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[72] Inventor Bernard Dixon
Harpenden, England
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[73] Assignees The Dixon Malt Company Limited;
The Enzymic Malt Company Limited
London, England
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[31] 25,457/67

[54] **MALTING APPARATUS**
16 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **259/97,** 195/129
[51] **Int. Cl.** **B01f 5/12**
[50] **Field of Search** 259/97, 23, 24, 95; 195/69, 70, 71, 128, 129, 130; 99/237

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Primary Examiner—Robert W. Jenkins
Attorney—Larson, Taylor and Hinds

ABSTRACT: A malting vessel has a vertical tube set within it, with its ends spaced from the top and bottom of the vessel, and there is a feed screw or a gas stream active in the tube so that a circulation of contents may be set up throughout the vessel, at will. Air or other gas at controlled temperature, humidity and pressure can be injected into the vessel at any time. When a feed screw is used it preferably has a special construction, with a conically flared lower end, the pitch of the screw in this region being progressively inversely proportional to its diameter.

A novel method of malting involves the setting up of a circulation of grain in a vessel in such a way that part of the grain batch is rising while another part is falling, gas being optionally injected at least into the part of the circulation where grain is falling.

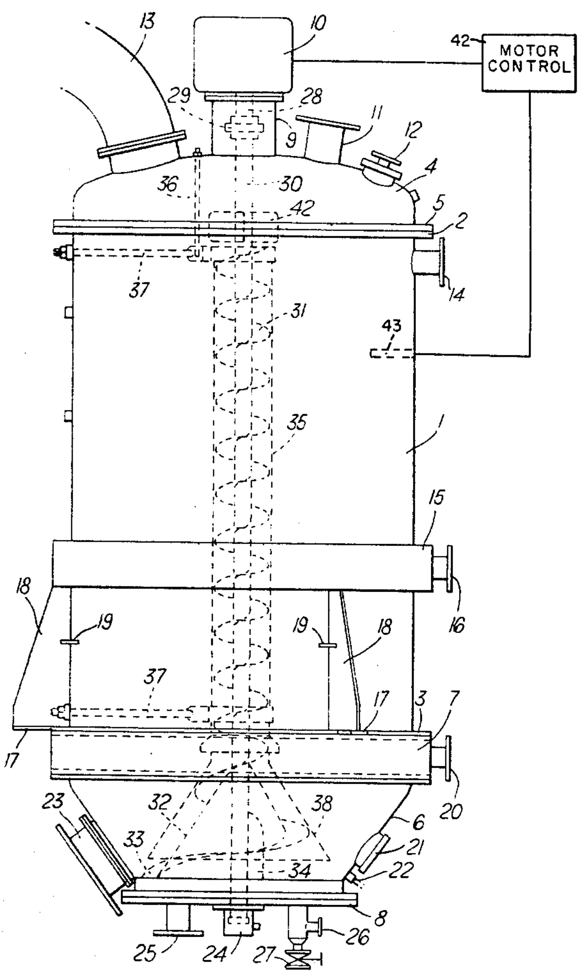
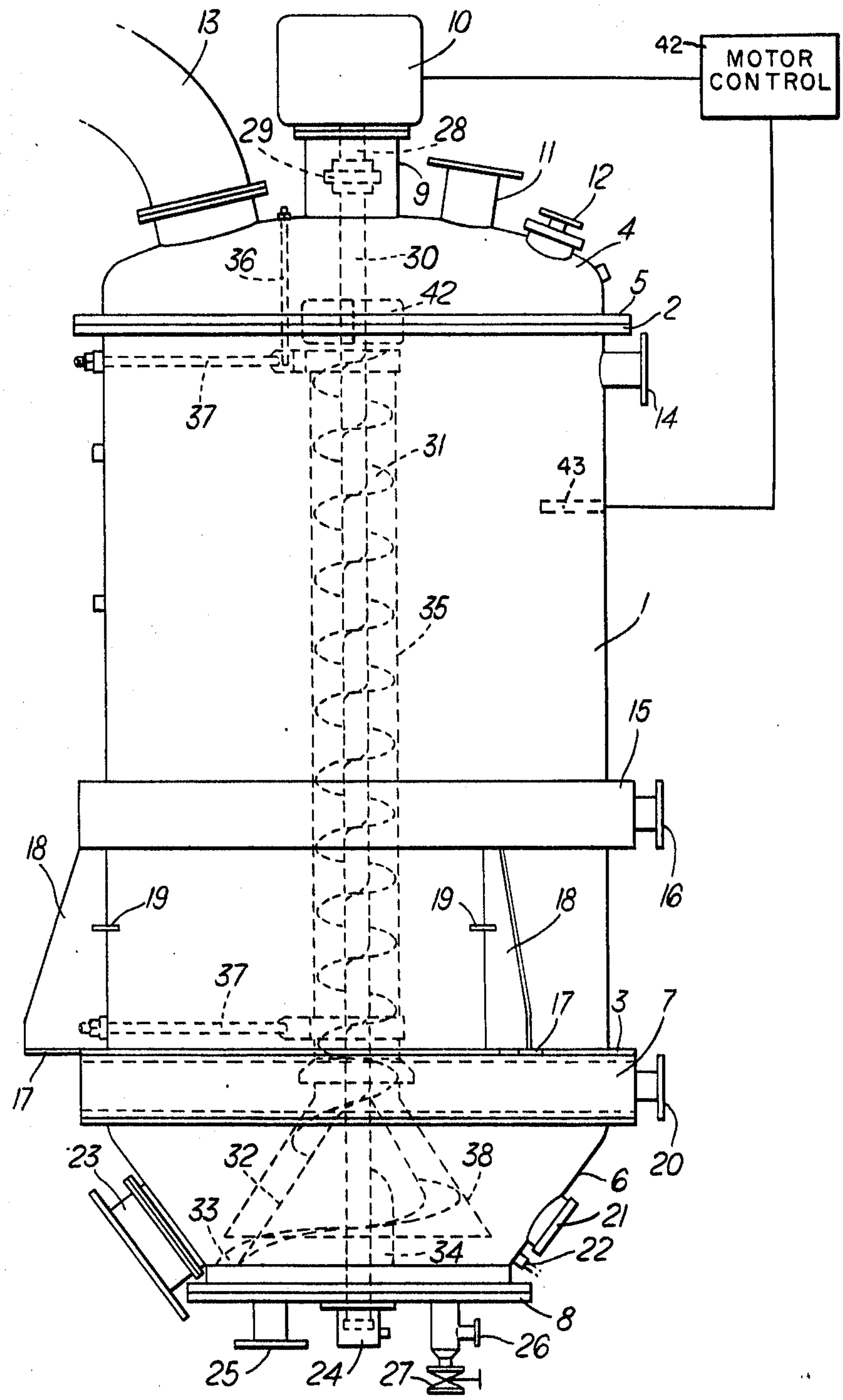


