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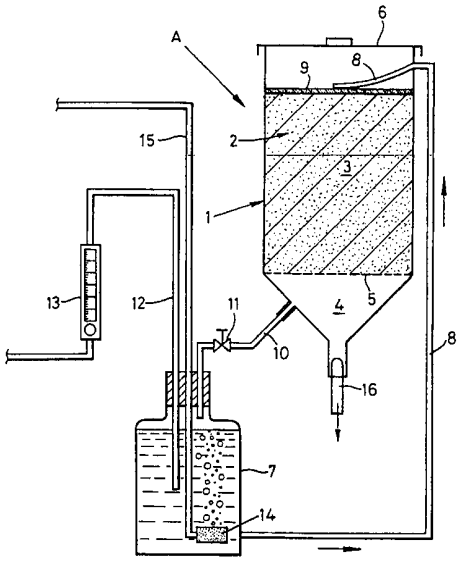

SCHEMATIC OF THE GERMINOX SEED AND MALTING TRIAL RIG FOR THE GERMINATION PHASE

(57) Abstract: A method of treating seed or cereal, comprising a germination phase wherein oxygenated water is caused to sift or percolate through a bed of the seed or cereal.

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IMPROVED GERMINATION METHOD OF SEED OR CEREAL

The present invention relates to the method of treating seed or cereals to accelerate natural germination.

EP-A-0030575 discloses a method of processing seed wherein after a bed of seed or cereal has been steeped in oxygenated water during which the temperature of the bed is controlled, the seeds or cereal are pregerminated in the non-steeped condition in a gaseous atmosphere of oxygenated air. More especially the oxygenated air contains not less than 33% of oxygen by volume, but preferably substantially pure oxygen is utilised for the gaseous atmosphere.

The above process of EP-A-0030575 serves to accelerate the natural germination of seed prior to planting or sowing in agricultural or horticultural processes and is also beneficial for the bulk treatment of cereals such as barley, and in particular by this process large quantities of such cereals can be brought to a state for natural germination and sprouting for the purpose of producing malted barley.

However, larger quantities of oxygen than expected have been found necessary to produce the inventive requirements for germination, pregermination and/or malting of seeds and the cost of providing the necessary oxygen gas atmosphere has been such as to prejudice the economic viability of the process for large scale adoption in seed/cereal treatments, except for low bulk, high value seeds such as flower seeds, ornamental plant seeds etc.

The process heretofore however, can be operated successfully, albeit with economic reservation, but only by injecting oxygen into the germination atmosphere of the seeds or cereal.

More especially it has been discovered that because of the closed circuit recycling of substantially pure oxygen gas through the bed of the seeds or cereals in a short time due to the respiration effects of the seed or cereal, oxygen gas is taken in and converted to carbon dioxide which enters the oxygen gas stream as a contaminant so that the percentage of volume occupied by oxygen gas is progressively reduced.

It has been further discovered that amounts of carbon dioxide gas in the circulating gas of 3% or over has the effect of drastically inhibiting the germination process and in severe cases actually stopping the germination process.

In order to maintain the carbon dioxide content of the oxygen circulating gas below 3% as was found to be necessary, 33.3 times the volume of oxygen to that of the carbon dioxide volume has to be added to the circulating gas to maintain the oxygen level at 97% and above of the total gas being circulated.

Consequently germinating cereal requires the uptake by wetted respiration of some 2% of its initial dry weight to complete its germination to a satisfactory stage in any such process then some 66 tonnes of oxygen will be required per 100 tonnes of seed to complete the germination of this quantity of seed.

It is the principal object of the present invention to provide an improvement in the seed treatment process which overcomes the above drawback.

In accordance with one aspect of the present invention in a method of treating seed or cereal, there is provided a germination phase wherein oxygenated water is caused to sift or percolate through a bed of the seed or cereal. Preferably the seed/cereal bed is contained in a vessel located in a closed loop with a container constituting a reservoir for cold water, with means, for example an aerator, being provided to oxygenate water in said container whereby treatment fluid in the form of oxygenated water is supplied to said vessel from the container and returned to the container. The vessel preferably includes a distribution means at the upper end of the seed bed whereby a substantially uniform spread of oxygenated water can pass to the bed via said distribution means. The lower end of the vessel can include a perforated support for the bed with a sump part below said support for percolated water and treatment water can be returned to the container by a return conduit portion of said closed loop extending between said sump part and the water container. Said return conduit portion of the closed loop may include a closable valve to facilitate an initial steeping phase of the bed. Further, the container can include a feed inlet for water replenishment.

