United States Patent

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[54] CONTINUOUS MICROWAVE GRAIN COOKER

3 Claims, 6 Drawing Figs.

[52] U.S. Cl. .... 99/237 R, 219/10.55
[51] Int. Cl. A23l 1/10
[50] Field of Search .... 99/237, 327, 355, 358, 446; 126/390; 219/10.55; 250/108; 333/22; 198/220 BA

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ABSTRACT: Apparatus for continuously cooking grain by means of microwaves in which the grain is fed continuously through a glass cylinder which extends through a microwave cavity. Water load jackets at the bottom and top of the cavity prevent undue leakage of microwave power at the input and output ports to maintain a safe level of leakage of microwaves.

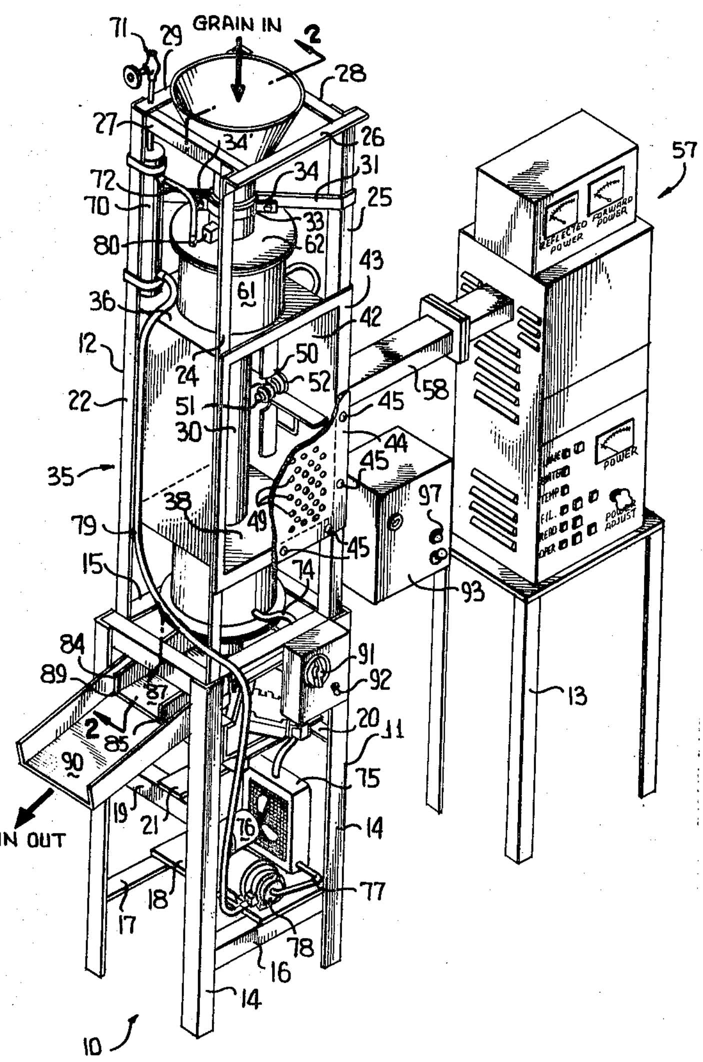

FIG. 1

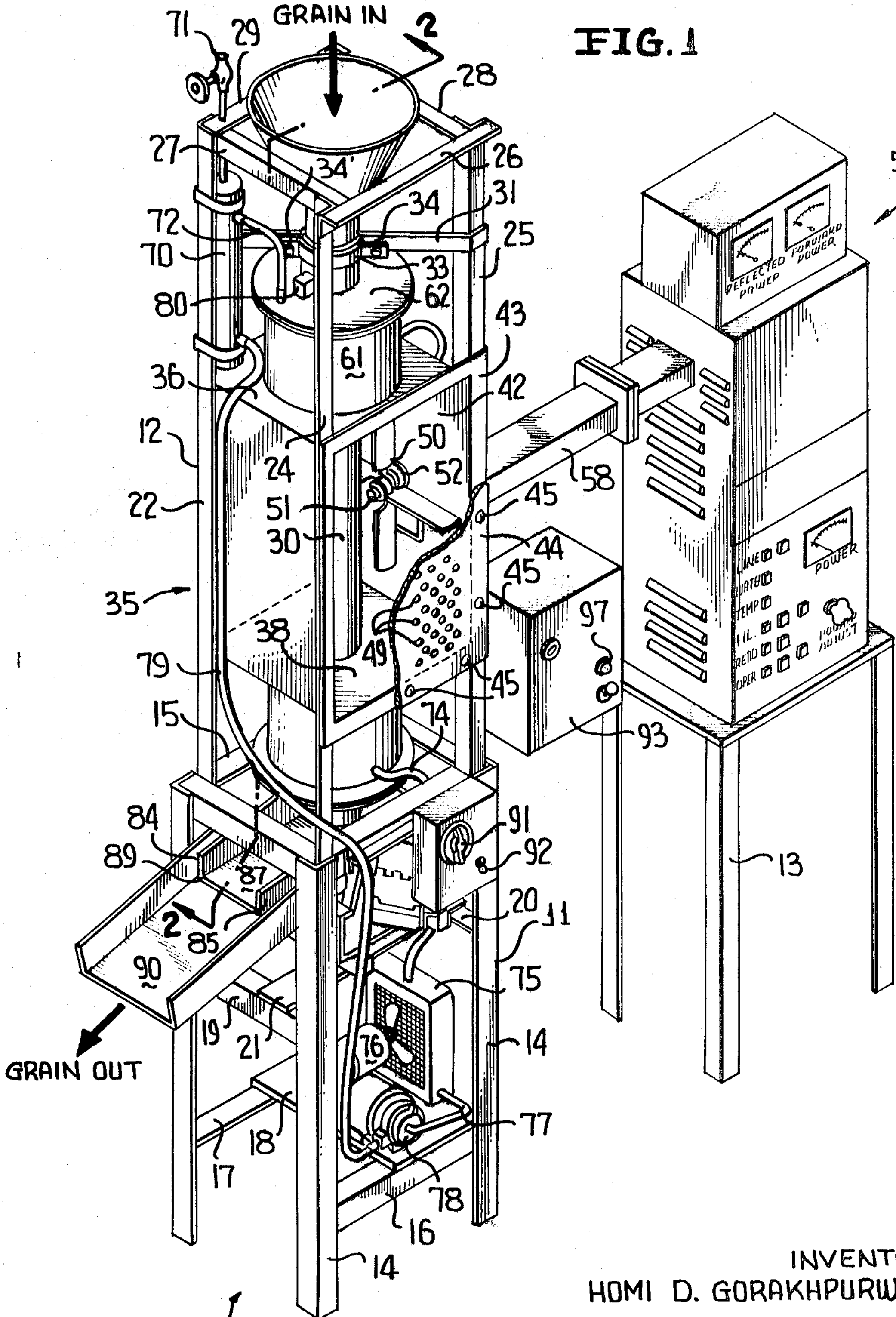

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FIG.2

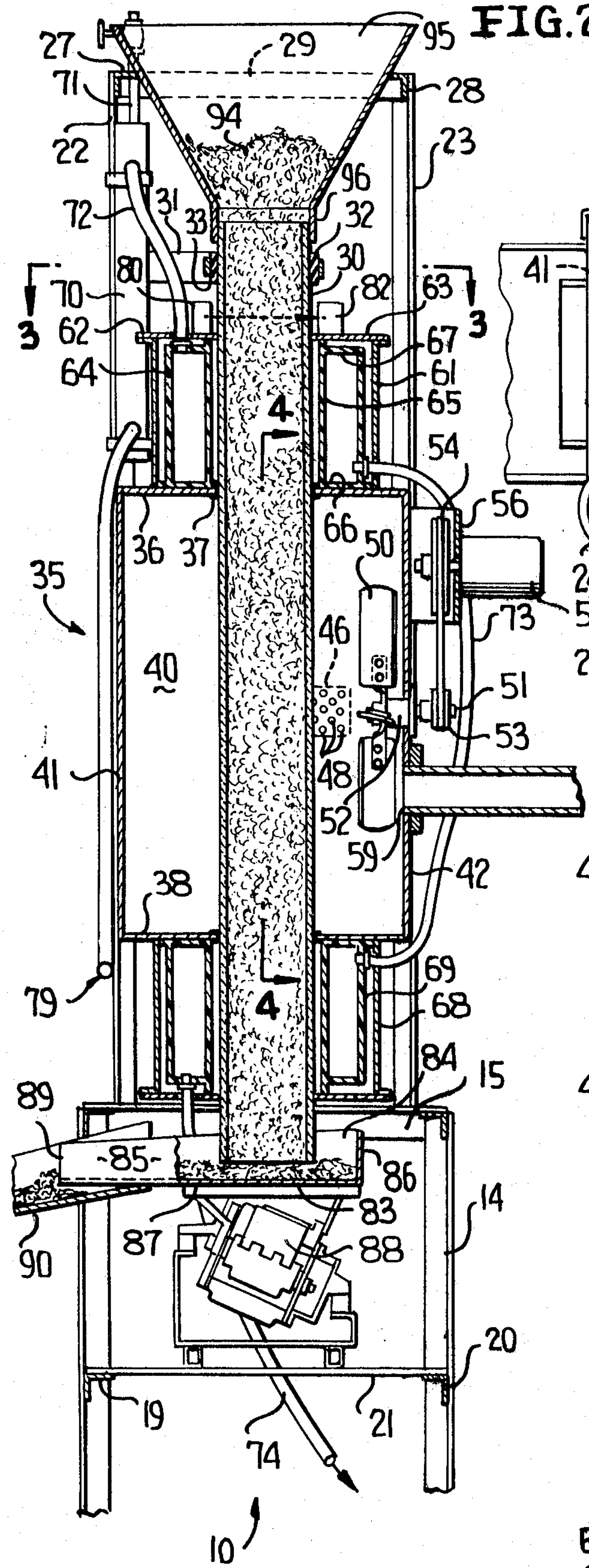


FIG.3

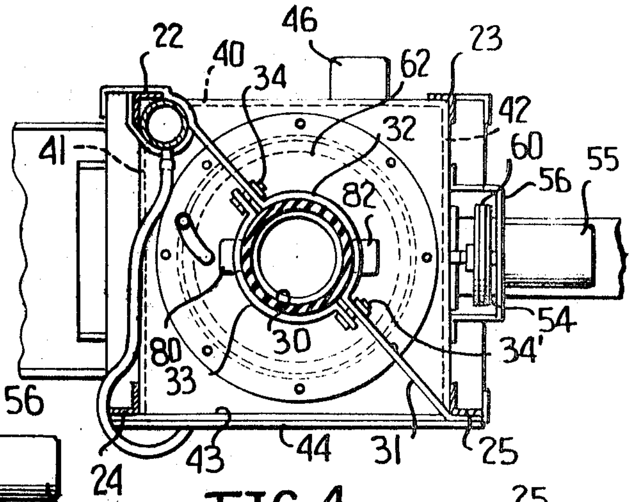
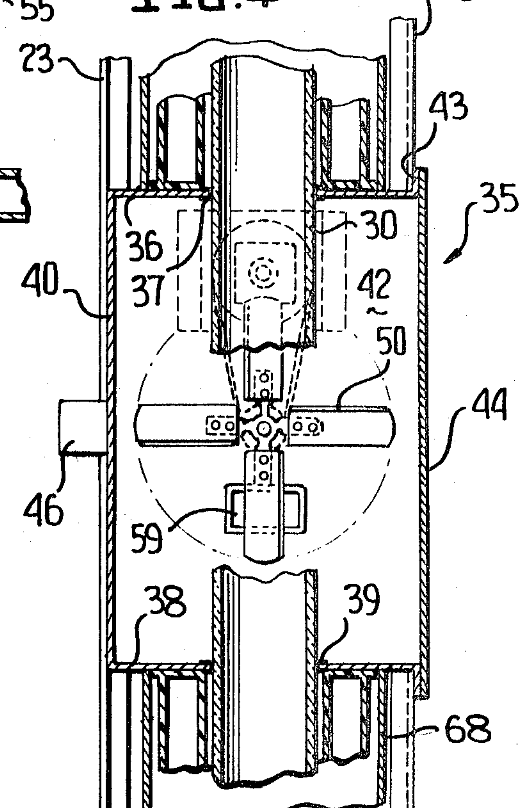