Fig. 1.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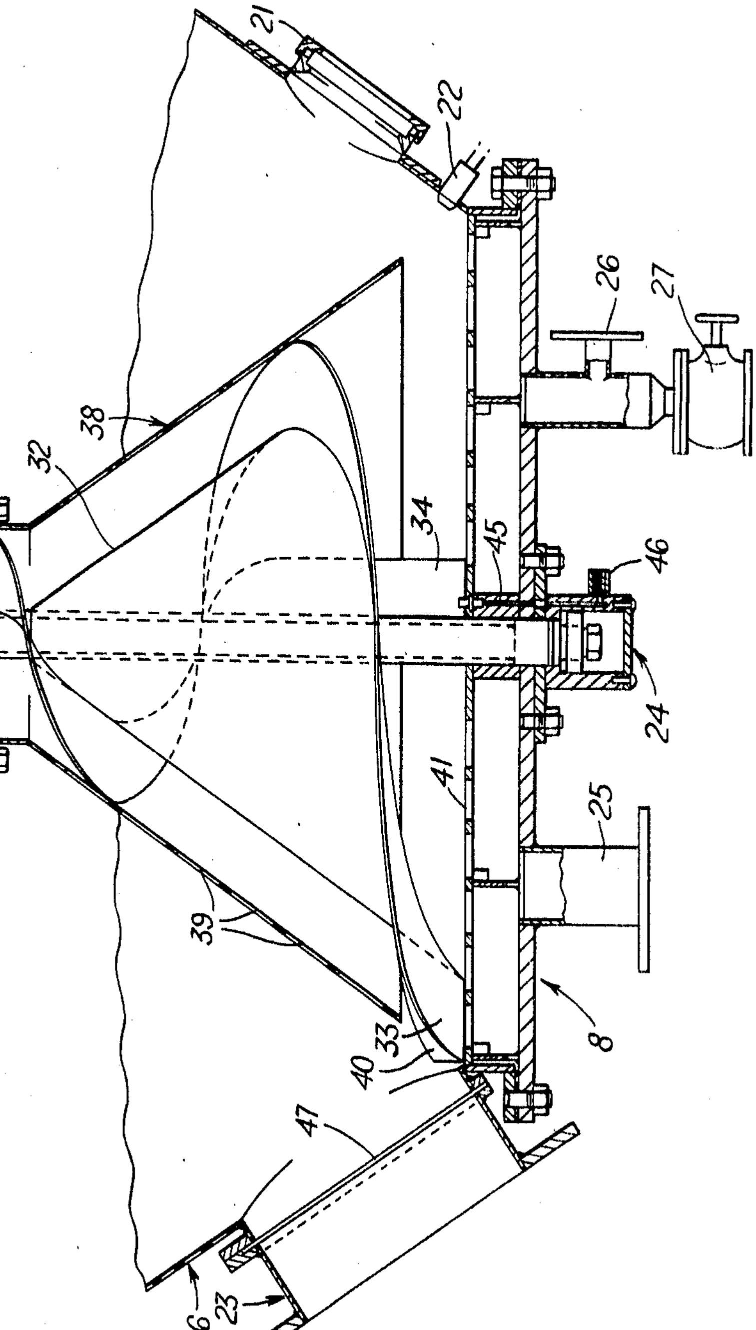
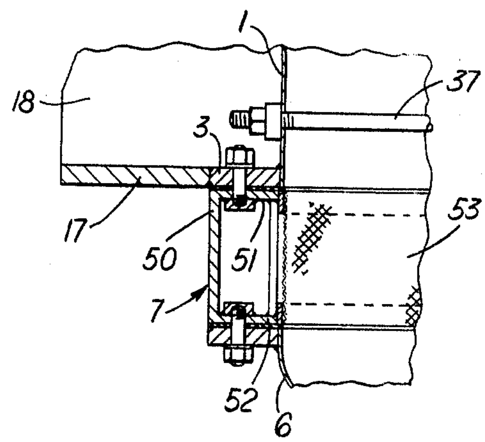