By the above invention method, a low flow of cold oxygenated water percolating through the seed/cereal bed can remove carbon dioxide gas present in the bed and additionally can maintain the bed cool by removing heat generated by grain respiration. The water flow provides

sufficient oxygen to permit the germination process to continue until the required stage of germination is reached for the intended use to which the germinated seed is to be put.

According to a second aspect of the present invention apparatus for carrying out said method of the first inventive aspect comprises a vessel adapted to contain a bed of seed or cereal, a source of oxygenated water, supply conduit means for passing oxygenated water from said source to the vessel for delivery to and passing through said bed, and distribution means in the vessel for receiving oxygenated water from said supply conduit means and serving to deliver a substantially uniform spread of oxygenated water over the cross-section of the bed.

The source of oxygenated water may comprise a water container constituting a reservoir for water, means for oxygenating the water in said reservoir including an oxygen feed and means for feeding water to the reservoir. Said water oxygenating means preferably comprises a porous ceramic aerator of suitable porosity to deliver the oxygen to the surrounding water in small enough bubbles to be readily absorbed into the water.

The oxygenated water from the vessel may be returned to the water container.

The vessel preferably includes a perforated support for the bed, and a part of the vessel can be located below said support. The vessel can include an openable portion to facilitate removal of the bed of grain or seed after treatment.

According to a third aspect of the present invention in a method of treating seed or cereal as disclosed in EP-A-0030575 wherein the seed or cereal is pregerminated in a gaseous atmosphere comprising oxygenated air and preferably pure oxygen there is included a further method step wherein the gaseous atmosphere is treated for the removal of a contaminant. By removing the contaminant, the otherwise reduction of oxygen presence in the gaseous atmosphere due to the contaminant presence is substantially avoided. Consequently the need for the uneconomic replenishing supply of oxygen to the germination treatment can be removed or substantially reduced. Therefore in a preferred embodiment, the additional method step serves for substantial removal of the carbon dioxide contaminant from the circulation of oxygen gas.

Preferably the oxygenated gaseous atmosphere is circulated to a reaction device for contact with an absorbing medium for removal of the contaminant. The gaseous atmosphere and the absorbing medium can be caused to have relative parallel flow or relative counterflow in the reaction device.

Preferably the reaction device comprises an enclosed packed tower incorporated in an oxygen gas circuit of the germination process.

The absorbing medium may comprise any one of (a) calcium oxide (lime) solution (b) a metallic carbonate solution, for example sodium carbonate or (c) essentially pure water.

Preferably the absorbing medium including absorbed contaminant is treated subsequent to the reaction with the oxygenated gas for removal of said contaminant and then when the contaminant removal stage is completed returned to the reaction device for further reaction with the oxygenated gas. Such treatment of the absorbing medium can be effected in a vessel to which additional fresh absorbing medium is applied, said vessel including a discharge for contaminant. However it is normally suitable to remove the contaminant during a period when the oxygenation process is not active by regenerating the absorbing medium to a contaminant free state at this time.

Embodiments of the present invention will now be described with reference to the accompanying drawings which show schematically in Figs 1 and 2 apparatus suitable for carrying out respectively the two aspects of the inventive process.

Referring to Fig 1, there is shown a pilot form of apparatus A for use in a germination phase of the treatment of seed or cereal, the apparatus A comprising a vessel 1 having an upper part 2 housing a bed 3 of seed or cereal, for example barley, and a lower sump 4. The part 2 includes a lower perforation plate 5 serving as a support for the bed 3, and the part 2 can be made of glass or enamel lined metal. A removable lid 6 is fitted to the top of the vessel 1 to facilitate supply of seed/cereal to the vessel 1 for the provision of the bed 3.

