United States Patent

Blixrud et al.

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[54] APPARATUS FOR TREATING GRANULAR MATERIAL

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[52] **U.S. Cl.** .....**99/237 R**, 99/348

[51] **Int. Cl.** **A23b 9/00**

[58] **Field of Search** .....99/237 R, 238, 234, 348, 80; 259/8, 23, 24, 43, 44

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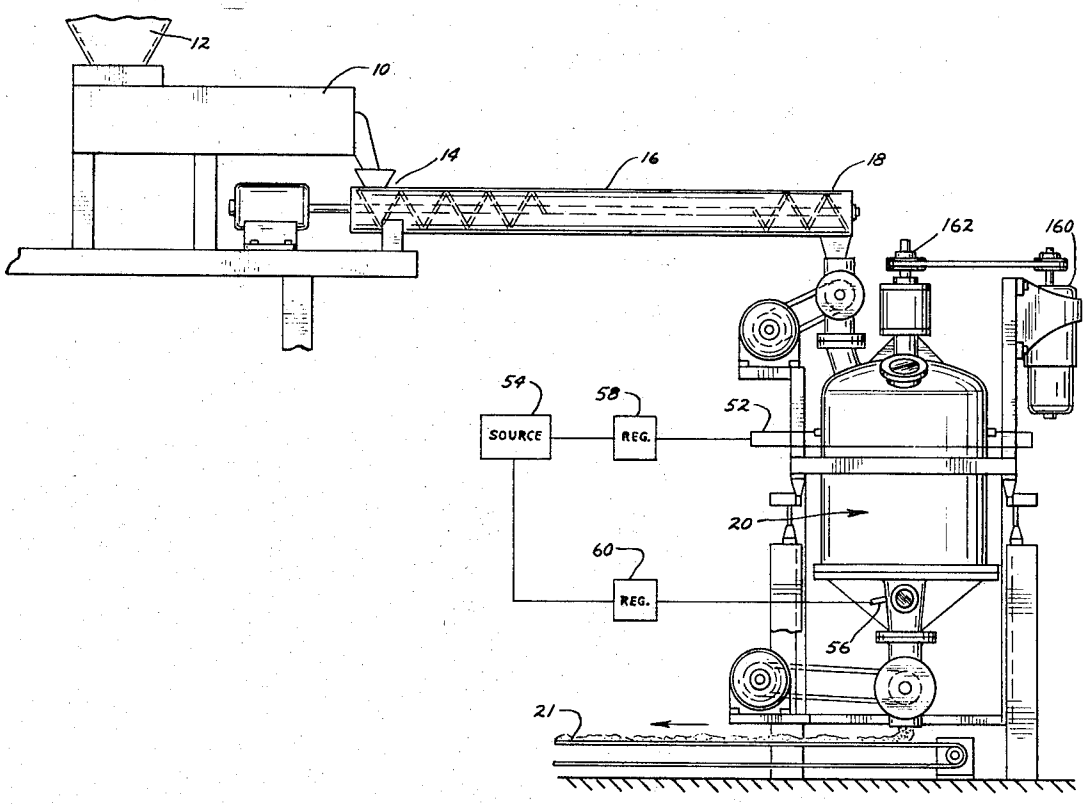
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[57] **ABSTRACT**

A vertically oriented pressure cooker for treating granular materials on a continuous basis. A cylindrical cooking chamber, having a flat bottom surface with a discharge opening centrally located therein, is at least partially filled with the material to be cooked, by introducing the material and pressurized steam into the top of the chamber. A vertical shaft is rotatably mounted within the chamber, and it has a pair of curved discharge arms secured to its bottom end, and a pair of leveling arms secured to it, proximate the upper part of the chamber. A cylindrical shield having a larger diameter than the diameter of the discharge opening surrounds the shaft. By rotating the shaft, a layer of material is transferred along the bottom surface of the chamber toward the discharge opening.

