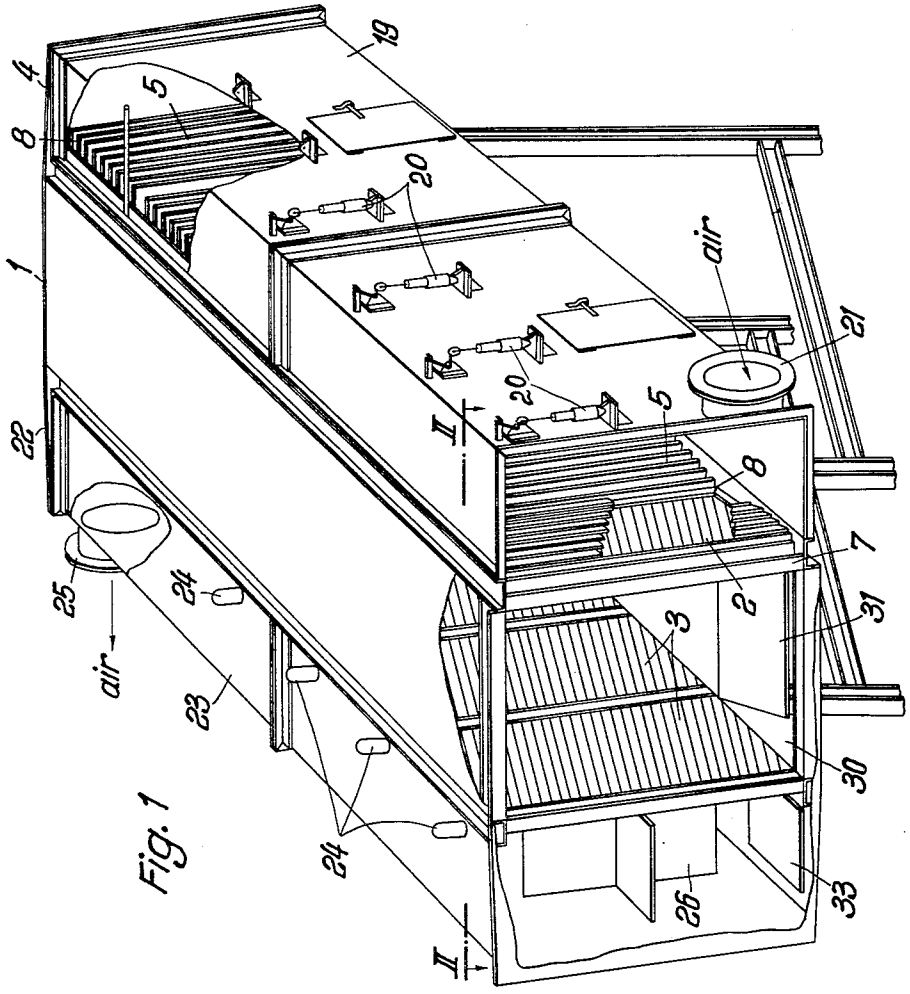


Fig. 1