The vessel 1 is in closed loop with a container 7 serving as a reservoir for cold oxygenated water whereby

said cold oxygenated water can be supplied to the bed 3. To this end a supply conduit portion 8 of the loop delivers the cold oxygenated water from the container 7 to the top surface of a water distributor 9 at the upper end of the bed 3. The water distributor 9 which can be in the form of a porous device serves to provide a substantially uniform distribution of the oxygenated water over the cross section of the seed/grain bed so enabling a substantially uniform flow of cold oxygenated water to percolate through the bed 3 towards the plate 5.

A return conduit portion 10 of the loop returns the water from the sump 4 to the container 7, a closable valve 11 being present in the conduit portion 10. A feed inlet line 12 including a rotameter 3 delivers cold feed water to the container 7, and aeration of the water is achieved by an aerator 14 supplied with oxygen (preferably pure) from a suitable source (not shown) via an oxygen supply line 15. The sump 4 further includes a valve - controlled discharge 16 for effluent. The sump 4 can be swingable or releasable to facilitate removal of the seed bed 3 from the vessel at the end of the treatment process.

In the treatment process, as an initial step the seed/cereal bed 3 is steeped in water for a predetermined period, as is done in the process described in EP-A-0030575, and in this step the valve 11 will be closed. After the initial steeping step, a germination step is applied by passing cold oxygenated water from the container 7 to the distributor 9 via conduit portion 8, whence a substantially uniform spread of the cold water passes onto the bed's cross section at the top of the bed 3. The oxygenated water feed via conduit portion 8

should be such that a shallow layer of water is always present on the top surface of the distributor 9. The cold oxygenated water percolates or sifts downwardly through this cooled bed 3 towards the plate 5. The seed/cereal absorbs the oxygen (0_2) from the percolating water, and carbon dioxide ($C0_2$) is formed in the bed: this $C0_2$ gas is removed by being dissolved in the water flow. Additionally the cold water removes heat generated by grain respiration and so maintains the bed in a relatively cool condition. The oxygenated water flow is preferably such as to maintain 3% $C0_2$ in gaseous form at about 18°C. The germination phase may last up to 2 days. The $C0_2$ gas can be subsequently removed from the water. As a final step, before removal of the bed from the vessel, the bed will be dried e.g. by passing hot air there through.

The germination phase of the trial must last 60 hours (98 hours if Gibberelic Acid (GA) is used) to simulate the new Germinoz Malting Process that would be used on the industrial scale. Samples of grain will be taken at regular intervals during the germination phase of the trial.

The samples must be surface dried and then frozen. Previous trials have shown that the samples freeze satisfactorily if they are placed in freezer bags and then laid flat on the freezing elements in a standard freezer compartment.

In the inventive aspect illustrated via Fig 2, the apparatus to the right of the dashed line A-A is that disclosed in EP-A-0030575 for carrying out the germination process whereas the items to the left of the

line A-A represent the apparatus for providing the improvement achieved by the second aspect of the present invention.

Although in the presently described treatments pure oxygen is passed through a bed of seeds or cereal, it is possible to use oxygenated air. The treatment can be applied to (a) seeds or plants which are to be planted or sown and these can comprise for example, plant seeds, grass seeds or cereals, or (b) to cereals e.g. barley in the production of malted barley in the brewing of malt beverages.

The bed of seeds (or cereals) are steeped in water, and means are provided to dry the seeds after the oxygen treatment is completed. For the treatment (a) above it is suggested 0.02 lbs (0/009 Kg) of pure oxygen per hour be evenly applied to 100 lbs (45.36 Kg) of the plant seed or cereal, while for the treatment (b) 0.05 lbs (0.0227 Kg) of pure oxygen are applied to 100 lbs (45.36 Kg) of cereal per hour.

Fig 2 again shows a basic or pilot form of apparatus A indicating a suitable layout of equipment for the pregermination of barley for the treatment (b) above according to the second aspect of the present invention. The apparatus A again comprises a vessel 1 including an upper part 2 housing a bed 3 of barley, and a lower sump 4 for water. The part 2 includes a lower perforated plate 5 to support the bed 3, and this part 2 can be made of glass, or metal or enamel lined metal. A removable lid 6 is fitted to the top of the vessel 1 and the sump 4 is fitted to part 2 by securing means 7 whereby with the

perforated plate 5 removed the germinated barley bed 3 can be discharged from the vessel 1.