20 Claims, 10 Drawing Figures



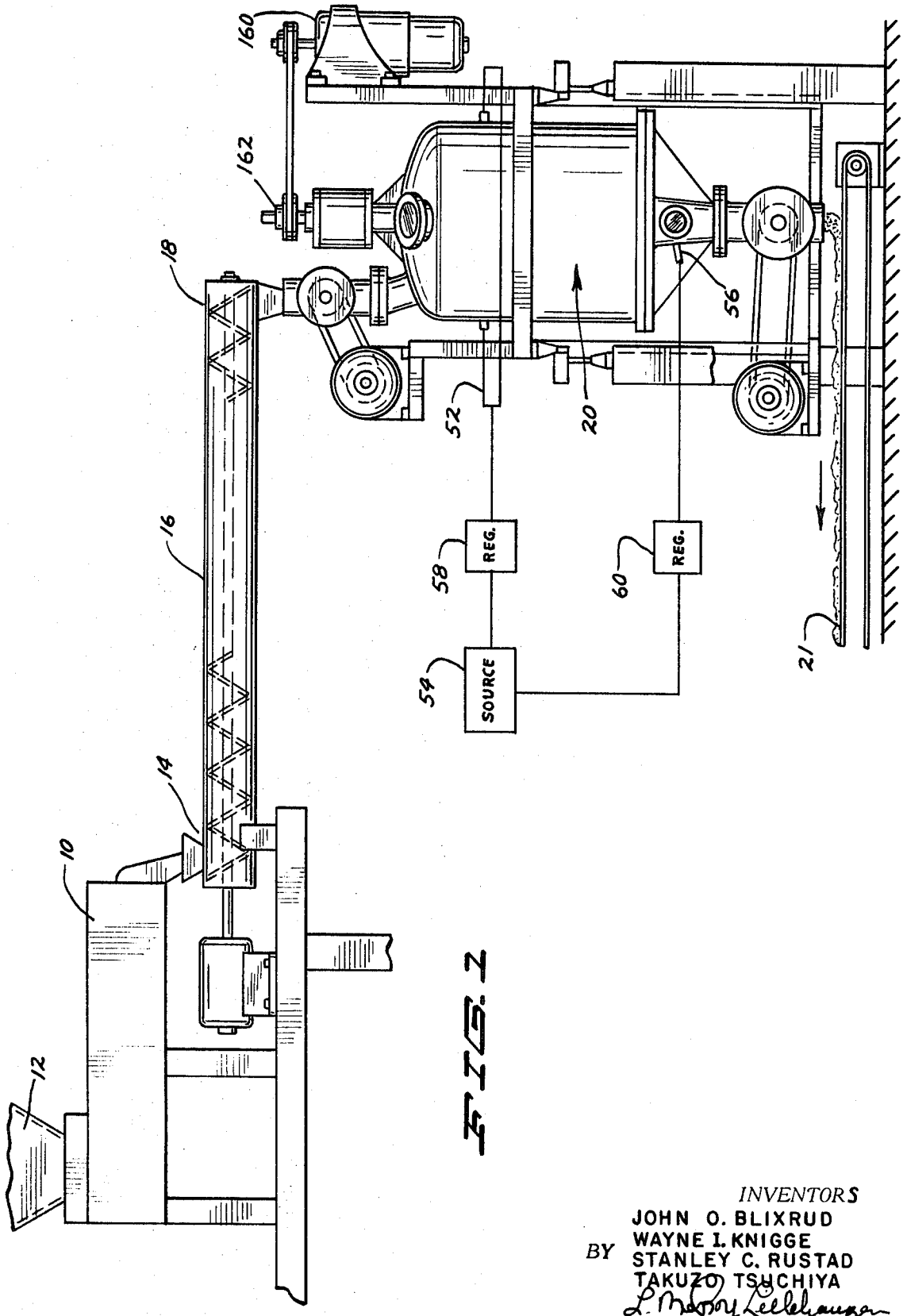


FIG. 2

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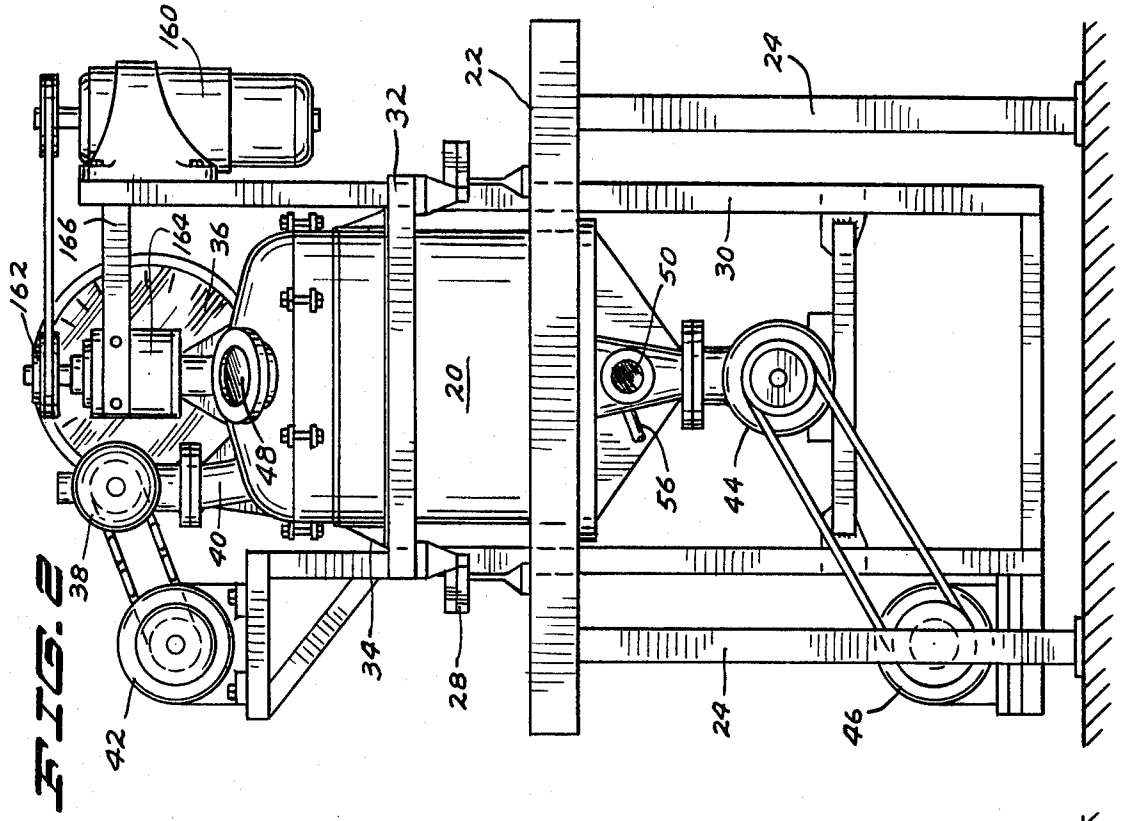


FIG. 2

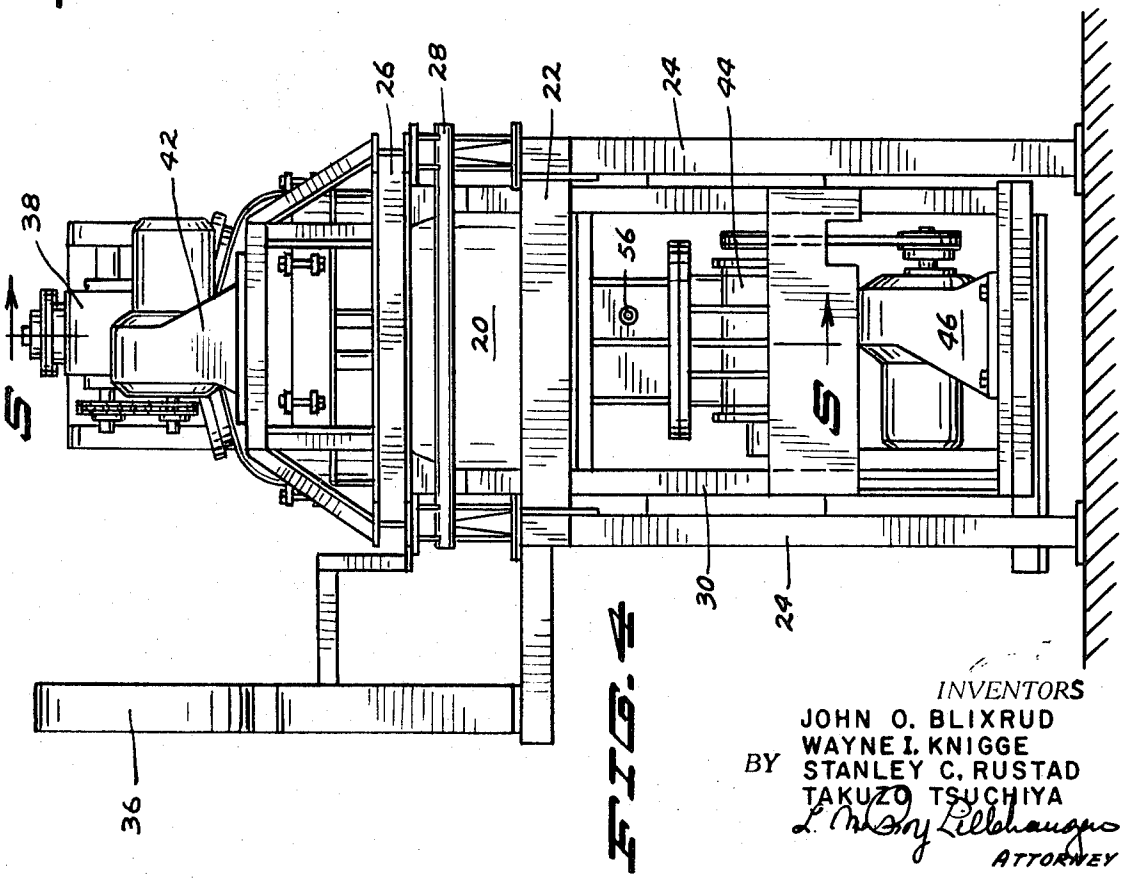


FIG. 4

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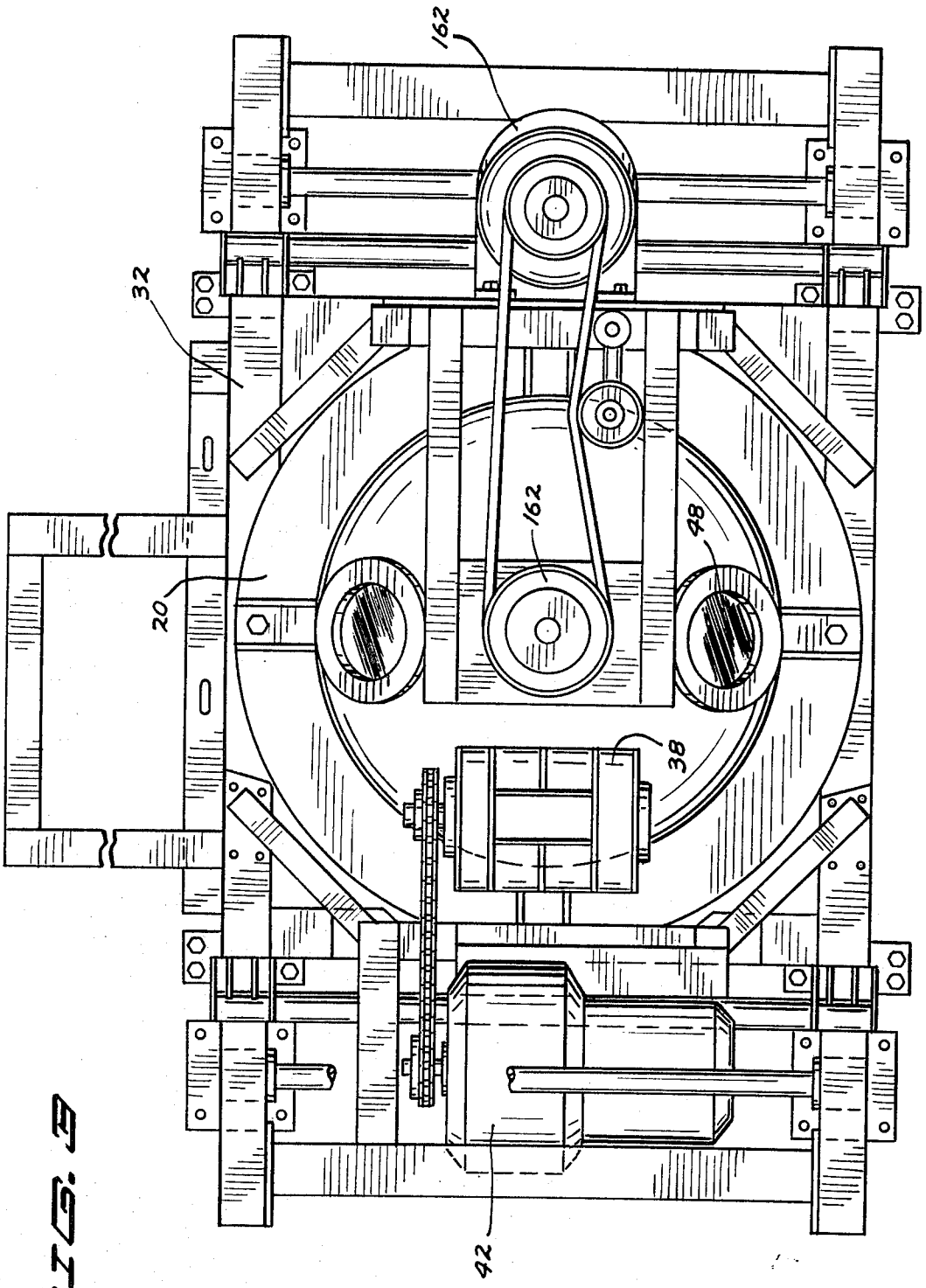