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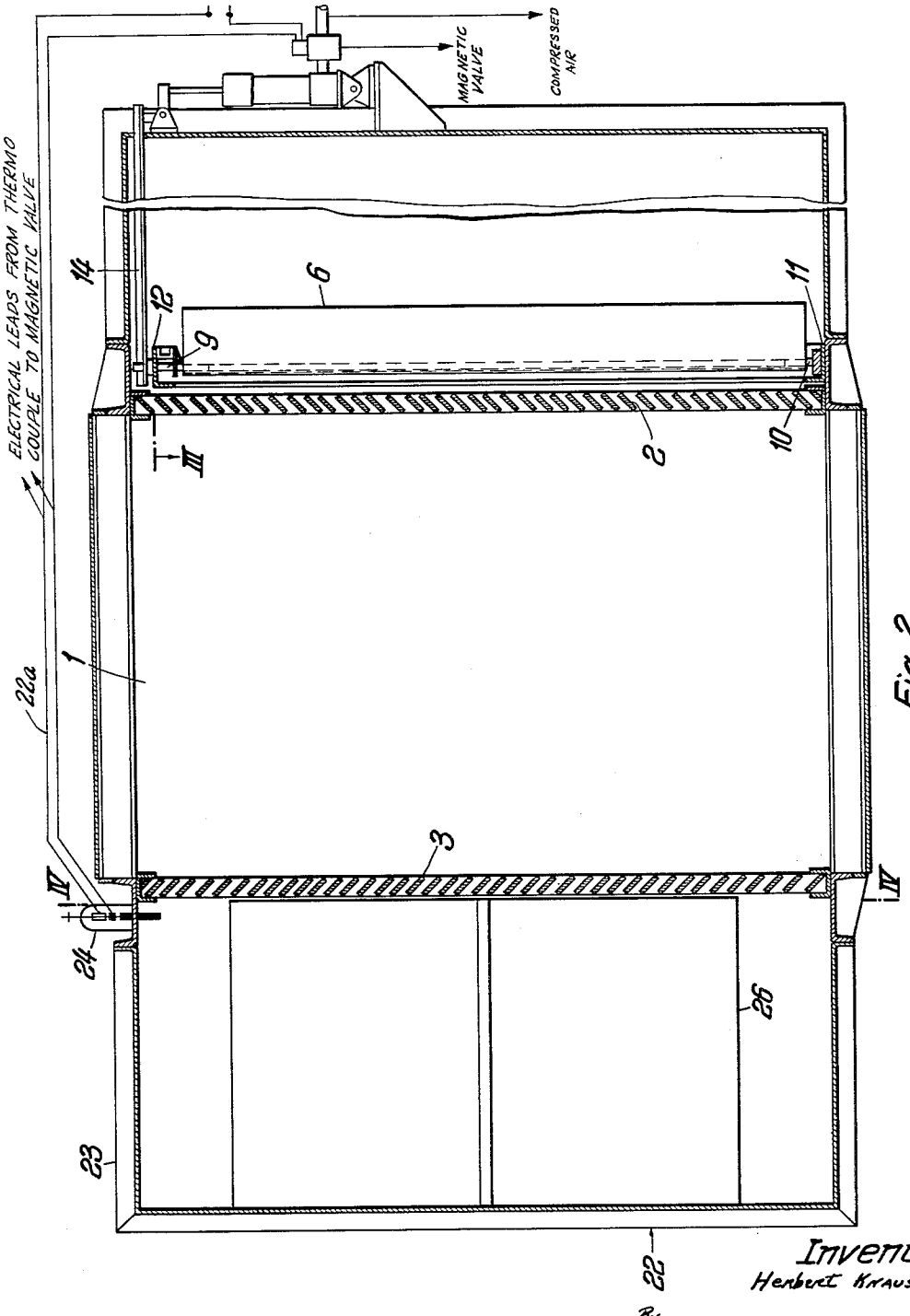