Fig. 2.

Fig. 3.



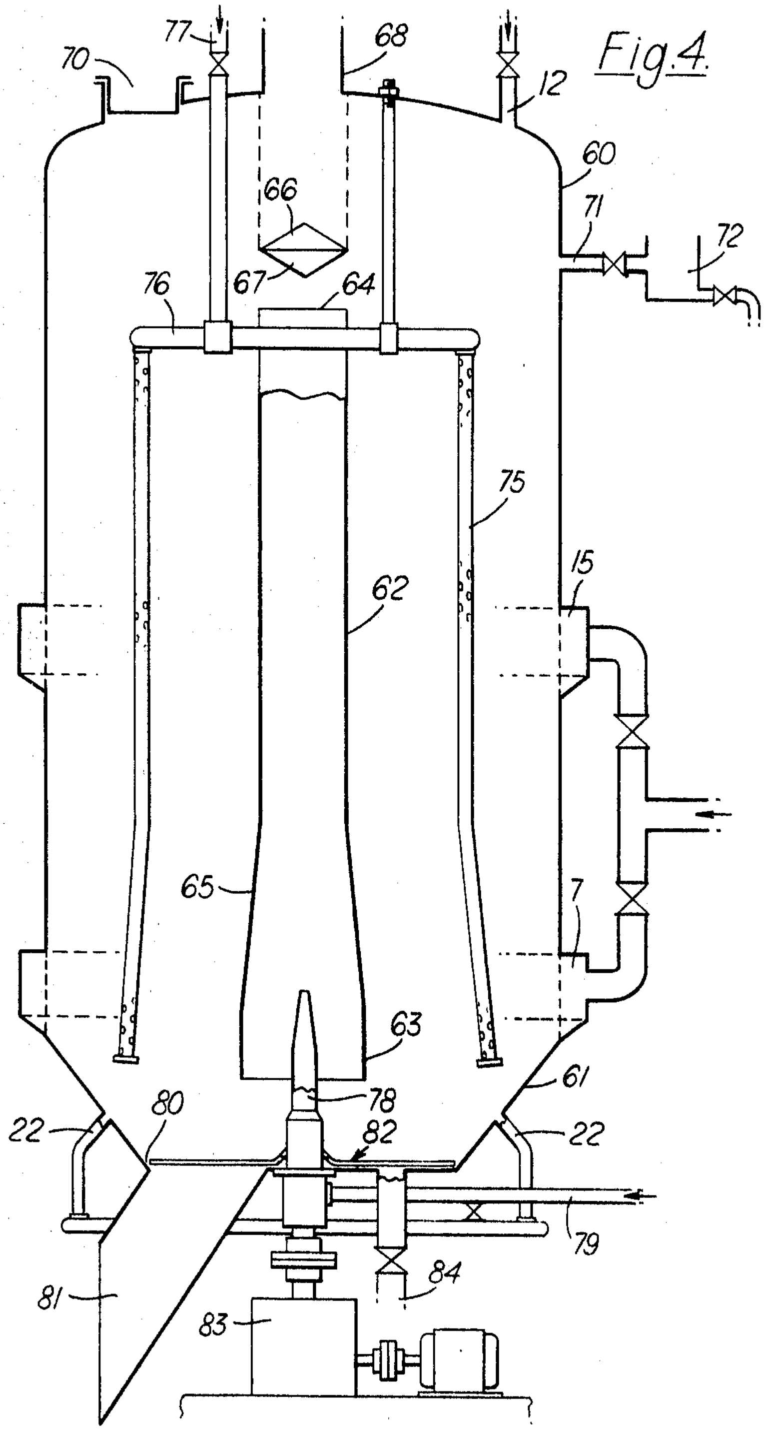

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Fig.4.