FIG. 3

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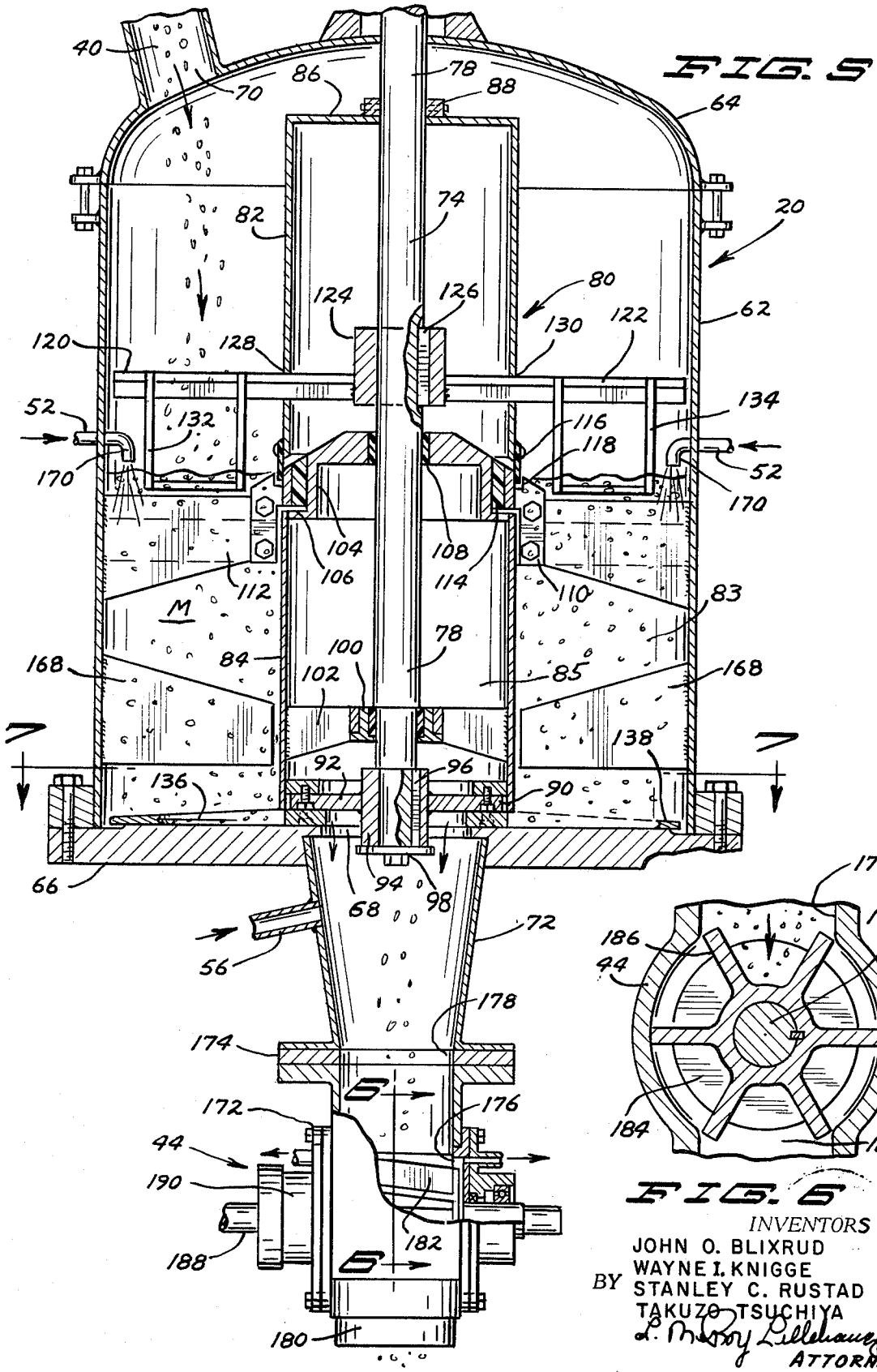
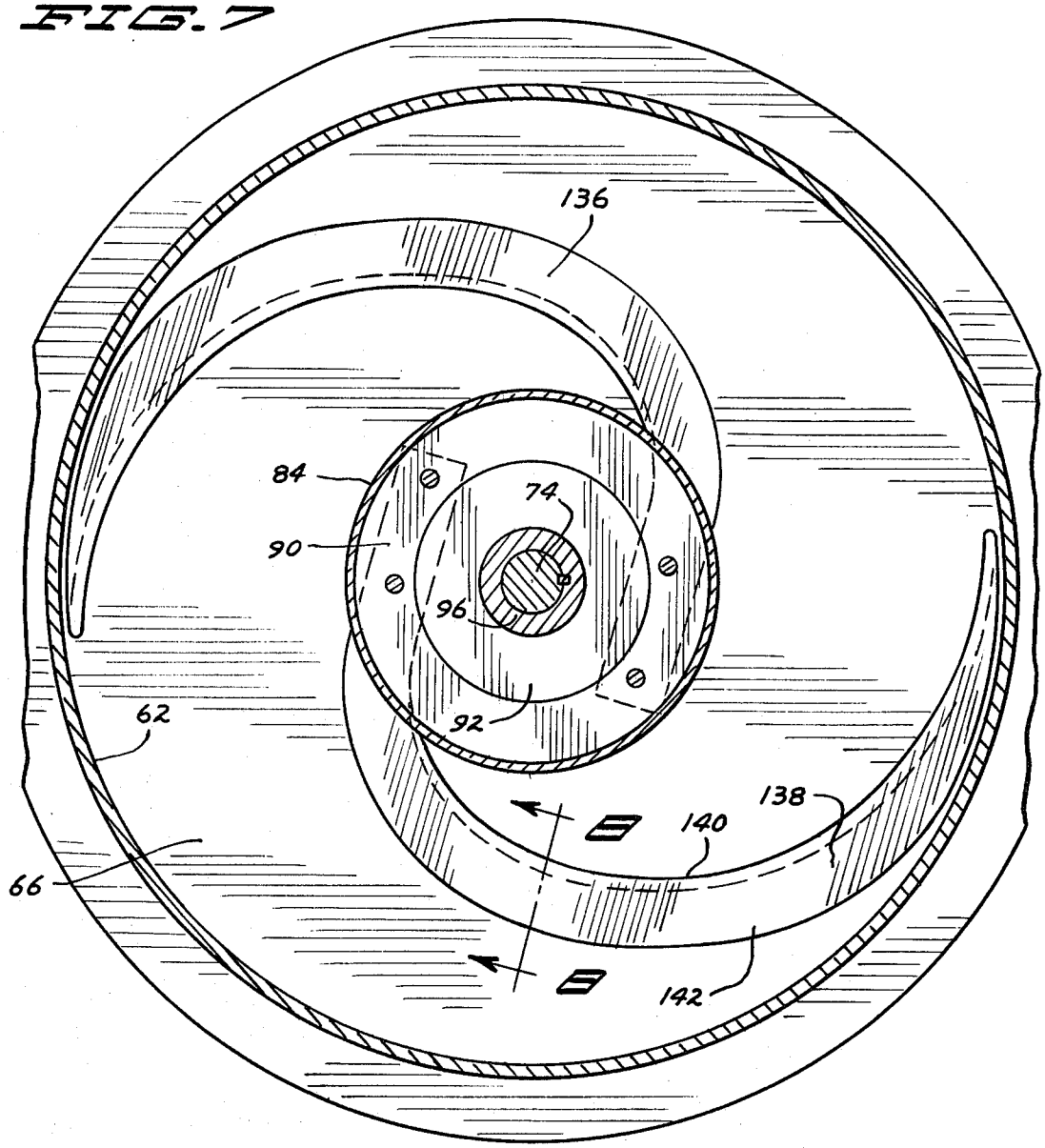