Fig. 2

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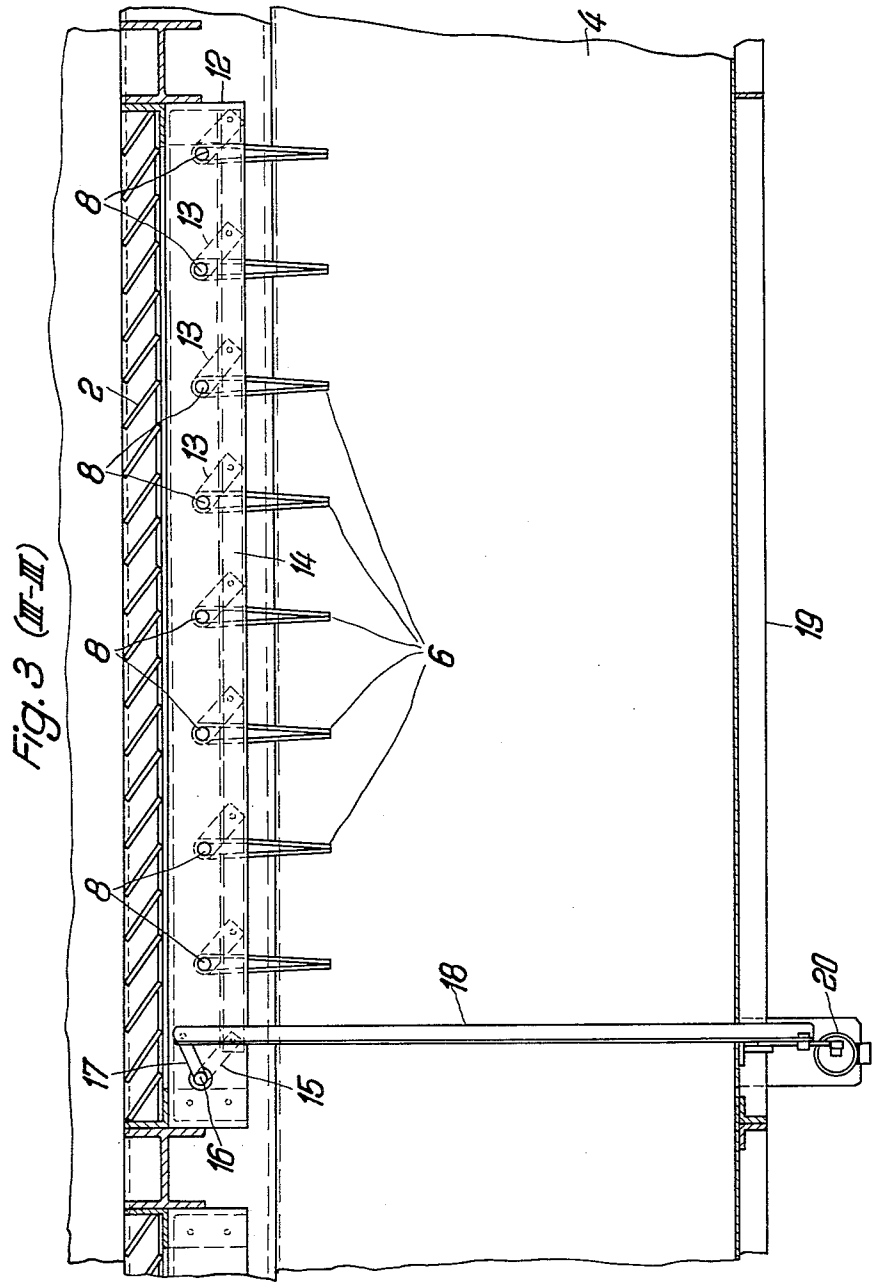


Fig. 3 (III-III)

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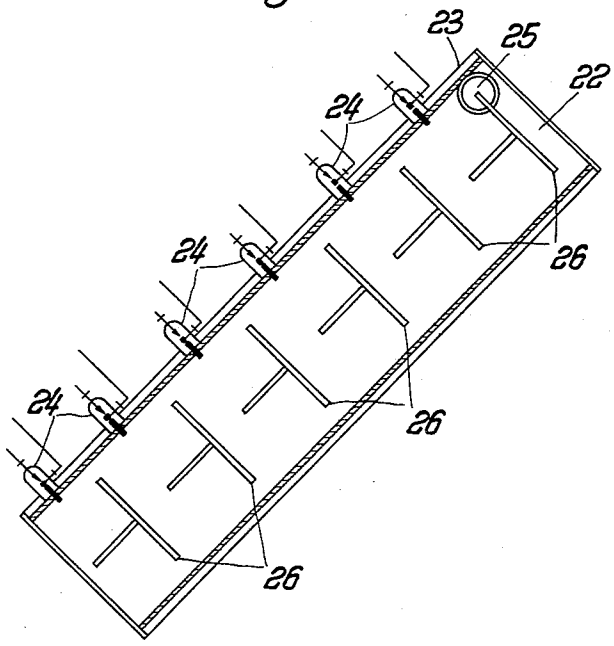
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Fig. 4 (IV-IV)