MALTING APPARATUS

This invention relates to malting apparatus, and a method of malting.

Developments in malting in past years have led away from the floor type of malting which involves large floorspace and high labor costs, towards the use of apparatus where grain can be malted in considerably greater depth. Problems have been encountered, in malting vessels which work with grain in depth, in ensuring uniformity of temperature and other conditions with consequent control of growth and modification over the whole batch. Mechanical stirring as distinct from circulation requires relatively great power, only takes place in one part of the grain and sets up no general circulation throughout the vessel. Attempts to use pneumatic stirring (e.g. Popp U.S. Pat. No. 2,891,892, United Kingdom Pat. No. 1,044,029) have concentrated on sudden injections of gas to cause explosive upheavals in the grain bed.

The present invention on the other hand provides for a continuous or intermittent circulation throughout the batch in the vessel during times when control is required, and for the injection of gas or gases of desired temperature and humidity into the grain either during its circulation or when stationary so that all parts of the batch of grain are kept under the correct conditions during the process. When circulating, all parts of the batch get, over a period of time, an exposure to standardized and controlled malting conditions.

This invention has for an object the provision of apparatus and methods whereby the malting of any grain, particularly barley, may be carried out under controlled conditions with high efficiency, that is to say with great evenness of temperature and other conditions in and surrounding the grain being treated.

According to one aspect of the invention, apparatus for malting grain includes a vessel containing an inner vertical tube having ends spaced from the top and bottom of the vessel, elevating means to move grain in opposite vertical directions inside and outside the inner tube and means for passing gas into the vessel.

The elevating means may be pneumatic, for example, a nozzle directed to discharge gas up the inner tube and served by a high-pressure gas inlet or may be mechanical, for example, a feed screw located within and coaxial with the inner tube, with control means for the temperature and humidity of the gas used for the pneumatic lift, if provided, and for the gas or gases passed into the vessel. In addition, a rotatable agitator may be provided at the bottom of the vessel, and there may be further controllable inlets, e.g. gas or additives.

There may be provided in the outer part of the vessel aerating legs arranged to be served with gas at any desired temperature, humidity and pressure and to discharge it into the grain being treated. Conveniently the legs may extend over at least the greater part of the length of the inner tube.

Near the lower end of the outer part of the vessel there may be inwardly directed air nozzles arranged to discharge air into the grain to prevent arching or bridging thereof.

A feed screw preferably is formed around a central shaft which has a conical skirt at its base portion, the base portion of the screw being formed around the conical skirt and fitting within a corresponding conical flared portion of the inner tube. The base portion of this screw may have a pitch which is progressively inversely proportional to the square of the diameter of the conical skirt.

According to another aspect of the invention I provide a method of malting grain which includes maintaining grain circulation in avessel by lifting part of the grain at one portion of the vessel and at the same time allowing part of the grain to fall in another to form a circulation. The method may include passing gas into the vessel during the circulation to enter at least that part of the grain which is falling in the vessel.

The vessel and method may be used either solely for the aerobic stage of malting or for any or all stages of any method of malting known to me. For example in a method which includes an anaerobic phase a charge of barley may be placed in the vessel, may be steeped in the vessel and subjected to aerobic and/or anaerobic phases in the vessel, the circulation and aeration facilities of the vessel being used as required during the aerobic modification phase or phases or during both aerobic and anaerobic phases. On the other hand, since the malting vessel is a more costly piece of capital equipment than the simple containers and vessels which would be required for steeping and/or initiating germination, the grain may be held in other vessels of a simpler construction during those stages and transferred to the present malting vessel only for certain other stages, e.g. its aerobic and/or anaerobic phases.

Particular embodiments of the invention and methods of carrying it out will now be described with reference to the accompanying drawings wherein:

FIG. 1 is a diagrammatic side elevation of a first embodiment,

FIGS. 2 and 3 are detail sectional views of parts of that embodiment, and

FIG. 4 is a diagrammatic side elevation of a second embodiment.