Pure oxygen from a suitable source such as oxygen cylinder is discharged in the vessel 1 below plate 5 by means of supply pipe 9. The cylinder includes means to control the oxygen flow, the oxygen being bubbled through water holder 10 by line 11 prior to supply to pipe 9. The oxygen passes through bed 3, and a recycling pipeline 12 having recirculatory fan 22 recycles the discharge gases to the base of the vessel 1 below plate 5. A treatment apparatus (to be described in detail later) generally indicated by reference T is included in the recycling pipeline 12. A vacuum is created in the vessel by suitable means, for example a vacuum pump (not shown). The pipeline 12 includes a sampling branch portion 14 for Oral and chromatographic sampling of gas. A recording thermocouple 15 for sensing the gas temperature is provided at branch 14. The line 9 (or other additional line) can serve for the supply of an inert gas to the vessel 1, e.g. CO_2 or nitrogen, in the place of oxygen at the stage of the process where pregermination of the barley has been completed and it is necessary to prevent further germination. The recycling pipeline 12 includes a cooler 21A.

Water from reservoir 16 is delivered to spray head 17 by conduit system 27 including pump 19, and is sprayed into the bed 3 for steeping of the barley and also to cool the bed.

Water descends to the sump 4 and overflow water is returned to reservoir 16 by pipeline 20: L1 and L2 indicate two possible controlled water levels in sump 4.

A foaming agent is supplied to the water in reservoir 25 so that there is created a foam layer below the bed 3 in vessel 1, and the return end of pipeline 21 includes a porous aerator head 33 which serves to create the foam layer.

It is normally essential that the barley of bed 3 be dried after pregermination is completed, preferably to contain not less than 8% by weight of moisture, and to this end a kilning system 21 is provided comprising a heat exchanger 22 having a heating coil 23 supplied with a heating medium such as steam, and an air supply line 24 delivering air to the heat exchanger 22 for heating, the line 24 including an air blower 25 and also an air conditioner 26 at its inlet end. A discharge line 27 provided with closure valve 28 delivers heated air to the sump 4. For drying of the barley, water is firstly drained from the sump 4 and the valve 28 then opened to permit heated air to enter the sump 4 and permeate inwardly through the bed 3: the air can be discharged from vessel 1 via a cover bore which is closable by plug 29. The bed temperature is normally maintained steady by circulating oxygen through or over the bed. The temperature is then elevated in an atmosphere of oxygen which is circulated and temperature-controlled to place the barley in a condition ready, when required for rapid malting.

If, however, the apparatus for carrying out the process is integrated, for example, with a brewery, it is not necessary to dry the barley. In this case, water is drained from the sump 4 and oxygen is admitted to the vessel 1 through the supply pipe 18 to pass through the

bed of barley and to permeate the barley until the barley is in a condition ready for malting.

A thermometer 30 measures the bed temperature and a scale 31 can be provided to check the bed depth: pipelines 18, 20 include closure valves 32.

Referring now to the treatment apparatus T, this apparatus T comprises an enclosed packed tower 69 housing a fill or packing 70 located on a perforated packing support grid 71, the supply portion (12B) of the recycling line 12 feeding into the tower 69 below the packing via untreated gas inlet 72 while the treated gas is discharged from above the packing 70 through treated gas outlet 73 into the return portion 12C of the recycling line 12. Absorbing solution is withdrawn from a holding tank 79 and pumped by pump 77 in a circulation pipe 75 to the top of the tower 69 whence the solution is fed into a perforated liquid distribution member 74. The member 74 creates uniform downward sprays (droplets) 82 of absorbing solution over the cross-section of the tower 69 and into the packing 70 for contact with the upward flow of gas fed in via pipe portion 12B, the solution in droplet form 83 passing from the bottom of the packing 70 into a reservoir at the bottom of the tower 69 constituting a liquid seal 76. The solution is returned to the holding tank 79 from the reservoir by a return line 78. Fresh absorbing solution is fed into the tank 79 via a pipe 80 for make-up of the solution in the tank, while spent absorbing solution is withdrawn from the tank 79 by a bottom discharge pipe 81.

The function of the apparatus T is to remove contaminant from the oxygenated gas recycled via line 12.