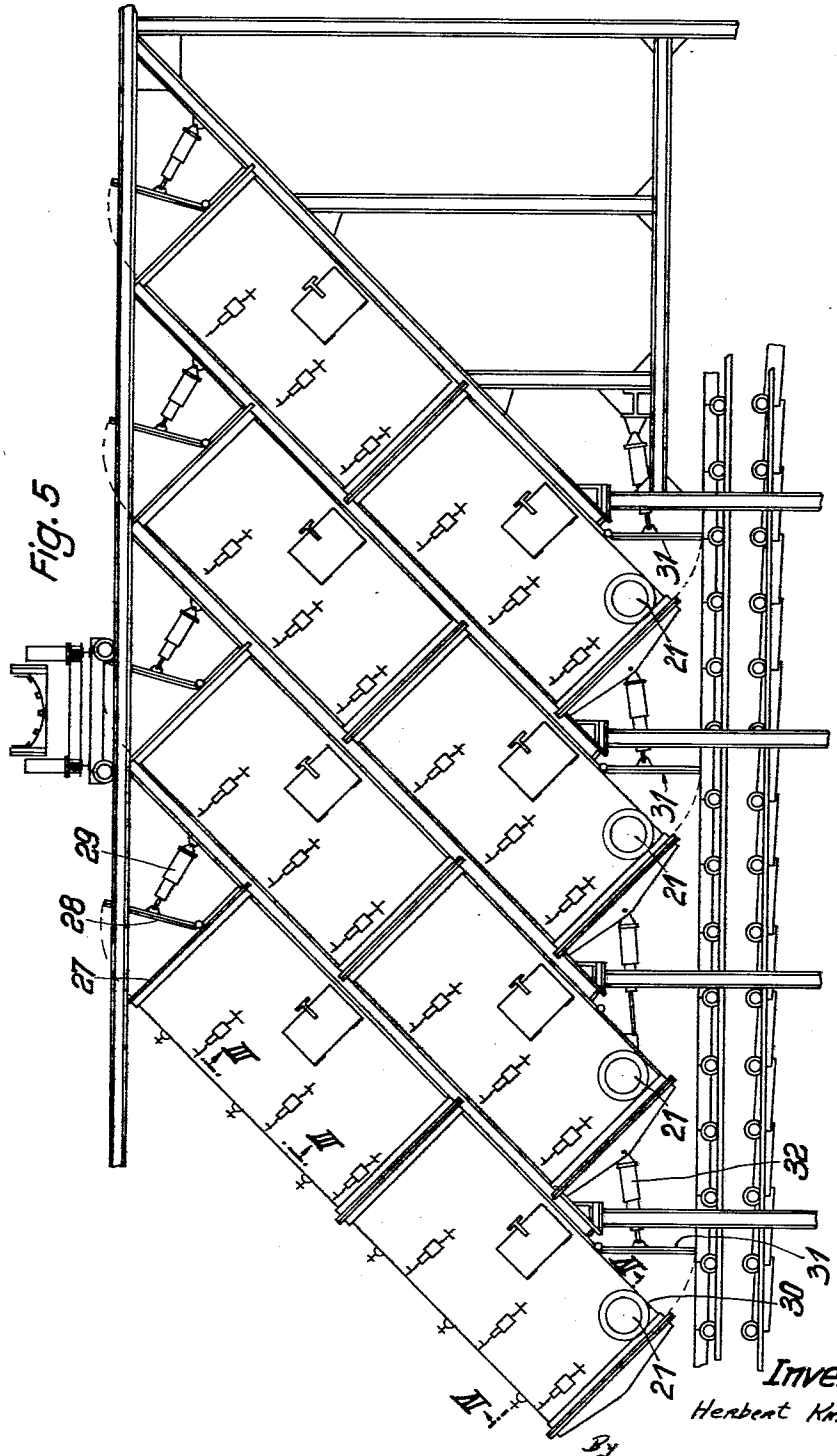
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APPARATUS FOR COOLING ORE SINTER AND SINTER MATERIAL