The first embodiment of the invention is shown in FIGS. 1, 2 and 3 of the drawings.

The vessel is a closed-ended cylindrical drum set with its main axis vertical. The vessel is made in three portions, the center portion **1** being a hollow open-ended cylinder having end flanges **2, 3**, a top closure **4** of the vessel being attached to flange **2** by a like flange **5**, and a bottom frustoconical portion **6** of the vessel being attached to flange **3** through a hollow ring portion **7** which will be more particularly described later.

The bottom end of the frustoconical section **6** is closed by a closure plate **8**.

The top closure **4** bears a mounting **9** for an electric motor **10** and also an inlet pipe **11** for grain and a narrower inlet pipe **12** for any additives that may be required to be used. There is also a wide gas outlet **13** fitted with a closure and release valve (not shown).

In the cylindrical portion **1** there is provided a valved outlet pipe **14**, leading to a floater box for receiving dust and other solid matter which it may be desired to remove from the vessel, and a first gas gallery **15** which has a gas inlet **16**. There are three or more protruding feet **17** at the lower part of this portion strengthened by trunnion plates **18** and horizontal gussets **19** for those plates. The feet are for supporting the vessel, preferably through load cells for indicating the total weight of vessel and contents. The ring **7** forms a second gas gallery and has a gas inlet **20**.

In the frustoconical portion **6** there is provided a sight glass **21** equipped with an internal wiper (and other sight glasses may be provided at suitable points over the whole of the vessel), an arch-breaking air jet **22** and a discharge port **23** equipped with a power-operated openable closure door which is gastight when closed.

In the baseplate **8** there is provided a bearing boss **24** receiving the lower end of a shaft which extends coaxially with the motor **10**, a drain outlet **25** and a gas withdrawal outlet **26** which has a valved drain **27** in a branch.

A shaft **28** of the drive motor **10** is coupled through a flexible coupling **29** to a hollow shaft **30** which extends as far as the bearing boss **24** in the baseplate of the vessel. This bears a feed screw **31** which at the bottom flares outwardly around a conical skirt **32** on the shaft **30** and ends in a shovel portion **33** traveling over the baseplate **8**. Above where the screw **31** terminates four paddles **42** project mutually at right angles to each other from the shaft and at the base a paddle **34** is provided. The paddle **34** is offset from the axis of rotation of the screw to sweep outwardly any grain falling inside the conical skirt **32**.

The conical skirt **32** terminates at the level of the lowermost revolution of the screw and reinforces its radially inner edge. The paddle **34** joins the skirt **32** adjacent the shovel part **33** of the screw.

The screw **31**, together with its portion which surrounds the conical skirt **32** works inside a stationary inner tube **35** which is supported within the vessel by stays and spacers such as **36**, **37**, and has at its bottom end (FIG. **2**) an outwardly flaring tube part **38** which has narrow elongate slots **39**.

The portion of the screw **31** which surrounds the conical skirt **32** has a conformation such that the pitch of the screw is at any one time inversely proportional to the square of the diameter of the skirt **32** which forms its inner boundary. This is to ensure that material, as it is drawn up outside the skirt **32** and inside the flared tube part **38**, is not axially compressed as it progresses into regions of successively lesser diameter. We call this part of the assembly, the scroll. Along the length of the cylindrical part of the tube **35** the screw pitch is constant.

The shovel portion **33** of the screw **31** is reinforced on its radially inner side by the extreme bottom end part of the skirt **32** and on its outside it has an upstanding edge lip **40** so that it forms a shovel for scooping up grain lying on the bottom plate of the vessel.

This bottom plate has an upper perforated decking **41** which has narrow slits of a size to permit drainage of liquid downwardly without permitting grain to pass. The perforations allow also for the passage of gas through the base.

The bottom of the conical part **38** of the tube **35** is spaced above the decking **41** of the baseplate **8**, and the shovel **33** works within that spacing. The paddle **34** displaces outwardly any grain which falls inside the radius of the shovel, and gas jets **2** are positioned around the perimeter of the upper decking **41**, but in the outside wall of the conical portion **6** of the vessel, ready to be used should any bridging or cavitation occur in the region of the gap between the decking **41** or portion **6** and the tube portion **38**.

A small nozzle **45** can be fed with gas or liquid through an inlet **46** in the bushing construction **24** so as to wash or blast off grain which might be in the area of the bottom portion of the shaft **30**, and in the baseplate **8** there is a drainage outlet **25** to permit flow-away of any liquid passing through the decking **41**, and gas suction outlet **26** will be used to assist in the rapid displacement of one type of atmosphere by another when need be.

The outlet door **23** has a guillotine slide plate **47** powered by, for example, a hydraulic ram, which slide plate when closed forms a gastight seal with the bearings in which it runs.