FIG. 5

FIG. 6

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FIG. 7



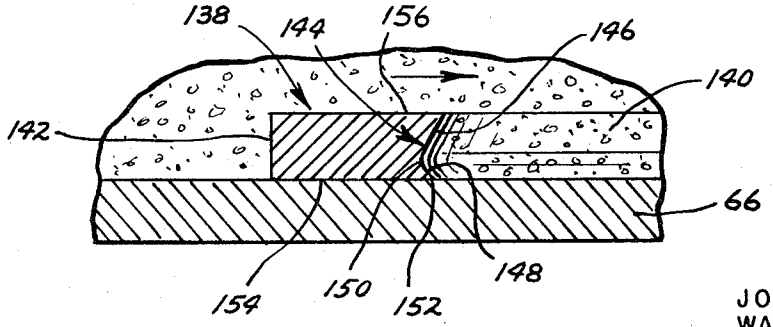


FIG. 8

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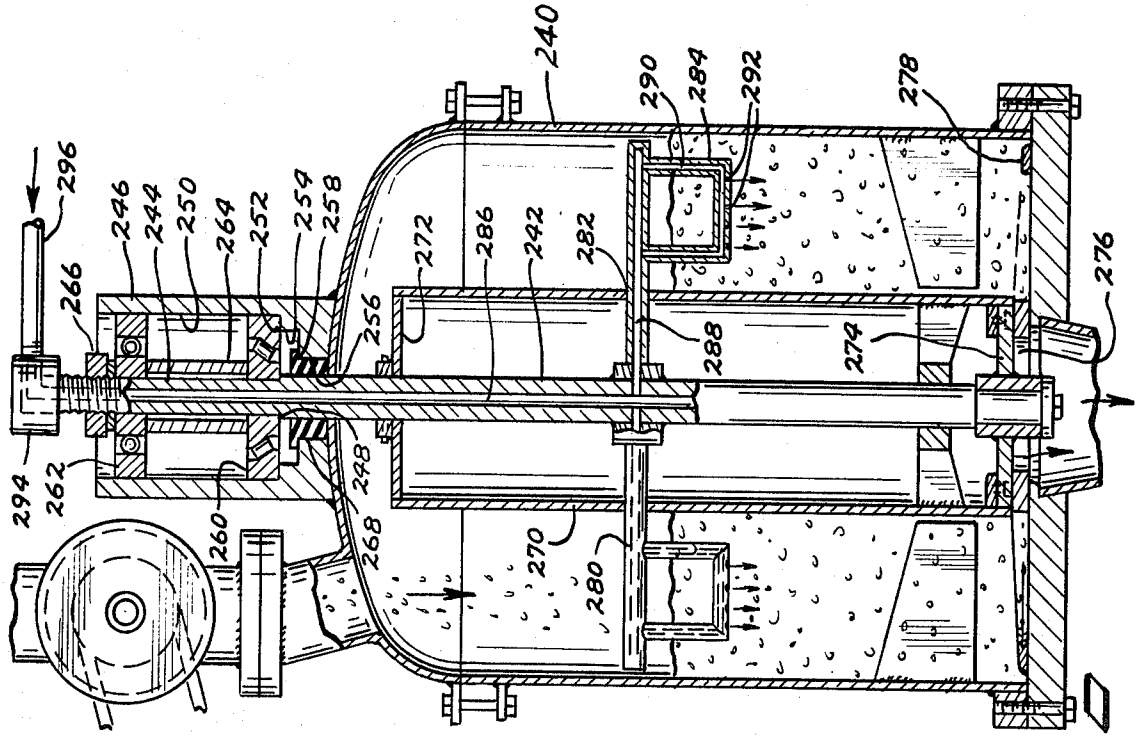


FIG. 10

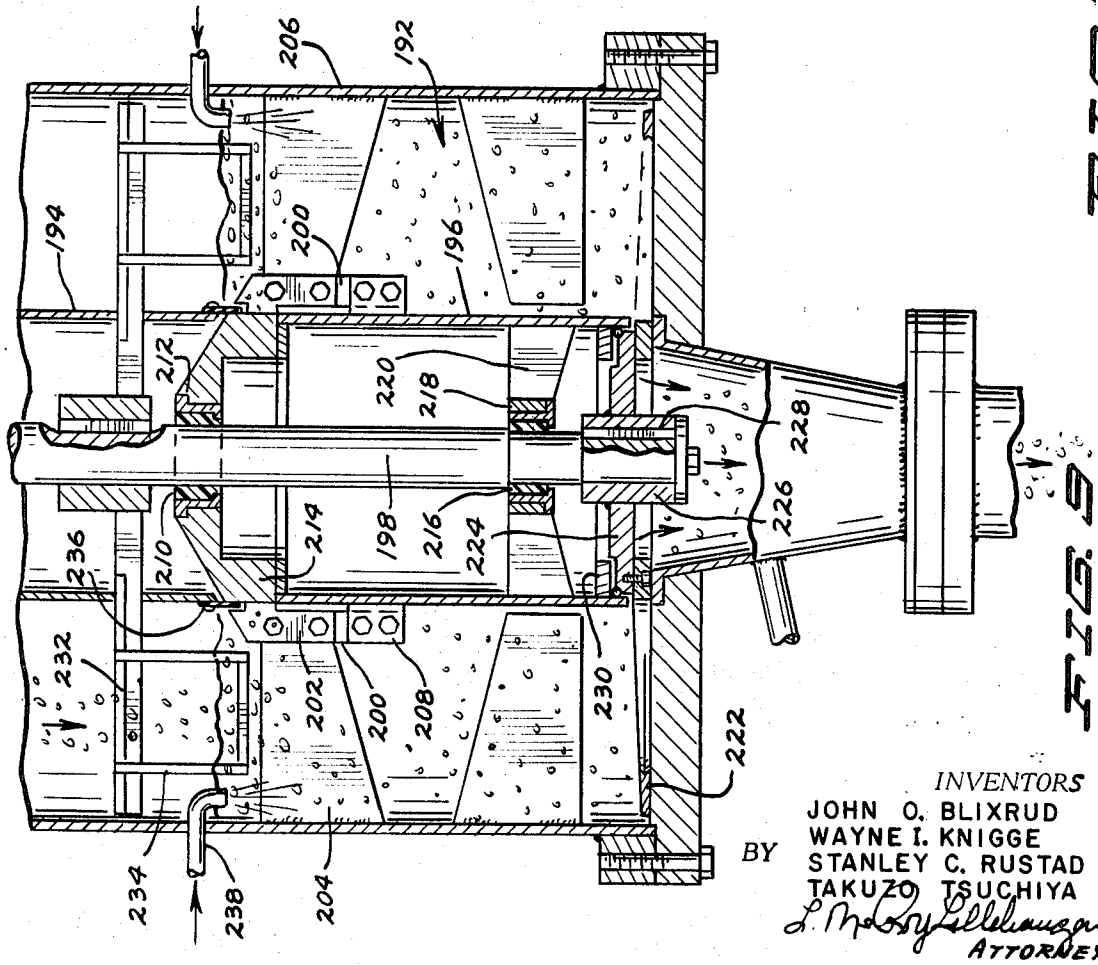


FIG. 9

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APPARATUS FOR TREATING GRANULAR MATERIAL

The present invention relates to an apparatus for treating granular material in a continuous process, and more particularly to an apparatus for continuously cooking cereal grains and/or other food products in a steam operated pressure-type cooker.

Cookers of various types are known to those in the art, for treating and cooking granular materials. Batch-type cookers, for example, have long been used for cooking materials such as cereal grains. In such devices, the ingredients to be cooked, are introduced into a closed container and subjected to pressurized steam for a prescribed period of time. After being cooked, the batch is discharged, and the cooker is charged with a new batch. Cookers of this type have a relatively low capacity, and a system of these cookers is expensive in construction and operation. Moreover, they are somewhat inefficient because considerable amounts of steam and heat are lost each time the apparatus is being emptied.