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APPARATUS FOR COOLING ORE SINTER AND SINTER MATERIAL

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2 Claims. (Cl. 34—54)

This invention relates to an apparatus for cooling hot iron ore sinter, hot ore pellets, hot cement clinkers, and similar materials. In particular, the invention is directed to the cooling of such materials in a hot bulk state from temperatures ranging from 600 to 1000° C. down to a temperature of from about 100 to 150° C., at which temperature the cooled materials can be put on ordinary rubber conveyor belts.

This invention is further directed to an apparatus for cooling materials by passing large quantities of air through the mass of hot material.

Prior art apparatuses are inadequate for producing the great flow of air required for the effective cooling of hot bulk materials. For example, in the apparatus shown in the patent to Warden-Stevens No. 1,787,878, the flow of air loses its effectiveness by the turbulence produced by the construction of the apparatus. Thus an apparatus for cooling roasted coffee, peanuts, and the like, such as shown in the patent to Watrous No. 2,045,319, needs comparatively small amounts of cooling air in which the turbulent flow produced in this apparatus is not of substantial concern. The same is true in apparatuses for drying grain, such as shown in the patent to Ohlheiser No. 2,655,734.

In the cooling of hot sintered ore, exceedingly large quantities of air must be passed through the hot bulky material. In cooling cement clinkers, about one and one-half standard cubic meters ($Nm.^3$) of cooling air are required for each kilogram of clinkers. Thus for a relatively low output of cooled clinkers amounting to 10 tons per hour, air is required in the amount of 250 $Nm.^3$ per minute. In cooling hot ore sinter, about 4.5 $Nm.^3$ of air is required per kilogram of sinter. Thus for cooling 10 tons of sinter per hour, air is required in the quantity of 750 $Nm.^3$ per minute. When such large quantities of air are moved, pressure drops caused by the design of the air inlet and the flow path of the air to the material are of great importance. Consequently, the prevention of energy loss in the flow of air used for the cooling of materials such as cement clinkers and ore sinter is of decisive importance in the economical design of the cooling apparatus.

The objects of this invention are to produce a cooling apparatus in which cement clinkers and ore sinter can be cooled on an industrial scale. Another object is to produce an apparatus in which pressure losses are avoided in the air being supplied to the hot material being cooled. A further object of the invention is to produce an apparatus in which the cooling speed is increased with a reduction in the quantity of air required for the cooling. A still further object of the invention is to keep the temperatures of the exhausted and heated air as high as possible so that usable heat can be recovered therefrom.

In general, these objects are obtained by constructing an apparatus having a container for holding the material being cooled and introducing the air into the container from an air inlet chamber which is co-extensive with the container and has a rectangular cross-section. The air inlet chamber is substantially free from any obstructions which would seriously impede the flow of the air therethrough and has a volume of at least one-third and preferably two-thirds of the volume of the cooling container. It has been found that such an air inlet chamber will produce a uniform flow of air into the cooling container

which is free of turbulence. The cooling container and its air inlet chamber are inclined with respect to the horizontal, and fresh air is introduced into the inlet chamber adjacent the bottom thereof.

The cooling chamber is of rectangular cross-section and has opposite vertical walls formed of louvered slats forming, respectively, the air inlet wall and the air exhaust wall for the container. An exhaust air chamber of rectangular cross-section extends over the entire length of the exhaust wall of the container. The air exhaust chamber has at least the same volume as the air inlet chamber. The air is discharged from the exhaust chamber through an opening located in the uppermost portion of the chamber. Groups of narrow movable shutters are mounted in the air inlet chamber along the inlet wall of the container, which groups are separately movable and opened and closed under thermostat control in response to the temperature of the air in the exhaust chamber.