Referring now to FIG. **3** there is shown the construction of the hollow ring **7** which acts to secure together the part **1** and part **7** of the vessel and acts also as a gas gallery for the input of gas into the vessel. The ring is generally of channel construction, the base **50** of the channel being a cylinder and its sidewalls **51** and **52** being parallel, horizontally disposed and bolted to flange **3** of the vessel **1** and the corresponding flange of the portion **6**, respectively. The mouth of the channel section which is thereby disposed inwardly of the vessel is covered by some foraminate covering **53** for permitting gas to pass freely but prevent grain from accumulating in the gallery.

The construction of air gallery **15** is similar insofar as a foraminate member is provided and an annular gas channel around the circumference of the vessel **1**.

The hollow shaft **30** may have perforations in it so that aeration of the grain may be continued even as it is being moved upwardly by the screw within the casing **35**.

In use, barley or other grain, which may be as harvested or which may be in any suitable stage of the malting process is admitted through the charging pipe **11**. It falls into the gap between the inner tube **35** and the outer wall of the vessel and charging is continued until a desired amount of grain is in the vessel. The depth of grain in such a vessel is very considerable. Experimentally, I have worked with grain depths of 7 feet or more, and a charge of 2 tons weight (when containing its desired 44—50 percent of moisture.)

If the grain was admitted in its harvested condition, it is steeped in the vessel, water being added through inlet **12** at a controlled temperature. Aeration during steeping may be carried out. A water circulation may be set up by using the drain outlet **25** and inlet **12**. After the steep, an aerobic germination period follows, and during this phase the motor **10** drives the shaft **30** and hence the screw **31** in rotation in such a sense as to lift grain from the bottom of the vessel to the top. The motor **10** may be of variable speed, and be controlled in its operation through a conventional control **42** by temperature or other condition sensing means **43** in the vessel. When the grain arrives at the top of the screw it is evenly distributed outwardly with the aid of the paddles **42** and there is thus set up a continuous and even circulation of the grain through the vessel, it being lifted by the screw **31** and then allowed to fall, outside the inner tube **35**. During this circulation gas is fed under controlled temperature and humidity conditions through one or both gas galleries **7**, **15**, through their respective inlets **20** and **16**, so that there is a gas flow upward through the grain which is falling downwards in the outer portion of the vessel. Gas having passed through the grain is exhausted through the pipe **13** and may be discharged to the air or may be recirculated after temperature, composition and humidity conditioning.

A charge of 2 tons weight being circulated at a rate so that there is one complete changeover each 5 minutes will suitably be supplied with air at a rate of approximately 800—1,000 cu. ft./min.

In the present embodiment there is a counterflow of grain and gas. During this phase the grain is chitting and rootlets are just emerging, and the continuous circulation and admixing ensures evenness of the rate of this development (as far as is at all possible) throughout the whole mass of the grain, and helps prevent matting of any rootlets which may be developing.

The vessel may also be used during an anaerobic phase or a resteeping process in which the rootlets are killed—the grain may be left static during this phase, the atmosphere inside being changed either actively or by virtue of respiration for one of CO_2 or other nontoxic nonrespirable gas (or water in the case of resteeping), or the circulation of grain may be continued. CO_2 or other gas may be passed into the vessel through gas galleries **7**, **15**.

The circulation facility may be used at any stage. When it is used, it assists a controlled and evenly dispersed supply of gas to the grain.

To unload the vessel, gas and other input is stopped, the door slide plate **47** is opened and the screw **31** driven in the opposite direction to that which would cause lift so that the shovel part sweeps round the baseplate and continuously disturbs the grain at the bottom of the vessel and pushes it out through the door **23**.

During either the aerobic or the anaerobic stages conventional malting additives may be provided, and water may be added in liquid form as well as by humidification of the gas. The gas used is dependent on the stage in the malting at which it is used, and may be air and/or carbon dioxide, or may be a mixture of carbon dioxide and another nontoxic nonrespirable gas.