Continuous cookers tend to overcome some of the disadvantages of batch cookers. Some cookers of this type involve a horizontally aligned chamber into which the material to be cooked, and pressurized steam are continuously introduced. An auger, or other suitable means, is provided for conveying the material through the cooker to a discharge end, at a predetermined feed rate. Vertically oriented continuous cookers have also been used for cooking granular materials; in such cookers, the cooking chamber is ofttimes provided with a cone-shaped lower end. During the cooking operation, the material flows to the bottom of the cooking chamber, after which it is discharged from the chamber. To the best of applicants' knowledge, such continuous cookers are often rather complicated in design, expensive to manufacture and construct, somewhat inefficient to operate, they require a substantial amount of space, and they have been difficult to keep clean.

It is one object of the present invention to provide a new and improved apparatus for cooking granular materials.

Another object is to provide an improved apparatus for cooking food materials which can be operated on a continuous basis in such a manner that the uncooked material is continuously introduced into the cooker at one end, while the cooked material is continuously discharged at the other end of the cooker.

A further object is to provide a vertically oriented continuous cooker having improved means for uniformly discharging the cooked material from the discharge end of the cooker.

A still further object is to provide a vertically oriented continuous cooker having a discharge system which removes material from the cooker in an improved and efficient manner.

Another object is to provide a continuous cooker having a system for readily adjusting the discharge rate of material from the cooking chamber, with respect to the input rate of material into the chamber, so as to maintain a predetermined cook time for the ingredients.

A still further object is to provide a vertical continuous cooker which is relatively simple to construct and operate, requires a minimum amount of space, and is efficient to operate.

Other objects and advantages will become apparent from a consideration of the following specification and accompanying drawings. Before proceeding with a detailed description of the invention, however, a brief description of it will be presented.

Preferably, the invention entails a vertically oriented, cylindrically shaped, pressure tight cooking chamber having a substantially flat bottom surface upon which the material being cooked, accumulates. An inlet opening is located at the top of the chamber for introducing material into the chamber, and a discharge opening is centrally located in the bottom surface, for removing material from the chamber. A vertically oriented shaft is rotatably mounted within the chamber. A pair of curved, horizontally aligned discharge arms are attached to the bottom end of the shaft so that they are juxtaposed over the bottom surface, and a pair of horizontal leveling arms are attached to the shaft proximate the upper portion of the chamber. A cylindrical shield surrounds the shaft and helps prevent material from flowing through the discharge opening in an uncontrolled manner, and it forms an annular band having a uniform thickness. When the shaft rotates, the curved arms transfer a layer of cooked material on top of the bottom surface, toward and into the discharge opening, while the leveling arms help distribute the material evenly within the chamber. At least one inlet opening is provided for introducing pressurized steam into the chamber, preferably at a point near, or slightly below, the top surface of the uncooked material in the chamber. As the cooked material is removed from the chamber, the bed of material within the chamber flows by gravity, toward the bottom of the chamber. The chamber is preferably mounted on a scale in such a manner that the total weight of material within the cooker can be readily determined and observed; by controlling the discharge rate of the material relative to the input rate, the required cooking time of the material within the chamber can be assured. In other words, during normal operation, a state of equilibrium exists within the cooker between the discharge rate and the input rate.

The invention will best be understood by reference to the following drawings, wherein:

FIG. 1 is a partial schematic view of a system for cooking materials on a continuous basis;

FIG. 2 is a front elevational view which illustrates the cooker in greater detail;

FIG. 3 is an enlarged top plan view of the structure shown in FIG. 2;

FIG. 4 is a side elevational view of the apparatus illustrated in FIG. 2;

FIG. 5 is an enlarged sectional view taken along line 5—5 of FIG. 4, which illustrates the cooker in greater detail;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 5;

FIG. 7 is an enlarged, partial sectional view taken along line 7—7 of FIG. 5;

FIG. 8 is a partial sectional view taken along line 8—8 of FIG. 7;

FIG. 9 is a partial sectional view which illustrates another embodiment of the invention; and

FIG. 10 is a sectional view which shows a further embodiment of the invention.

FIG. 1 illustrates a system for continuously treating or cooking a granular material, such as a selected cereal grain. As depicted, the system includes a feeder 10 for conveying materials to be cooked, such as the cereal grain, flavoring ingredients, etc., from an appropriate source 12 at a prescribed feed rate, into the inlet end 14 of a mixer 16. As the mixed material is discharged from the discharge end 18 of the mixer, it is introduced into a vertically oriented cooking chamber designated generally by numeral 20. As the material enters the cooking chamber 20, it forms a bed of material which passes from the top of the chamber to the bottom thereof, by gravity. While in the chamber, the granular material is subjected to pressurized steam for a predetermined period of time, so that the ingredients are completely cooked prior to being discharged from the cooking chamber. The cooked material is discharged from the cooker 20 onto a conveyor 21, after which it can be further processed if desired.

FIGS. 2–4 illustrate the cooker 20, and the manner in which it is supported, in greater detail. A main frame structure 22, which includes four vertical legs 24, is positioned on the floor of a plant or manufacturing facility. An intermediate frame 26 is supported by the main frame 22, by means of a scale mechanism designated generally by numeral 28, so that it is suspended above the floor, and supported solely by the main frame 22. The intermediate frame 26 also includes four vertical legs 30 which are connected to each other by appropriate cross members, to form a structure for supporting the cooking chamber 20. The outer surface of the chamber 20 is secured to cross members 32 at 34, by appropriate means (not shown

in detail), so that the chamber **20** is indirectly supported by the main frame **22**, by means of the intermediate frame **26**.

The scale mechanism **28** is a commercially available item, which can be readily purchased on the market; thus, it will not be described in detail. Toledo Scale Company of Toledo, Ohio, for example, manufactures a number of tank scales which might be satisfactorily used. Generally, scales of this type include a system of torsion pipes, lever arms, and appropriate mechanical linkages for connecting the lever system to an indicating head **36**, which registers the total weight being exerted on the scale. Satisfactory results have been obtained by using Model No. 2382 with a No. 33 Head, manufactured by the Toledo Scale Company. As the total weight of the intermediate frame **26**, the chamber **20**, and the ingredients within the chamber changes, such changes are readily indicated on the indicating head **36**. It might be pointed out that if desired, the scale system might be tared by procedures known to those in the art, so that only the weight of the material within the cooker registers on the indicating head **36**.

A first rotary valve **38** is mounted proximate the top of the cooking chamber **20**, and it is interposed between the discharge end **14** of the mixer **16**, and an inlet opening in the top of the chamber, by an appropriate conduit **40**. A motor **42**, mounted on the intermediate frame **26**, is operatively connected to the rotary valve **38** by appropriate means. A second rotary valve **44** is attached to the bottom of the cooking chamber so that cooked material is discharged from the chamber directly into the valve **44**. A motor **46** provides motive power for the valve **44**. Rotary valves of this type are generally well known to those in the art. Such valves permit material to be introduced into, and discharged from, the cooking chamber without reducing the pressure within the chamber. Openings **48** and **50**, each provided with tempered sight glass, are provided for permitting an operator to look into the interior of the cooking chamber **20** while the cooking operation takes place.

Pressurized steam is introduced into the upper portion of the cooking chamber by means of conduits **52** (note FIG. **1**) which are connected to a steam source **54** by appropriate conduits. Pressurized steam is also introduced into the lower end of the cooker by means of a conduit **56**, which is also connected to the steam source **54**. Pressure regulators **58** and **60** control the amount of steam introduced into the conduits **52** and **56**, respectively.

FIG. **5** illustrates the cooker **20** in greater detail. Generally, the cooking chamber **20** is comprised of an elongated cylindrical shell **62**, a rounded cover or top **64**, and a circular end plate or bottom surface **66**. The cover **64** and the bottom plate **66** are secured to the shell by appropriate means, e.g. bolts, so that pressure tight seals are formed. The plate **66** is provided with a discharge opening **68** centrally located therein, and an inlet opening **70** is provided in the cover **64** so that it is proximate the upper portion of the cooking chamber. The conduit **40** introduces uncooked material from the rotary valve **38** into the cooking chamber. A short hopper **72**, having almost vertical sidewalls, is secured at one end to the bottom **66**, so that it surrounds the discharge opening **68**. The second rotary valve **44** is secured to the bottom of the hopper **72** so that the cooked material passes from the chamber **20** into the rotary valve **44**.