Baffle plates are installed in the exhaust chamber in the same number and corresponding location as the groups of shutters in the inlet chamber. These baffle plates are at right angles to the longitudinal axis of the exhaust chamber and positioned at about the same height as the uppermost shutter in a group of shutters. By so doing, the temperature of the air entering the exhaust chamber from any particular part of the cooling container is more specifically determined so that each thermostat is more effective in actuating its respective group of shutters. These baffle plates furthermore function to separate dust from the exhaust gas.

The means by which the objects of the invention are obtained are disclosed more fully with reference to the accompanying drawings, in which:

FIGURE 1 is a perspective view of the cooling apparatus of this invention with portions cut away to show the interior of the apparatus;

FIGURE 2 is a cross-sectional view on the line II—II of FIGURE 1;

FIGURE 3 is a cross-sectional view taken on the line III—III of FIGURE 2;

FIGURE 4 is a cross-sectional view taken on the line IV—IV of FIGURE 2; and

FIGURE 5 is a side view of an assembly of a plurality of the cooling units shown in FIGURE 1.

The central cooling container **1** is of rectangular cross-section and inclined to the horizontal. Side walls **2** and **3** are formed of spaced louvered slats directed inwardly and downwardly of container **1**, with wall **2** being the air inlet wall and wall **3** the exhaust air wall. Air inlet chamber **4** is co-extensive with wall **2**. This chamber is of uniform rectangular cross-section and has a volume preferably amounting to two-thirds of the volume of cooling container **1**. Mounted along the inlet side of wall **2** is a shuttered wall **5**. This shuttered wall is composed of a plurality of groups of narrow movable shutters **6** whose longitudinal axes are parallel to the end edges **7** of air inlet wall **2**. These shutters extend completely along wall **2** so that this wall is entirely covered over when the shutters are closed.

The individual shutters **6** pivot on their longitudinal edges **8** by being mounted on pins **9** and **10** connected to brackets **11** and **12**, respectively, note FIGURES 2 and 3. Thus the shutters can be rotated so as to extend at right angles to wall **2**, as shown in FIGURE 3. Arms **13** fixed to pins **9** beneath bracket **12** are connected to bar **14**. Arm **15** connects bar **14** to a pin **16** pivotally mounted in bracket **12**. Arm **17** also fixed to pin **16** is pivotally joined to rod **18** which extends across the inlet chamber and through the outer side wall **19** of the air inlet chamber **4**. Rod **18** is there connected to a hydraulically operated mechanism **20**. Any other suitable

actuating mechanism can be used for opening and closing shutters 6.

An essential feature of the invention lies in that the shutters 6 forming the wall 5 are separated into groups of shutters, each group being separately operable along the length of wall 5. In other words, the groups of shutters respectively cover different portions along the inclined inlet wall 2. Each group is individually moved by its respective operating mechanism 20. Preferably, each shutter group covers about one-sixth of the total area of wall 5 and each shutter group is composed of eight individual shutters 6. Each shutter group has its own operating mechanism so that the shutters in a group can be either opened or closed so that portions of the air inlet wall can be either opened for the passage of air or closed. Each individual shutter 6 is very small in proportion to the size of air inlet chamber 4. Consequently, each shutter when opened does not extend far enough into the air inlet chamber 4 to throttle or otherwise interfere with the free flow of air in the chamber. Thus chamber 4 is substantially unobstructed and free of air turbulence, even when the shutters are in open position. Furthermore, a non-turbulent air cushion having a volume of at least one-third and preferably two-thirds of the volume of cooling container 1 is created in front of air inlet wall 2 without being disturbed by shutters 6, even while they are being opened or closed. Consequently, the arrangement of the shutters 6 permits a uniform flow of air into container 1. The use of groups of shutters makes it possible to prevent the flow of cooling air into the portions of the material in cooling container 1 which have been sufficiently cooled. This enables the entire amount of air in chamber 4 to be available to uncooled portions of material in chamber 4, with the result that the temperature of the exhaust air is kept at a high value and from which heat can be recovered.