In particular, this contaminant is constituted by carbon dioxide in the recycled gas. More especially this carbon dioxide is formed by the respiration effects of the seed or cereal, during the closed circuit recycling of substantially pure oxygen gas through the bed of seed or cereal whereby the oxygen gas is taken in by the seed/cereal and converted into carbon dioxide which enters the oxygen gas stream as a contaminant. As a consequence the percentage volume occupied by the oxygen in the gas is reduced, and as explained previously this has a very deleterious affect on the germination process. However, the absorbing solution droplets 82 in the tower 69 have the function of absorbing carbon dioxide from the upflowing gas contacted by the droplets in the packing 70, so that substantially pure oxygen can be returned to the vessel 1 via return pipe portion 12C. The packing 70 is designed to maximise the liquid/gas contact and thereby increase the efficiency of carbon dioxide absorption. A suitable absorbing solution will be chosen to give effective results and suitable solutions can be calcium oxide (lime) solution or a metallic carbonate solution such as for example sodium carbonate although essentially pure water could also be used. The flow rate of the absorbing solution droplets through the packing 70 will of course be chosen to give optimum results.

By way of example the vessel 1 could contain a bed of between 10 to 100 tonnes.

By the above treatment, the barley can be malted in approximately 48 hours (including 12 hour steeping), and this compares with seven days presently required for malting. Additionally there is improved germination

efficiency and less loss of malting products than previously.

In the germination treatment process it has been found necessary to begin the seed drying process some hours before the seed has actually reached its optimum stage of germination. This is because under the effect of the oxygen gas the germination and seed respiration process naturally continues until the substrate moisture within the seed is reduced to the point at which germination ceases. The use of oxygen gas as the drying agent operates by alternately absorbing moisture from the seed and then losing moisture by condensation in a gas heat chiller heat exchanger. Drying in oxygen prolongs the respiration process centred at the seed embryo. This ensures that the exothermicity of respiration thus engendered increases the rate at which the water is transferred and evaporated from the living embryo. It will be noted that this effect allows higher oxygen circulation temperatures to be employed because the embryo and the seed is cooled by evaporation cooling. When large bulks of seeds are being processed it is clear that the drying process is an extremely critical one. Drying large bulk batches requires close control and monitoring to achieve the desired success.

Possible modifications in the process are set out below:

1. Using the process it would be possible to take any batch size of seeds to the desired termination optimum end point.

Thereafter the oxygen supply could be stopped. The germination vessel and circuit could then be purged with nitrogen gas. The nitrogen atmosphere could then be maintained while the drying process proceeds at a high psychometric temperature range. This will then deliver dried seed in the shortest possible time interval necessary to reach the desired final moisture content of the seed. This level should be 2% below the normal regain moisture content. It is expected that the change from a complete aerobic (O_2) atmosphere to a completely inert and anaerobic (N_2) atmosphere will be sufficient to suppress the normal enzymatic activity required for germination and respiration. In addition it is expected that the actions of both aerobic and anaerobic bacteria will also be suppressed.

The process of drying would be used for bulk seed treatments e.g. cereals or for malting.

2. Where the process is to be used to treat expensive seed types (of, say 5000/tonne and above) then the following system may be adopted.

These cases would be where seed is being sown immediately or within a few days, or 1 to 2 weeks or treatment.

The seed at the optimum end point of the process would be extracted from the treatment plant in a continuous stream. It would then be passed through a specifically designed liquid nitrogen (cryogenic) freezing system and held at the appropriate vaporising temperature until required for sowing. The seeds would then be allowed to partially defrost during the sowing

process. It is expected that seeds sown by conventional Stanhay type belt seeder, hopper fed seeders or possibly by the Supersonic seeder described in the present applicant's International publication WO93/13641 would thaw in the soil and grow almost immediately and with a vigour characteristic of seed treated by the process.

3. Where seed is in bulk and required to be transported and stored elsewhere it is proposed to dry the seed at the end of the process using an adapted cryogenic, inert gas accelerated freeze drying process. In this process the sublimation of ice crystals to vapour at the critical point is assisted and controlled by a microwave powered sublimator apparatus. The quantity controlled throughout could be balanced by a positive feed back controller to give the desired final moisture content. Recirculation of seed may be necessary. It should be possible to heat the seed solid substrate in preference to the ice crystals and any surface water that may be present. This is because of the microwave effect on the higher density seed material.