A shaft **74** is rotatably mounted within the cooking chamber **20** so that its longitudinal axis is vertically oriented. Preferably, the shaft **74** is mounted within the chamber **20** by rotatably supporting its upper end **76** in suitable bearings so that its lower end **78** is cantilevered within the chamber **20**. In this regard, FIG. **10** illustrates one such arrangement for supporting the shaft **74**; this arrangement will be described in greater detail hereinbelow. Cantilevering the shaft **74** eliminates the requirement for bearings and bearing supports in the lower portion of the chamber **20**. If preferred, of course, such bearings and supports might be provided; it has been found, however, that they do have a tendency to cause material to collect or become deposited on the members.

A cylindrical sleeve or shield member **80**, comprised of upper and lower portions **82** and **84**, respectively, is positioned within the chamber **20** so that it surrounds the shaft **74**, and is substantially coaxial with it. An annular space **83** is formed between the walls of the chamber and the shield **80**, and the granular material, designated by letter M, is deposited within this space. Furthermore, the shield **80** forms an inner-compartment **85** which surrounds the shaft, in which none of the material is permitted to accumulate; the compartment **85** has a larger diameter than the diameter of the opening **68**. A plate member **86** is secured to the top of the upper portion **82**, and it is sealed relative to the shaft **74** by means of a split collar **88**. A ring-shaped member **90** is secured within the bottom end of the lower shield portion **84**, and a circular plate **92**, having an opening surrounded by a hub **94**, is attached to the ring **90** by appropriate means. As shown, the diameter of the plate **92**, and thus the shield **80**, is larger than the discharge opening **68**, and it is spaced from the bottom surface **66** by a prescribed distance.

Since the shield **80** and the plate **92** have a larger diameter than the discharge opening **68**, the granular material M is effectively prevented from freely flowing through the discharge opening **68**. Moreover, it might be emphasized that the shield **80** cooperates with the outer chamber wall to define the annular space **83**. It has been found that by keeping the thickness of this annular space relatively narrow, the curved discharge arms **136** and **138** are able to remove a layer of material from the chamber more efficiently, because just a portion of the bottom surface, rather than the entire surface, has material thereon. No specific dimensions of the annular space are herein set forth, because the relative thickness can vary; it should be borne in mind, of course, that the shield diameter should be larger than the diameter of the discharge opening. It might also be pointed out that omission of the shield **80** generally tends to permit cooked material to flow through the opening **68** in an uncontrolled manner so that the rotary valve **44** might become choked or plugged, and operation of the discharge arms would be rendered inefficient. As a result, cooked material tends to be removed primarily from the center portion of the chamber, and not from an area proximate the chamber walls. While the shield has been described as being cylindrical, a cone-shaped shield might be satisfactory for some applications as well, the base of such cone being larger than, and proximate the discharge opening in the bottom of the cooker.

The bottom end **78** of the shaft **74** is positioned within the hub **94** and it is connected to the hub by means of a key **96**. A retaining washer and nut assembly **98** effectively seals the bottom end of the shaft and the hub **94** together. A bushing **100**, mounted in supporting webs or fins **102**, aids in supporting the shaft **74** with respect to the shield portion **84**. The upper end **104** of the shield portion **84** is formed having a reduced diameter so that it forms a shoulder **106** with the main part of the shield portion **84**. A bushing **108** surrounds the shaft **74** so that it is interposed between the shaft and the top of the shield portion **84**. A bearing housing **110**, supported by web arms **112**, houses a bearing **114**; such bearing **114** being interposed between the upper end of the shield **104** and the housing **110**. A shield drum ring **116** surrounds the lower end of the upper shield **82**, and it fits within a groove **118** formed in the bearing housing **110**, thus providing a tight seal between the shield portions **82** and **84**.

A pair of horizontal leveling arms **120** and **122** are fixedly connected to the shaft **74** by means of a hub **124** and key **126**, so that they project radially away from the shaft axis. As illustrated, the arms are disposed proximate the upper portion of the chamber **20** so that they project through openings **128** and **130**, respectively, in the upper shield portion **82**. A pair of U-shaped members **132** and **134** are secured to the under surface of arms **120** and **122**, respectively, so that they project toward the bottom of the chamber. The arms **120** and **122** are positioned on the shaft **74** so that as the shaft rotates, the members **132** and **134** level or distribute the granular material as it is introduced into the cooking chamber.

A pair of elongated, curved sweep or discharge arms **136** and **138** are secured to the bottom end **78** of the shaft, and more particularly the circular plate **92**, so that they are juxtaposed over the bottom surface **66** of the chamber. In this regard, note FIGS. **7** and **8** as well. As shown in FIG. **7**, the arm **138** is secured to the plate **92** at a point on the left side of the shaft **74** and hub **96**, so that it effectively curves or sweeps around the shaft **74**, toward and along the wall of the chamber so that it terminates on the right side of the shaft **74**. The arm **136**, on the other hand, is attached to the plate **92** at a point on the right side of the shaft so that it curves around the shaft, toward and along the chamber wall, but on the opposite side when compared to the arm **138**. As shown more fully in FIG. **8**, the arms **136** and **138** are positioned adjacent to the bottom surface **66** so that they contact or sweep along such surface, as the shaft **74** is caused to rotate. For purposes of description, each arm will be described as having an inner curved surface **140** and an outer curved surface **142**. Each inner surface **140** is provided with an elongated indentation or groove **144**. As viewed in FIG. **8**, the groove **144** is formed so that it has a first sloping surface **146** which forms an angle of prescribed magnitude with the top surface **156**, and a second sloping surface **148** which is shorter than the surface **146** and which forms an angle of a prescribed magnitude with the bottom surface **154** of the arm. An edge **152** is formed by the sloping surface **148** and the bottom surface **154** of the arm. The surfaces **146** and **148** meet to form a somewhat curved portion designated by numeral **150**. The top surface **156** of each arm is tapered slightly from a maximum dimension proximate the shaft **74**, to a minimum dimension proximate the chamber wall. In other words, the thickness of the discharge arm increases from its outer extremity toward the point of attachment proximate the shaft **74**.

As the shaft **74** is caused to rotate, the discharge arms **136** and **138** sweep along the bottom surface **66** of the chamber and transfer a layer of material equal to the thickness of the arms, toward the center of the chamber, and more specifically toward the discharge opening **68**. The specific cross-sectional shape of the inner surface **140** of the arms, aids in preventing the layer of material from tending to slide over the top surface **156** of the arms, because the sloping surface **146** tends to exert a slight downward force on the material proximate such surface; the edge **152** and the surface **148**, on the other hand, tend to scrape or lift the cooked material off the bottom surface **66**. Thus, each arm **136** and **138** engages a layer of material and transfers it toward the center of the chamber.

Rotational movement is imparted to the shaft **74** by means of a variable speed motor **160**, mounted at the top of the intermediate frame **126** (note FIGS. **2** and **4**). The motor **160** is operatively connected to a pulley **162** secured to the top end **78** of the shaft. As depicted in FIG. **2**, a support structure or bearing housing **164** is provided for supporting the shaft **74**; such housing **164** in turn being attached to the intermediate frame **26** by a horizontal cross member **166**. The bearing housing will be described in greater detail below, in conjunction with the description of FIG. **10**.

As illustrated in FIG. **5**, a number of vertically aligned webs or fins **168** are secured to the inner surface of the chamber **20** so that they are spaced around the shield **80**. These fins aid in causing the material to move downwardly within the chamber during the cooking process, rather than in a helical manner due to the rotational effect of the shield **80**. The ends **170** of steam conduits **52** within the chamber, are bent or curved so they direct the steam in a downward direction. Preferably, the tip of the conduit should be positioned proximate the top surface of the material M within the cooking chamber so that the steam is directed onto the top surface of the material. In some instances, it might be preferred to introduce the steam below the top surface of the material, and in other instances it might be preferred to position the conduits closer to the top of the chamber. While two conduits **52** are shown for introducing the steam, it should be recognized that additional conduits could be added as well.

A brief description of the rotary valves **38** and **44** might be in order. Generally, valves of this type are well known in the art, and they are sometimes referred to as "star" valves. It has been found that both valves can be of the same general construction, although it is preferred to use a somewhat larger size for the bottom valve **44**. FIGS. **5** and **6** illustrate the general construction of one type of rotary valve used with good results. The valve **44** includes a housing **172** which is secured to the hopper **72** at **174** to provide a pressure tight seal. A fixed, tapered liner **176** is positioned within the housing, and an inlet passage **178** and a discharge passage **180** communicate with the liner **176**. A tapered rotor **182**, having a plurality of pockets **184** formed by radially projecting webs **186**, is fixedly mounted on a rotatable shaft **188**, driven by the motor **46**. Appropriate adjusting means are provided in a housing **190**, for adjusting the clearance between the liner **176** and the rotor **182**. Valves of this type might include a variety of features, such as an appropriate vent for permitting the steam to escape from a pocket filled with cooked material, before the cooked material is discharged from the valve.