The inlet 21 to chamber 4 is positioned adjacent the lower end of the chamber. By so placing the opening, it is possible to diminish turbulence caused by the expansion of the air flow into the chamber and to a certain extent damp any fluctuations in air pressure in the chamber 4 before such fluctuations can have any effect on the air passing through wall 2. Such fluctuations inherently occur as the result of the change in direction of the flow of the air in a relatively small space.

An air exhaust chamber is mounted on the air exhaust side of container 1 and is co-extensive with exhaust wall 2. Chamber 22 has the same form and is about the same size as inlet chamber 4. Thermostats 24 are mounted in the upper longitudinal wall 23 of chamber 22. These thermostats project into the interior of chamber 22 and are connected by an electrical circuit 22*a*, FIGURE 2, to the operating controls for the mechanisms 20 which actuate shutters 6 in order to close them at predetermined temperatures and having them locked shut so that they cannot reopen until the whole batch has been cooled down. There is one thermostat for each group of shutters 6, and each thermostat is mounted at about the same vertical height as its respective shutter group. Consequently, at least a part of the air passing through the area covered by a shutter group also passes by the thermostat for that group. While it is opportune to mount the thermostats in the upper wall 23 of chamber 22, yet these thermostats could be mounted on the floor of the chamber or elsewhere in the chamber.

The air exhaust opening 25 is positioned adjacent the upper end of chamber 22. This position is important for the satisfactory measurement of the temperature of the air exhausted from container 1 into chamber 22 so that the cooling effect of the air in inlet chamber 4 and the regulation of the cooling of various portions of the material in container 1 is accurately controlled.

T-shaped baffle plates 26 are shown mounted in exhaust chamber 22 but are not absolutely necessary. They are of advantage if arranged so that they subdivide chamber 22 into as many sections as there are thermostats or shutter groups so that a separate section corresponds to each shutter group. These baffle plates, in addition to being dust separators, are useful in determining the state of cooling of a portion of the hot material in container 1 and with respect to a particular shutter group. This, in turn, assists in a more exact application of the cooling air to various portions of the material in container 1, plus an increase in the cooling effect of the air being used and an improvement in the heat recoverable from the exhaust air.

As shown in FIGURE 5, the unit of FIGURE 1 can be assembled into groups. Each unit has a charging opening 27 in its upper end closed by a hinged lid 28 which is operated by a hydraulic piston 29. A discharge opening 30 in the bottom of the unit for container 1 is closable by a hinged cover 31 operated by a hydraulic piston 32. A dust removing door 33, FIGURE 1, is mounted in the lower end of the bottom of chamber 22.

The operation of the apparatus is as follows. Bottom lid 31 is closed and lid 28 opened and the container filled with hot material having a temperature ranging from 500 to 1000° C. Lid 28 is then closed and all of the shutters 6 comprising shutter groups are opened so as to uncover wall 2. The thermostats 24 are set so that each group of shutters will be closed whenever the exhaust air passing that thermostat drops below a preselected temperature, as, for example, 150° C. The lowering of the temperature of the air at that thermostat indicates that the portion of the material adjacent that thermostat has become sufficiently cooled. The shutters being opened, cooling air is forced under pressure into air inlet chamber 4. This air is distributed at a substantially uniform pressure entirely over shutter wall 5 and through inlet wall 2 into container 1. The air passes transversely through the hot material in container 1 and is quickly heated so that a portion of the air moves rapidly upward. This results in that the material in the upper portion of container 1 is cooled more rapidly when the material being cooled is composed of particles of substantially the same size and that the temperature of the remaining material in container 1 has a progressively increasing temperature in a downward direction. The top portion of the material is therefor cooled first and the air passing transversely through container 1 drops in temperature, thus causing thermostat 24 to activate mechanism 20 to close the group of shutters covering the upper portion of container 1 and keeping it locked until the whole batch has been cooled down. This means that cooling air is not wasted by being passed through material which has been sufficiently cooled and makes the volume of air available for being applied to the uncooled portions of the material. This saving of air increases the efficiency of the apparatus and energy is saved by not moving unnecessary quantities of air. Also, the cold air is prevented from passing through a cooled portion of the material and mixing with other exhaust air. Thus the heat of the exhaust gases is maintained so that it can be extracted in a suitable heat exchange apparatus. The cooling process is repeated step by step downwardly of container 1 by successively closing groups of shutters 6 and having them locked shut so that they cannot reopen. When the lowermost shutter group closes, the material in container 1 has been completely cooled. When the material being cooled is in the form of pieces having a substantially regular shape, as in the case of cooling pellets of ore, the time intervals between the closing of the successive shutter groups is very short as a rule. This is because the entire mass of material in container 1 is subjected to a uniform distribution of cool air. This also means that the automatic control of the shutter groups is not as important as it is when the material being cooled is composed of pieces of irregular shape, as, for example, crushed sinter cake. When particles of regular shape are used, the cooling is obtained by reason of the non-turbu-