FIG.4



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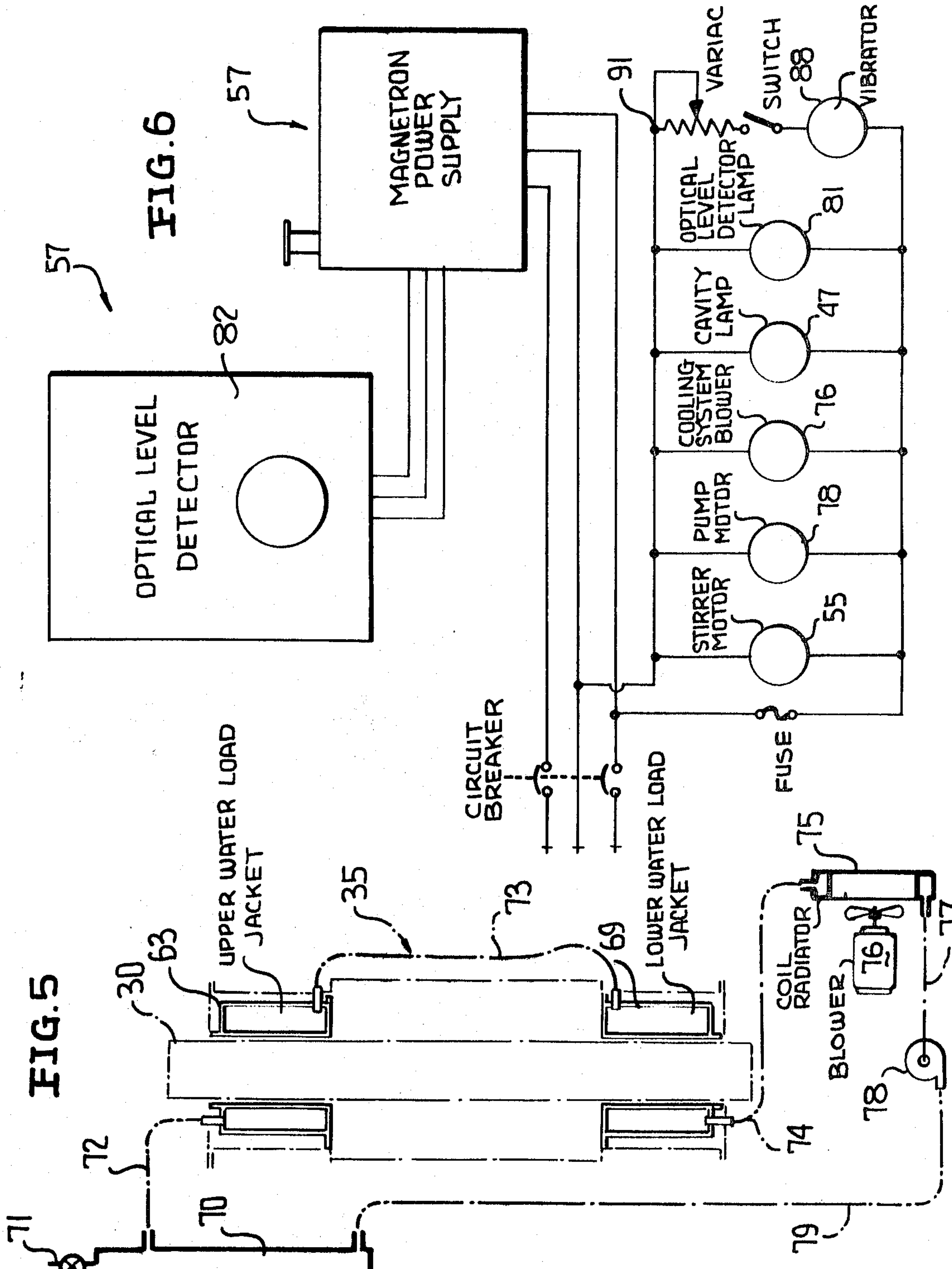

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CONTINUOUS MICROWAVE GRAIN COOKER

BACKGROUND OF THE INVENTION

Field of the Invention—The present invention relates to the cooking of grain at temperatures sufficient to produce gelatinization, disruption of starches, and sufficient softening of the kernels to permit the grain to be subsequently rolled into a cohesive, highly nutritional flake.