Steam is introduced into the cooking chamber **20** at such a rate that a constant steam pressure is maintained within the cooking chamber. It has been found that a steam pressure of about 18–21 psig, and a corresponding temperature of about 250°–260° F., works satisfactorily for cooking most cereal grains. It should be realized, of course, that pressures much higher, e.g. 40 psig, or much lower, e.g. 5 psig, than this amount might be used for certain applications as well. At higher pressures, the required cook time decreases.

The feed rate of material into the cooker is determined by a number of factors, such as the desired cook time of the ingredients, the specific type of material being cooked, the pressure and temperature conditions within the chamber, the size or volume of the chamber, the amount of material within the chamber, and the like. It has been found that a cook time of about 55–65 minutes at a pressure of about 18–21 psig is adequate for most cereal grains. As an example, if the total weight of the material within the chamber is maintained at about 600 pounds, and a cook time of about 60 minutes is desired, a constant feed rate of about 10 pounds per minute into and out of the chamber should be maintained. The discharge rate of material from the chamber can be varied by increasing or decreasing the rotational speed of the shaft **74**; generally, it should be approximately the same rate as the input rate.

In operation, ingredients to be cooked, such as wheat and one or more flavorants, are fed from the feeder **10** into the mixer **16**, from which they are discharged into the rotary valve **38** and the cooking chamber **20**, at a prescribed feed rate. Pressurized steam is also introduced into the top of the chamber **20** through the conduits **52**, at a prescribed pressure, as well as through the conduit **56** into the bottom of the cooking chamber. In this regard, it has been discovered that introduction of steam into the bottom of the chamber helps equalize the pressure within the chamber, and helps prevent the material from being forced out through the discharge opening **68**, due to the pressure within the chamber. It might be mentioned that the steam tends to condense on the walls of the chamber, thus adding moisture to the material therein. If this is found to be objectionable, a steam jacket, or insulation, might be provided on the exterior of the cooking chamber; or if preferred, the chamber walls might be heated by appropriate heat elements.

The material is permitted to accumulate within the chamber until at least half of the desired load, as shown on the indicator head **36** of the scale, is deposited therein. The motor **160** can then be energized so that the shaft **74** is caused to rotate at a relatively slow speed. A slow speed is selected so that a minimum amount of material is discharged from the chamber. As the top surface of the material within the chamber increases in height, it tends to accumulate in an area directly below the inlet opening **70**. As the shaft **74** rotates, however, the leveling arms **120** and **122** distribute the material within

the chamber. Since the plate **92** is larger than the discharge opening **68**, very little, if any, material is discharged from the chamber **20**, until the shaft **74** is caused to rotate.

As the weight of the material within the chamber increases, the force exerted on the scale **28** also increases until the desired weight figure is indicated on the indicator head **36**. Since the shaft **74**, the shield **80**, and the sweep arms **136** and **138**, are being rotated, a certain amount of material is removed from the chamber through the discharge opening **68**. The amount of material being removed, of course, depends upon the rotational speed of the shaft. It might be necessary to dispose of the initial part of the material discharged from the cooker, due to incomplete cooking, since it may not have been in the chamber for the required amount of time. Once the material has been within the chamber for the prescribed amount of time, under the prescribed pressure and temperature conditions, the system can be operated on a continuous basis, and the material passes or settles to the bottom of the chamber by gravity. The rotary valves **38** and **44** permit the material to be introduced into, and discharged from, the cooking chamber without adversely affecting the internal pressure of the chamber. If the pressure does drop, it can be increased by adjusting the pressure regulators **58** and **60**. If desired, pressure relief valves might be provided in the walls of the chamber **20** for permitting steam to escape if the pressure exceeds a prescribed maximum. It has been found that the displacement volume of the bottom rotary valve **44** should be slightly greater than the displacement volume of the unloading device, i.e. the shaft **74** and the arms **136** and **138**, so as to prevent any of the material from being static in the hopper **72**.

As described above, as the curved discharge arms **136** and **38** are caused to rotate about the shaft axis, a layer of material corresponding to the approximate thickness of the discharge arms is transferred along the bottom surface **66** toward the discharge opening **68**. Movable, curved arms of this type assure that a layer of material covering the entire bottom surface of the chamber is removed, rather than material from isolated or selected areas. In the event that the weight of the material within the chamber exceeds the predetermined amount as shown on the indicator head **36**, the operator can increase the discharge rate of the material from the chamber, by increasing the rotational speed of the shaft **74**. Conversely, if the discharge rate is too fast, the amount of material will not reach the predetermined weight figure, as shown on the indicator head **36**, and the material will not be adequately cooked. In other words, by reducing the rotational speed of the shaft **74**, the operator can reduce the discharge rate of material from the chamber. Thus, feed through the cooker is in a state of equilibrium when the weight of the material within the chamber, as shown by the indicator head **36**, remains constant.

While the above system has been described as being semi-automated, because the operator can regulate the rotational speed of the shaft **74**, the entire system might readily be made automated to such an extent that deviations or fluctuations in the total weight of the material within the cooking chamber, automatically cause the rotational speed of the shaft **74** to increase or decrease. Moreover, it should be recognized that other types of systems might be used for sensing and controlling the weight of material within the cooker. Load cells, for example, might be used for suspending the cooker and its contents. Load cells and their operation are well known to those skilled in the art, and will not be described in further detail.

FIG. **9** illustrates another embodiment of the invention, which is quite similar to the embodiment already described. In this construction, the lower portion **196** of a cylindrical shield **192** remains stationary relative to the upper shield portion **194** and the shaft **198**. Two support bars **200** are attached to support members **202** on opposite sides of the shield, such support members in turn being attached to the interior of the cooking chamber **206** by webs or fins **204**. A pair of ears or lobes **208** are secured to opposite sides of the lower shield **196**, and they in turn are secured to the support bars **200**. A bushing **210** is mounted in a bearing retainer **212**, the latter being supported at the top end **214** of the lower shield; this structure provides a rotatable support between the shaft **198** and the lower shield **196**. The lower end of the shaft **198** is also rotatably mounted relative to the lower shield by means of a bearing **216** mounted in a bearing retainer **218**, the latter being supported by webs or fins **220** secured to the inner surface of the lower shield **196**.

A pair of curved discharge arms **222** are secured to a circular plate or disc **224** by appropriate means, such plate being attached to the shaft **198** by means of a hub **226** and key **228**. A ring-shaped member **230** is secured to the inner surface of the lower shield **196**, and an appropriate seal is provided for preventing material from passing between the plates **224** and the ring **230**, into the interior of the shield **192**. A pair of leveling arms **232**, each having a U-shaped member **234** secured thereto, are attached to the shaft **198** so that they are rotatable with the shaft. Since the upper shield portion **194** rotates relative to the lower shield portion **196**, a shield drum ring **236** provides a seal between the two components.

A pair of conduits **238** are provided for introducing pressurized steam into the chamber **206**. Note that the conduits are positioned so that the steam is injected directly into the bed of granular material at a point slightly below its top surface.

The operation of this embodiment is substantially the same as the operation of the apparatus described in FIG. **5**. The major difference is that the lower shield **196** remains fixed, while the shaft **198**, the arms **222** and **232**, the plate **224**, and the upper shield **194** are caused to rotate. Moreover, the pressurized steam is introduced directly into the bed of material being cooked, rather than onto the top surface of the granular material as described hereinbefore.

FIG. **10** illustrates another embodiment in which a vertically oriented shaft **242** is cantilevered within a cooking chamber **240** by rotatably supporting its upper end **244** in a bearing housing **246** located at the top of the cooking chamber. The bearing housing is similar to the bearing housing **164** referred to generally above. Note that the upper end portion of the shaft has a slightly smaller diameter than the remainder of the shaft so that a shoulder **248** is formed. The inner surface of the housing **246** is formed into three sections, a first cylindrical section **250** which is larger than, and which forms a first shoulder **252** with a second cylindrical section **254**, and a third cylindrical section **256** which is smaller than, and which forms a second shoulder **258** with the second cylindrical section **254**. A pair of bearings are positioned within the first cylindrical section **250**. An angular contact bearing **260**, capable of withstanding both thrust and radial loads, is positioned on the first shoulder **252**, and it is separated from a second bearing **262** which is capable of withstanding radial loads, by a sleeve or bearing spacer **264**. As shown, the shoulder **248** formed on the shaft **242** abuts against the under surface of the bearing **260**, and a lock nut and washer **266** threadedly engages the top of the shaft so as to lock the bearings and spacer together. A shaft seal **268** positioned within the third cylindrical section **256**, prevents dust and other material from entering the bearing housing **246** from the cooking chamber.