Modifications are of course possible. Thus instead of the tower 69 the seed bed in the vessel itself could be adapted to serve as a scrubber device with the seed constituting filler packing. In particular, a quantity of water or other absorption medium can be fed through the bed so that it flows over the surface of the seed or cereal of the bed in a film and absorbs the carbon dioxide gas present. This water (or other medium) will of course require to be extracted from the germination vessel 1 for treatment to remove the absorbed carbon dioxide, for example similar per the holding tank 79, and thereafter returned for further absorption of carbon

dioxide in the seed/cereal bed. The oxygen gas could be arranged to flow in the opposite direction in vessel 1.

CLAIMS

1. A method of treating seed or cereal, comprising a germination phase wherein oxygenated water is caused to sift or percolate through a bed of the seed or cereal.

2. A method of treating seed or cereal according to claim 1, comprising the steps of placing the seed/cereal bed in a vessel located in a closed loop with a container constituting a reservoir for cold water, providing oxygenated water in said container whereby treatment fluid in the form of oxygenated water is supplied to said vessel from the container and returned to the container.

3. A method of treating seed or cereal according to claim 2, wherein the water is oxygenated by an aerator.

4. A method of treating seed or cereal according to claim 2 or 3, wherein the vessel includes a distribution means at the upper end of the seed bed whereby a substantially uniform spread of oxygenated water passes to the bed via said distribution means.

5. A method of treating seed or cereal according to any one of claims 1 to 4, wherein the lower end of the vessel includes a perforated support for the bed with a sump part below said support for percolated water and treatment water is returned to the container by a return conduit portion of said closed loop extending between said sump part and the water container.

6. A method of treating seed or cereal according to claim 5, wherein an initial steeping phrase of the bed is

facilitated via said return conduit portion of the closed loop which includes a closable valve.

7. A method of treating seed or cereal according to any one of claims 2 to 6, wherein water in the container is replenished via a feed inlet.

8. Apparatus for carrying out the method of claims 1 to 7 comprising a vessel adapted to contain a bed of seed or cereal, a source of oxygenated water, supply conduit means for passing oxygenated water from said source to the vessel for delivery to and passing through said bed, and distribution means in the vessel for receiving oxygenated water from said supply conduit means and serving to deliver a substantially uniform spread of oxygenated water over the cross-section of the bed.

9. Apparatus according to claim 8, wherein the source of oxygenated water comprises a water container constituting a reservoir for water, means for oxygenating the water in said reservoir including an oxygen feed and means for feeding water to the reservoir.

10. Apparatus according to claim 9, wherein said water oxygenating means comprises a porous ceramic aerator of suitable porosity to deliver the oxygen to the surrounding water in small enough bubbles to be readily absorbed into the water.

11. Apparatus according to any one of claims 8 to 10, wherein the vessel includes a perforated support for the bed wherein a part of the vessel can be located below said support.

12. Apparatus according to any one of claims 8 to 11, wherein the vessel includes an openable portion to facilitate removal of the bed of grain or seed after treatment.

13. A method of treating seed or cereal wherein the seed or cereal is pregerminated in a gaseous atmosphere comprising oxygenated air and pure oxygen wherein there is included a further method step wherein the gaseous atmosphere is treated for the removal of a contaminant.

14. A method according to claim 13, wherein carbon dioxide contaminant is removed from the circulation of an oxygenated gaseous atmosphere.

15. A method according to claim 14, wherein the oxygenated gaseous atmosphere is circulated to a reaction device for contact with an absorbing medium for removal of the contaminant.

16. A method according to claim 15, wherein the gaseous atmosphere and the absorbing medium are caused to have relative parallel flow or relative counterflow in the reaction device.

17. A method according to claim 15 or 16, wherein the reaction device comprises an enclosed packed tower incorporated in an oxygen gas circuit of the germination process.

18. A method according to any one of claims 15 to 17, wherein the absorbing medium comprises any one of (a) calcium oxide (lime) solution (b) a metallic carbonate

solution (c) sodium carbonate or (d) essentially pure water.