SUMMARY OF THE INVENTION

The present invention includes a gain hopper to receive and dispense the grain to a Pyrex glass tube through which the grain is gravity moved. The glass tube is enveloped at the top and bottom by a water load jacket and is surrounded by a microwave chamber intermediate of the water load jackets. The tube is subjected to microwave energy received from a microwave generator and the grain within the tube has its temperature raised to from 130° to 180° F. in order to produce a gelatinization and disruption of starches along with softening of the kernels of the grain. In subsequent steps the cooked grain is rolled into a cohesive, highly nutritional flake.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the invention shown partially broken away and in section for convenience of illustration;

FIG. 2 is an enlarged fragmentary vertical sectional view taken on the line 2—2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a fragmentary horizontal sectional view taken along the line 3—3 of FIG. 2, looking in the direction of the arrows;

FIG. 4 is a fragmentary vertical sectional view taken along the line 4—4 of FIG. 2, looking in the direction of the arrows with parts broken away for convenience of illustration;

FIG. 5 is a coolant flow diagram; and

FIG. 6 is a wiring diagram illustrating one form that the circuit may take.

Referring now to drawings in detail wherein like reference characters indicate like parts throughout the several Figures, the reference numeral **10** indicates generally a continuous grain cooker constructed in accordance with the invention. The cooker **10** includes a generally rectangular upstanding base **11** having a frame **12** supported thereon and extending upwardly therefrom. A control base **13** is positioned adjacent the base **11**. The base **11** includes four upstanding angle iron legs **14** connected at their upper ends by a rectangular angle iron frame **15**. A horizontal strut **16** connects an adjacent pair of the legs **14** near the lower ends thereof and a second horizontal strut **17** connects the opposite pair of the legs **14** adjacent their lower ends with the struts **16, 17** arranged in the same horizontal plane in spaced parallel condition. A platform **18** is secured to and rests on the struts **16, 17**.

A strut **19** is spaced above the struts **16, 17** and extends perpendicularly thereto and is mounted on an adjacent pair of the legs **14**. A strut **20** is mounted on a pair of the legs **14** opposite the strut **19** and lies in the same horizontal plane therewith. A platform **21** extends between and is supported on the struts **19, 20**. An angle iron post **22** is supported on and secured to the frame **15** at its lower end and extends perpendicularly upwardly from the frame **15**. A second post **23** is arranged in spaced parallel relation to the post **22** and is also mounted on the frame **15**. A third angle iron post **24** is secured to the frame **15** in spaced parallel relation to the post **22** and diagonally oppositely of the post **23**. A fourth angle iron post **25** is secured to the frame **15** is spaced parallel relation to the post **24** and the post **23** and diagonally oppositely of the post **22** with the post **22, 23, 24** and **25** forming a generally rectangular open framework. An angle iron bar **26** connects the upper ends of the posts **24, 25** while a bar **27** connects the upper ends of the posts **22, 24**. A bar **28** connects the upper ends of the posts **23, 25** and a bar **29** connects the upper ends of the posts **22, 23**. The bars **26, 27, 28** and **29** lie in the same generally horizontal plane at the very top of the frame **12**.

A cylindrical glass tube **30** is positioned centrally of the posts **22, 23, 24, 25** and extends parallel thereto. The glass tube **30** should have a wall thickness of about one-quarter inch and be formed of a high temperature use glass such as "Pyrex" or the like. The tube **30** is supported at its upper end by a clamp bracket **31** secured at one end to the post **25** and the opposite end to the post **22**. The bracket **31** extends horizontally and has a semicircular jaw **32** formed intermediate the opposite ends thereof for engagement with the tube **30**. A second semicircular jaw **33** is adjustably and removably secured to the bracket **31** in opposed relation to the jaw **32** by a pair of bolts **34**, as can be clearly seen in FIG. 3.

The tube **30** extends from a point slightly below the frame **15** to a point spaced from but below the bars **26, 27, 28** and **29**.