The second embodiment of the invention uses as elevating means, instead of the screw **31**, an air current. This embodiment is shown diagrammatically in FIG. **4**. The chamber **60** is fabricated in stainless steel and has a column about 10 feet high and 4 feet 6 inches in diameter, of generally cylindrical form, the lower part **61** of the chamber tapering inwardly. Located vertically within the chamber and coaxial therewith is an inner tube **62** corresponding to casing **35**, the bottom end **63** of which is about 9 inches from the bottom of the chamber and about 12 inches in diameter, while the top end **64** is about 2 feet from the top of the chamber and about 9 inches in diameter. Conveniently the inner tube is tapered in the bottom portion, the tapered part **65** being about 2 feet 6 inches to 3 feet long. Just above the top end **64**, but spaced therefrom by a few inches, is a deflector having upper **66** and lower **67** conical deflecting surfaces, and above this is an inlet **68** for the grain. This is formed in the top wall of the chamber and is provided with means for ensuring an airtight seal. Also in the top wall of the chamber are a water inlet **12** having valve means to control the flow of water and a gas outlet **70**, fitted with a pressure release valve that may be set to allow the escape of gas from the chamber at atmospheric or other predetermined pressure. Gas received by the outlet can be recirculated, as will be described. Thermometers, pressure gauges and glass inspection windows are provided in the wall of the chamber where necessary.

Level with the top of the inner tube there is an outlet pipe **71** having valve means and communicating with a floater box **72**.

Gas galleries **7**, **15**, are provided as before, the wall of the chamber being provided with grilles which constitute the inner wall of the galleries and permit gas to pass into the chamber.

The number and disposition of the galleries may be varied as required. Alternatively, or in addition, there may be gasifying legs consisting of a number of vertical tubes **75**, blind at their lower ends and apertured along their length (the apertures may be larger or more frequent towards the blind end), arranged vertically approximately midway between the walls of the outer chamber **60** and inner tube **62**. There may be any required number of legs, say six or eight, extending as far as from the level of the top **64** of the inner tube to the level of its bottom **63**. At their upper ends, the legs are connected via a gas-distributing ring **76** to an exterior gas supply through gas inlet **77**.

Such gasifying legs may be provided in the first embodiment described.

A gas nozzle **78** is located in the middle of the bottom wall of the chamber and extends vertically up into and coaxial with the inner tube **62**, the nozzle projecting about 12 inches into the lower end of this tube. The nozzle is served with high-pressure gas (e.g. air at a pressure of the order of 10—30 p.s.i.) from a suitable external source **79** at a predetermined or controllable temperature. The bottom wall **80** of the chamber has an aperture communicating with a closable discharge outlet **81**, and above the bottom wall of the chamber there is a mechanical agitator **82** consisting of radially extending arms arranged to be rotatable by means **83** below the chamber and including a suitable source of power such as an electric motor, whereby the radial arms may be caused to rotate and sweep across the bottom of the chamber and facilitate movement of the grain. The bottom wall of the chamber also is provided with an outlet **84** for liquor with a suitable control valve.

The gas nozzle **78** may be so mounted as to be adjustable in height relative to the lower end of the inner tube.

In operation of this embodiment, barley or other grain which may already have been steeped is charged through the inlet **68** onto the upper surface **66** of the deflector and is deflected outwardly so as to fall down into and fill the space between the outside wall of the inner tube **62** and the wall of the chamber **60**. This continues until the chamber has been filled to the required extent. Water at a desired temperature may be introduced into the chamber in a predetermined quantity for adjustment of the moisture content. During an aerobic phase gas at the desired temperature and pressure and which may be recycled from the outlet **70** is introduced through the ducting system via the upper and lower galleries **7**, **15**, to pass through the grilles into the body of the grain and out through the gas outlet. The high pressure gas inlet to the nozzle **78** is opened and a current of gas moving at the desired speed, pressure, and temperature passes up the inner tube **62**.

Grain at the bottom tapered part **61** of the chamber **60** is forced radially inwardly as it falls under gravity so that it comes underneath the lower end **63** of the inner tube **62**. where it is entrained by the gas stream from the nozzle and begins to be carried up the inner tube, its place being taken by more grain passing in radially at the bottom, while the elevated grain is deflected by the lower surface **67** of the deflector at the top **64** of the inner tube so as to pass radially outwardly and fall upon the grain at the top of the chamber. A circulation of the grain is thus built up and in a short time a steady rate of flow will have been obtained so that the grain is moving up the interior of the inner tube continuously and is then recirculating down round the outside of the inner tube and is eventually again passed up the inner tube.

This recirculation may be continuous throughout a given phase of treatment of the grain, or may be interrupted.

It may be necessary to alter the moisture content after steeping, and this may be done by adding water or spraying from a suitably disposed device, or by controlling the humidity of the gas used.

In this embodiment the grain is thus subjected to various influences which will dissipate local rises in temperature. First, the grain in the inner tube is being subjected to gas of a predetermined temperature served through the nozzle; secondly, the falling grain is subjected to the passage of the gas from the grilles in the upper and lower gas galleries, whereby gas is caused to pass constantly through the body of the grain; and thirdly, the constantly moving grains are continuously mingled. In addition, the agitator **82** may be employed further to mingle the grains. The first-mentioned of these is a facility not afforded by the first embodiment.