19. A method according to any one of claims 15 to 18, wherein the absorbing medium including absorbed contaminant is treated subsequent to the reaction with the oxygenated gas for removal of said contaminant and then when the contaminant removal stage is completed returned to the reaction device for further reaction with the oxygenated gas.

20. A method according to claim 19, wherein such treatment of the absorbing medium is effected in a vessel to which additional fresh absorbing medium is applied, said vessel including a discharge for contaminant.

21. An apparatus for treating used seed or cereal substantially as hereinbefore described with reference to and as shown in the accompanying figures.

22. A method of treating seed or cereal substantially as hereinbefore described.

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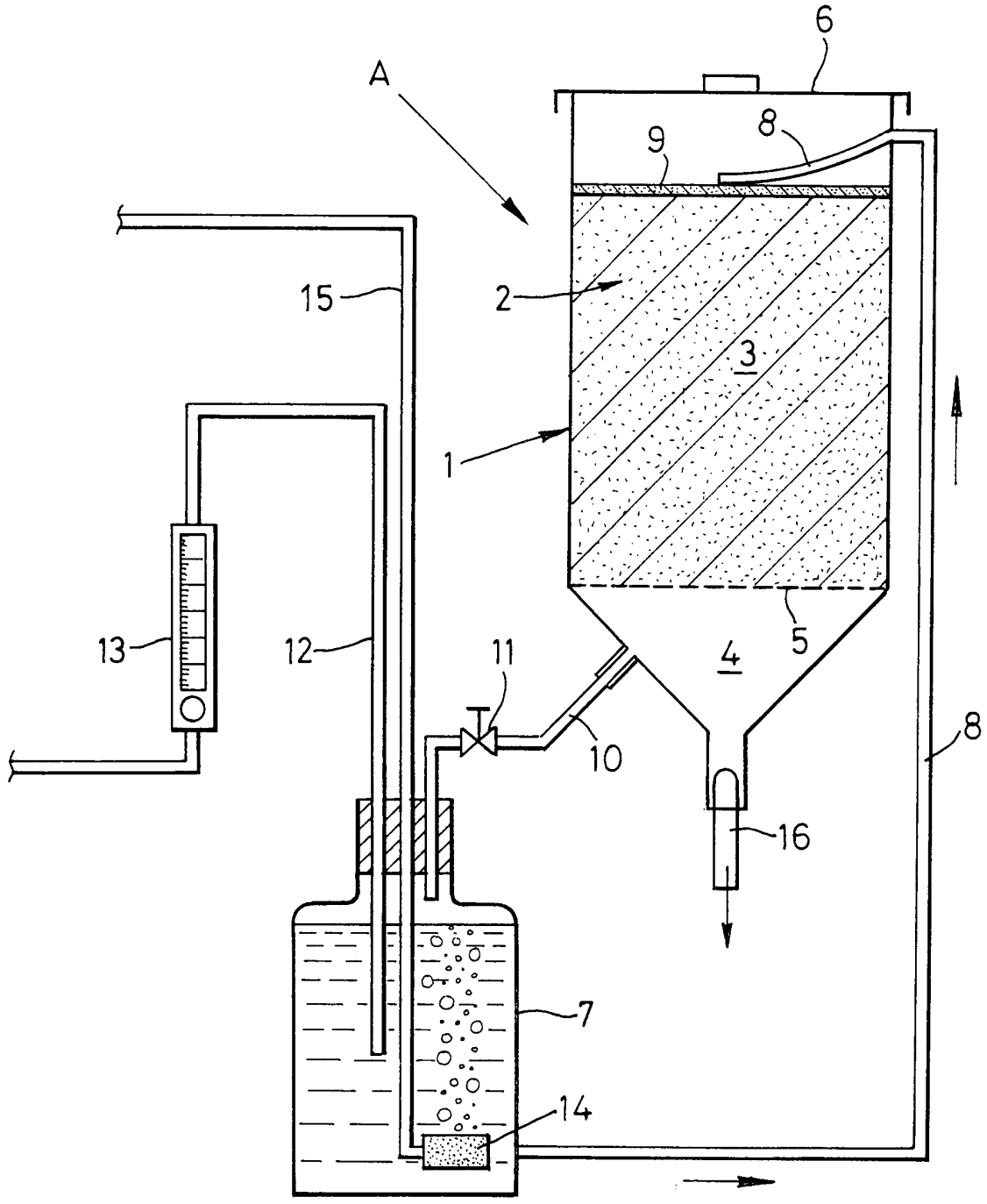