A microwave cavity generally indicated at **35** is positioned within and secured to the posts **22, 23, 24** and **25** surrounding the tube **30** in the intermediate portion thereof. The microwave cavity **35** includes a generally rectangular top wall **36** through which the tube **30** passes. A caterpillar grommet **37** seals the top wall to the tube **30**. A generally rectangular bottom wall **38** is arranged in parallel relation to the top wall **36** and is spaced therebelow. The tube **30** passes through the bottom wall **38** and a caterpillar grommet **39** seals the tube **30** to the bottom wall **38**. A generally rectangular rear wall **40** integrally connects the top wall **36** to the bottom wall **38** and is secured to the poses **22, 23** along the side edges thereof. A generally rectangular sidewall **41** is integrally joined to the backwall **40** and the top and bottom walls **36, 38**, respectively, extending between and secured to the posts **22, 24**. A sidewall **42** is integrally secured to the rear wall **40** and to the top and bottom walls **36, 38**, respectively, and is secured to the posts **23, 25**. The top and bottom walls **36, 38** and the sidewalls **41, 42** are provided at their front edges with a peripheral flange **43**, as can be clearly seen in FIG. 1. A generally rectangular front wall **44** is removably secured to the flange **43** by a plurality of removable fasteners **45**. The walls of the microwave cavity **35** are formed of stainless steel and have polished inner surfaces.

A lamp box **46** is secured to the rear wall **40** and contains a cavity lamp **47** shown in FIG. 6. The wall **40** has a plurality of perforations **48** communicating with the lamp box **46** to permit light therefrom to enter the microwave cavity **35**. The front wall **44** has a plurality of perforations **49** formed therein to permit the interior of the microwave cavity **35** to be visible to an observer. A four-bladed stirrer **50** is positioned within the microwave cavity and is mounted on a shaft **51** which extends through a bearing block **52** mounted in the sidewall **42**. A pulley **53** is mounted on the outer end of the shaft **51** and underlies a pulley **54** carried by a motor **55** which is mounted on a bracket **56** on the sidewall **42**. A microwave generator and control unit **57** is mounted on the control base **13** and has a generally rectangular wave guide tube **58** extending therefrom to the microwave cavity **35** and passes through the sidewall **42** in a generally rectangular opening **59**. The blades of the stirrer **50** are arranged to rotate past the opening **59** as can be seen in FIGS. 2 and 4. A belt **60** connects the pulleys **53, 54** to permit the motor **55** to rotate the stirrer **50**.

A cylindrical housing **61** is mounted on the top wall **36** and extends upwardly therefrom having a circular top wall **62** secured thereto. A generally cylindrical water load jacket **63** is positioned within the housing **61** and includes a cylindrical outer wall **64**, a cylindrical inner wall **65** concentric thereto and a circular bottom wall **66** along with a circular top wall **66** which respectively connect the top and bottom edges of the cylindrical walls **64, 65**. The outer wall **64** and the bottom and top walls **66, 67** are formed of a fiber glass impregnated plastic while the inner wall **65** is also formed of fiber glass impregnated plastic. The bottom and top walls **66, 67** are also impregnated with powdered aluminum.

A housing **68** identical to the housing **61** is secured to the bottom wall **38** of the microwave cavity **35** and has therein a water load jacket **69** identical to the water load jacket **63**. A water reservoir **70** is secured to the post **12** adjacent the upper end thereof and has a valved conduit 71 to provide for the release, when present, of air locked within the coolant (water) flow system. A tube 72 extends from the upper portion of the reservoir 70 through the top wall 62 of the housing 61 into the upper portion of the water load jacket 63. A tube 73 extends out of the lower portion of the water load jacket 63 into the upper portion of the water load jacket 69 and a tube 74 extends out of the lower portion of the water load jacket 69. A radiator coil 75 is mounted on the platform 18 and is connected to the tube 74. An electric cooling fan 76 is mounted on the platform 18 and is arranged to move air through the radiator 75 to cool the water therein. A tube 77 extends from the bottom of the radiator 75 to a water pump 78 which is in turn connected by a tube 79 to the lower portion of the reservoir 70.

An optical level detector lamp housing 80 is mounted on the top wall 62 of the housing 61 and contains an optical level detector lamp 81. An optical level detector 82 is also mounted on the top wall 62 in diametrically opposed relation to the housing 80 in a position so that rays from the lamp 81 will pass through the tube 30 prior to reaching the optical level detector 82.