A cylindrical shield **270** having a top cover or plate **272**, and a bottom plate **274** which is attached to the bottom of the shaft **242** by appropriate means, is caused to rotate as the shaft rotates. As shown, the diameter of the plate **274** is larger than a discharge opening **276** in the bottom surface of the chamber. Appropriate seals are provided for preventing any material from entering the interior of the shield **270**. A pair of curved discharge arms **278**, similar to the discharge arms described hereinbefore, are attached to the bottom plate **274**, and a pair of leveling arms **280** are secured to the shaft **242** so that they project through openings **282** in the shield **270**. Each of the arms **280** is provided with a U-shaped member **284** secured to its under surface.

A somewhat different system is shown for introducing pressurized steam into the chamber **240**. The shaft **242** is provided with an elongated passage **286** therein which is coaxial with the shaft axis. Each of the leveling arms **280** is also provided with an elongated passage **288**, which is perpendicular to, and which intersects with, the passage **286**, and each of the U-shaped members is provided with a U-shaped passage **290**, which intersects with the passages **288**. A plurality of discharge ports **292** are located in each U-shaped member **284**, for discharging steam from the passages into the chamber. Thus, a continuous passage is provided from the top of the shaft **244** to the interior of the chamber. A rotary union **294** is secured to the top of the shaft, and it permits pressurized steam to be introduced into the cooking chamber **240** from an appropriate source (not shown) through conduit **296**, while the shaft is rotating.

The operation of this embodiment is basically the same as the previous embodiments, in that the granular material forms a bed in the cooking chamber, having a height dependent upon the input rate, relative to the discharge rate of material. As the shaft **242** rotates, the shield **270**, the discharge arms **278**, and the leveling arms **280** rotate about the shaft axis. Pressurized steam is introduced directly into the bed of material through the passages **286, 288,** and **290**, thus causing the granular material to be cooked. As the curved discharge arms **278** revolve about the shaft axis, cooked material along the bottom surface of the chamber is transferred to the discharge opening **276**, and ultimately through such opening to the exterior of the cooking chamber.

In the above description and attached drawings, a disclosure of the principles of this invention is presented together with some of the embodiments by which the invention may be carried out.

Now, therefore, we claim:

1. A continuous pressure cooker for cooking granular material comprising a substantially pressure tight cooking chamber aligned along a vertical axis so that it has a top end and a bottom end, the surface of said bottom end being substantially flat, an inlet opening proximate the top end for introducing material into the chamber against the pressure therein, a discharge opening at the bottom of the chamber for removing material from the chamber without reducing the pressure therein, said material passing from the upper portion of the chamber to the lower portion thereof by gravity, means for introducing pressurized steam into said chamber, movable means at the bottom of said chamber for discharging the cooked material from the chamber by transferring a layer of the material proximate the bottom surface of the chamber toward the discharge opening, and means for controlling the discharge rate of the material from the chamber.

2. The combination of claim **1** wherein a shaft is mounted within said chamber so that it is rotatable about said vertical axis, and a shield member is provided which surrounds at least the lower portion of said shaft, the cross-sectional dimension of the lower portion of said shield being larger than the cross-sectional dimension of the discharge opening.

3. The combination of claim **2** wherein means are provided within the chamber for aiding in directing the material vertically toward the discharge end of the chamber.

4. The combination of claim **2** which includes hopper means, and means for securing said hopper means to the discharge end of the chamber so that it surrounds the discharge opening, and steam inlet means are provided in said hopper means for introducing pressurized steam into the bottom of the chamber.

5. The combination of claim **1** wherein a shaft is mounted within said chamber so that it is rotatable about said vertical axis, and the movable means for discharging the material from the chamber includes at least one elongated discharge arm connected to the bottom end of said shaft so that it is juxtaposed over the bottom surface of the chamber, said discharge arm transferring cooked material along the bottom surface of the chamber toward the discharge opening.

6. The combination of claim **5** wherein the chamber has a circular cross section and the discharge opening is centrally located in the bottom surface of the chamber.

7. The combination of claim **6** wherein means are provided over said discharge opening for minimizing the amount of material which passes through said opening, said discharge arm being interposed between said means and the bottom surface of the chamber.

8. The combination of claim **6** wherein the shaft is supported and journalled at its upper end so that its lower end is cantilevered toward the bottom surface of the chamber, a tubular shield member is provided within the chamber which surrounds said shaft so that an annular space is formed between the walls of said chamber and said shield, said shield member having an upper end and a lower end and a larger cross section than the cross section of the discharge opening, and means are provided at each end of the shield for preventing the granular material from entering said shield member.

9. The combination of claim **8** wherein at least one horizontal arm member is fixedly attached to the vertical shaft proximate the upper end of the shield member, in such a manner that it projects through the surface of said shield.

10. The combination of claim **9** wherein the horizontal arm is provided with projecting means on its undersurface for leveling material within the chamber, as the arm rotates about the shaft axis.

11. The combination of claim **8** wherein means are provided for fixedly connecting said shield member to the shaft so that it rotates about the shaft axis as the shaft rotates.

12. The combination of claim **8** wherein the shield is comprised of two parts, an upper portion which is fixedly connected to the shaft so that it rotates with said shaft, and a lower portion which is rotatably mounted relative to the shaft by fixedly connecting a portion of it to the inner surface of the chamber, and sealing means are provided for preventing material from passing between the joint formed by said two sections.

13. The combination of claim **6** wherein a pair of discharge arms are provided on opposite sides of the shaft, each arm having its longitudinal axis horizontally aligned and having a curved configuration which extends from the shaft toward and along the curved surface of the chamber, said arms transferring a layer of material along the bottom surface of the chamber toward the discharge opening as the shaft rotates.

14. The combination of claim **13** wherein each discharge arm has a prescribed thickness, an inner curved surface, and an outer curved surface, said inner curved surface having an indentation therein.

15. The combination of claim **5** wherein at least one horizontal leveling arm is fixedly attached to the vertical shaft proximate the upper end of the chamber.

16. The combination of claim **15** wherein a passage is provided in the vertical shaft which extends along the longitudinal axis of said shaft, a horizontal passage is provided in the horizontal arm which intersects with the passage in the shaft, at least one orifice is provided in the arm member which forms an opening from the horizontal passage into the cooking chamber, and means for linking said shaft and shaft passage to a source of pressurized steam.

17. The combination of claim **5** which includes a first rotary valve, means for attaching said first rotary valve proximate the upper part of the chamber so that the material to be treated passes through said valve before it passes through the inlet opening into the chamber, a second rotary valve, means for attaching said second rotary valve proximate the lower part of the chamber so that the cooked material passes through the discharge opening and through said second rotary valve, said rotary valves maintaining the pressure within the cooker at a prescribed level.

18. The combination of claim **1** wherein the discharge rate of material from the chamber is controlled relative to the input rate of material into the chamber.

19. The combination of claim 18 wherein the controlling means includes a scale having an indicator head, said cooker being mounted on said scale so that any changes of the weight of material within the cooker are registered on the indicator head.

20. A continuous pressure cooker which comprises a substantially pressure tight cylinderical cooking chamber aligned along a vertical axis so that it has a top end and a bottom end, the surface of said bottom end being substantially flat, an inlet opening for continuously introducing material to be cooked into the chamber, a discharge opening at the bottom of the chamber for continuously removing the cooked material from the chamber, means for introducing pressurized steam into said chamber, means associated with said inlet and discharge openings for maintaining a predetermined pressure within the chamber, a vertically oriented shaft rotatably mounted within said chamber, movable means connected to said shaft proximate the discharge opening for transferring a layer of cooked material along the bottom surface of the chamber through said discharge opening as the shaft rotates, means including a shield member which surrounds at least the lower portion of said shaft, for effectively preventing said material from flowing through the discharge opening unless the shaft rotates, scale means, and means for positioning said cooker on said scale means so that any changes of the weight of material within the cooker are registered by said scale means.

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