SCHEMATIC OF THE GERMINOX SEED AND MALTING TRIAL RIG FOR THE GERMINATION PHASE

Fig.1

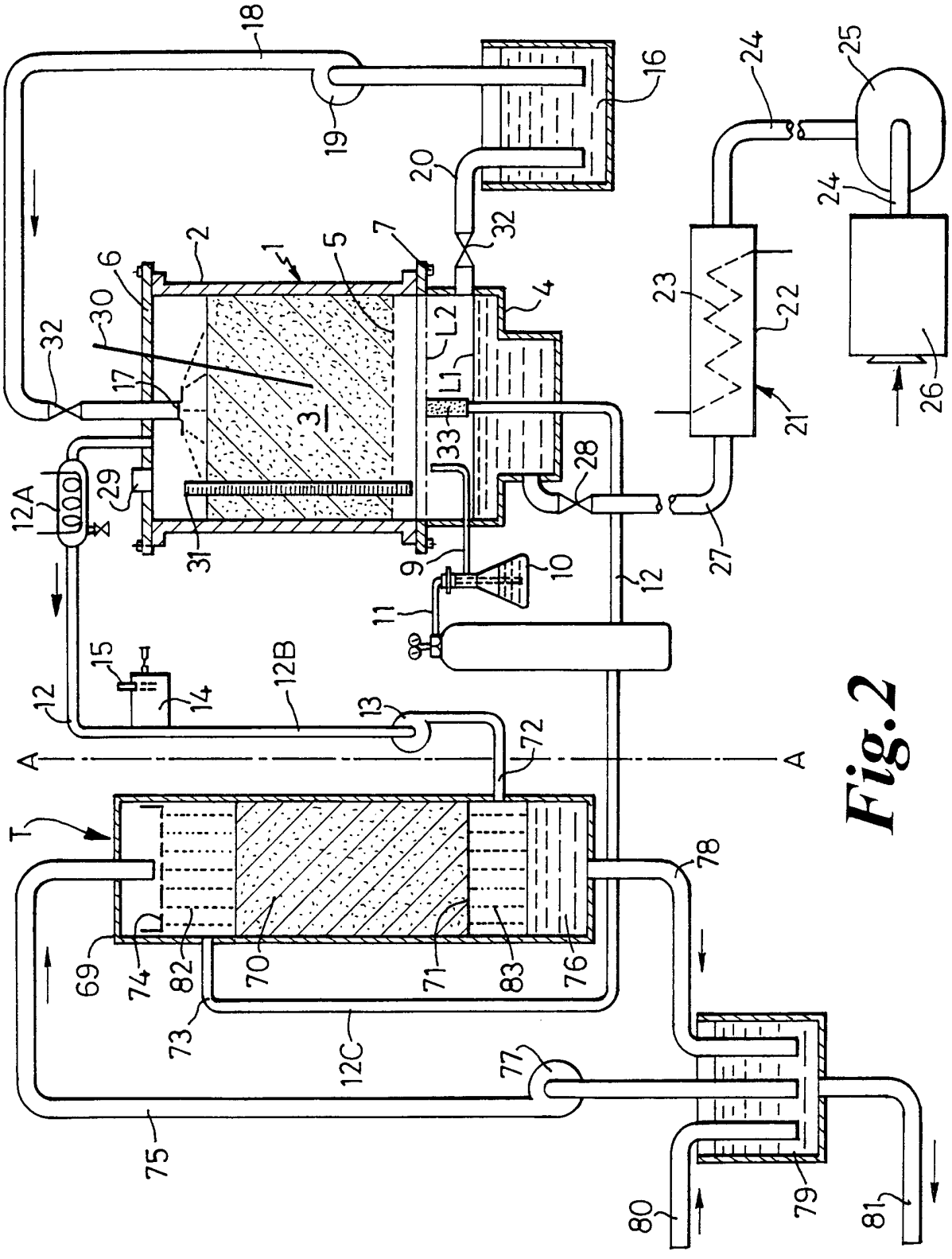
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Fig. 2