After the desired processing of the grain has been accomplished, the outlet aperture in the bottom of the chamber is opened and if and when required the agitator is employed to assist efficient emptying of the vessel through the outlet aperture.

The agitator **82** may be a rake with upstanding teeth, or it may be of blade form.

The provision in these embodiments of the various facilities described enables malting to be accomplished by any method known to me and with a greater degree of control than heretofore. The whole of the malting, or only one or more parts of the whole process may be performed in the vessel. Owing to these being carried out in a closed chamber, any desired microclimate may be established and maintained as regards temperature, and humidity and environment of gas and air surrounding the grain. The instrumentation may be elaborated by the provision of sensing means located in any desired places in the apparatus, whereby temperature gradients may be sensed and corrected, e.g. by alteration of the air temperatures at the galleries, legs or in the nozzle, before they assume proportions of any magnitude.

The movement of the grain achieved by the lifting, effectively prevents matting of any rootlets.

Apparatus embodying the invention can have a high-capacity size ratio in comparison with other malting apparatus, and is therefore susceptible to economic production of malt.

I claim:

1. A malting apparatus which includes a vessel adapted to receive grain for malting and containing an inner vertical tube having ends spaced from the top and bottom of the vessel, elevating means adapted to elevate grain inside the inner tube from the bottom of the vessel towards the top, gas inlet means adapted to pass gas into the vessel at least adjacent the bottom of the vessel, and gas outlet means adapted to pass gas from the vessel at the top of the vessel, whereby a countercurrent of gas passing from gas inlet to gas outlet may be set up inside the vessel against grain elevated by the elevating means and falling outside the tube from the top of the tube to adjacent the bottom of the vessel.

2. A malting apparatus according to claim **1** wherein the elevating means is a nozzle directed to discharge gas up the inner tube and served by a high-pressure gas inlet.

3. A malting apparatus according to claim **2** wherein means are provided for conditioning the gas discharged from the nozzle.

4. A malting apparatus according to claim **1** wherein the elevating means is a feed screw, working in the inner tube and means are provided for driving the screw in rotation.

5. A malting apparatus according to claim **4** wherein the bottom end of the screw sweeps a horizontal, planar baseplate of the vessel, an openable outlet for grain is provided at the bottom of the vessel radially outside of the horizontal, planar baseplate, and the drive means for the screw are reversible whereby on reversal of the drive means and opening of the outlet, the bottom end of the screw aids discharge of grain from the outlet by pushing it from the baseplate radially towards and out of the outlet.

6. A malting apparatus according to claim **5** wherein the said baseplate is perforated.

7. A malting apparatus according to claim **4** wherein, adjacent and above the top of the screw, there is provided a plurality of paddles rotatable with the screw.

8. A malting apparatus according to claim **1** wherein said inner tube is stationary.

9. A malting apparatus according to claim **1** wherein the said gas inlet means is a gallery peripherally around the vessel and having a gas-passing surface flush with an inner peripheral wall of the vessel.

10. A malting apparatus according to claim **9** wherein the said wall has a cylindrical portion and a frustoconical base portion and the said gallery is provided in the said cylindrical portion, closely adjacent the frustoconical base portion, and a second said gallery is provided, spaced from and above the first.

11. A malting vessel according to claim **1** wherein additional to the said gas inlet means, at least one further gas inlet means is provided, at at least one level between the first said inlet and the said gas outlet.

12. A malting apparatus which includes a vessel containing an inner vertical tube having ends spaced from the top and bottom of the vessel, a feed screw acting to move grain upwardly inside the inner tube, means for driving the feed screw in rotation and means for passing gas into the vessel at least outside the inner tube, the screw being formed around a central shaft which has a conical skirt at its base portion, the base portion of the screw being formed around the conical skirt and fitting within a corresponding conical flared portion of the inner tube.

13. A malting apparatus according to claim **12** wherein the screw terminates at its base in a shovel part, protruding below the conical flared portion of the tube and of a size to sweep, during one revolution, the gap between the base of the flared portion of the tube and the bottom of the vessel.

14. A malting apparatus according to claim **12** wherein the pitch of the base portion of the screw is progressively inversely proportional to the square of the diameter of the conical skirt.

15. A malting apparatus according to claim **12** wherein the central shaft is hollow and has gas-passing apertures.

16. A malting apparatus which includes a vessel containing an inner vertical tube having ends spaced from the top and bottom of the vessel, elevating means comprising a feed screw working in the inner tube to cause a lifting vertical movement of grain in the inner tube, the grain being free to fall outside the inner tube but inside the vessel, variable speed motor means to drive said screw means, and control means to alter the speed of the motor in accordance with temperature conditions sensed in the vessel.