lent and uniform air flow through the mass of material and no portion of the material is cooled substantially sooner than any other portion. Consequently, the disadvantages of prior known apparatuses of continuing to pass air through already cooled portions of the material is avoided and the temperature of the exhaust air is kept higher, even when there is no automatic control.

However, the material being cooled is frequently of irregular shape. Consequently, all portions of the material cannot be cooled at practically the same time inasmuch as there is an uneven flow of air through the material in spite of the uniform air pressure created at air inlet wall 2. The automatic control of the shutter groups now becomes important because they prevent the waste of cooling air and the lowering of the temperature of the exhaust air. The shutter groups will not necessarily close in sequence from top to bottom of the chamber 4. The closure of any particular group of shutters depends on the temperature to which the portion of the material in container 1 served by that shutter group has been lowered to the desired degree. This also depends upon the composition of the material in that portion of the container and its permeability to air.

This application is a continuation-in-part of my copending application Serial No. 687,073, filed 30 September 1957, and now abandoned, for "Cooling Devices."

Having now described the means by which the objects of the invention are obtained, I claim:

1. An apparatus for cooling batches of hot bulk material such as ore pellets and cement clinkers having temperatures ranging from about 600 to 1000° C. down to temperatures of about 100 to 150° C., comprising an elongated inclined cooling container of uniform rectangular cross-section and having material inlet means at the top and material outlet means at the bottom, an air inlet side wall consisting of narrowly spaced louvered slats, an opposite air exhaust side wall consisting of narrowly spaced louvered slats, an air inlet chamber of uniform rectangular cross-section attached to said louvered air inlet side wall, said louvered air inlet side wall being common to said air inlet chamber and with the volume of said air inlet chamber being from at least one-third to two-thirds of the volume of said cooling container, an air inlet opening adjacent the bottom of said air inlet chamber, groups of narrow louvered shutters mounted in said air inlet chamber close to and over the whole of said air inlet wall, opening and closing means for each of said groups of louvered shutters for controlling air flow through portions of said air inlet side wall corresponding, respectively, to each of said groups of louvered shutters, an exhaust air chamber of the same cross-section and size as said air inlet chamber joined to said air exhaust side wall of said cooling container, said louvered air exhaust side wall being common to said cooling container, an air outlet opening adjacent the top of said exhaust air chamber, and temperature responsive means mounted in said exhaust air chamber near said louvered air exhaust side wall at about the same height and corresponding, respectively, to each of said groups of louvered shutters for controlling said opening and closing means of said groups of louvered shutters according to the temperature of the exhaust air coming from each portion of said cooling container.

2. An apparatus as in claim 1, further comprising a plurality of T-shaped baffle plates mounted in said exhaust air chamber corresponding to said groups of louvered shutters for leading the air of the individual zones formed by said groups of louvered shutters to the corresponding temperature responsive means, and for precipitating particles of material carried by the exhaust air coming from said cooling container.

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