A pan 83 is mounted under the open lower end of the tube 30 and has opposed sidewalls 84, 85 connected by a rear wall 86 and supporting a bottom wall 87. An electric vibrator 88 is mounted on the platform 21 and supports the pan 83 with the open front end 89 thereof overlying a delivery chute 90. Actuation of the vibrator 88 causes the pan 83 to vibrate and move grain therein out the open end 89 thereof into the delivery chute 90. The speed of the vibrator 88 can be varied by a Variac control 91 in order to control the flow of grain through the tube 30. An off-on switch 92 controls the flow of current to the vibrator 88. The magnetron power supply 57 has a plurality of indicators, gauges and controls for conventional operation.

A control unit 93 is attached to the post 25 and contains a control circuitry for the optical level detector 82.

In the use and operation of the invention grain which can be seen at 94 is placed in the hopper 95 of funnel-shaped design which is supported on the bars 26, 27, 28, 29 and has its lower end 96 engaging about the upper end of the tube 30. The grain feeds downwardly from the hopper 94 and intercepts the light from the lamp 81 to thus signal through the optical level detector 82 that grain is present in the upper end of the tube 30. The grain passes downwardly through the tube 30 and through the microwave cavity 35 and on into the pan 83. Vibration of the pan 83 will move the grain outwardly therefrom into the chute 90 for further processing. Microwaves from the microwave generator 57 enter the microwave cavity 35 through the opening 59 and the stirrer 50 moves the microwave patterns around in the microwave cavity 35 so that the temperature of the treated material is substantially uniform throughout the area of treatment. The grain 94 remains within the area of the microwave cavity 35 for a period of time sufficient to raise the bulk temperature of the grain to between 130° and 180° F. so as to gelatinize, disrupt the starches and soften the kernels to permit them to be rolled into a cohesive, highly nutritional flake. The period of time is determined by the type of grain and the condition of the grain being heated, but in any case is of relatively short duration.

When the grain 94 drops below the optical level detector 82, light from the lamp 81 reaches the optical level indicator 82 and simultaneously shuts off the microwave generator 57 and indicates the empty condition to the operator by lighting a control lamp 97 on the control unit 93.

The glass tube serves four important purposes in this machine. First, it acts as a containment vessel for grain dust preventing possible dust hazards; second, it makes possible a sealed cavity design that will not require a door opening for periodic dust accumulation cleanup, which eliminates shutdown time and the possible accidental exposure of the operator to microwave energy; third, the glass tube prevents accumulation of condensed water on the cavity walls, thus assuring a maintained low energy loss cavity wall design which reflects in high efficiency; fourth, the dielectric constant at the optimum thickness of the glass tube acts to a certain extent as an impedance matching transformer for more efficient transferring of the microwave energy into the grain.

Another important feature of the machine is the minimization of the microwave power leakage at the input and output ports of the microwave cavity 35 below accepted safe levels. The glass tube 30 at the output and input ports is enveloped by water loads of cylindrical structure. The microwave leakage at two ports is absorbed by the continuously circulated water in the two water loads as shown in cooling system diagram in FIG. 5. A major feature of these water loads is that all sides except that presented to the glass tube are formed of plastic impregnated with fiber glass and powdered aluminum while the inside wall next to the glass is of clear plastic impregnated with fiber glass only. When microwave energy leaves the cavity at either port, it is trapped by the outer aluminized plastic fiber glass shell and is then absorbed in the water. The microwave energy absorbed by the water heats the water which is then cooled by the cooling system.

Having thus described the preferred embodiment of the invention it should be understood that numerous structural modifications and adaptations may be resorted to without departing from the spirit of the invention.

I claim:

1. A continuous apparatus for cooking grain, by means of microwave energy, to produce gelatinization, disruption of starches and softening of the grain, said apparatus comprising a vertically positioned glass tube, said glass tube having an inlet, an outlet and an intermediate portion between said inlet and outlet; means for feeding grain into the inlet of said glass tube; receptacle means positioned at the outlet of said tube for receiving and conveying grain from said tube; means operably associated and connected to said receptacle for varying the rate of feed therefrom; a microwave chamber positioned at, and surrounding said intermediate portion of said vertical glass tube, means for injecting and evenly distributing microwave energy in said chamber whereby the temperature of the grain within said glass tube is raised to a temperature in the range of from about 130°–180° F. to produce gelatinization and disruption of the starches of the grain and softening of the kernels of the grain; first and second fluidtight, microwave energy-absorbing jackets positioned adjacent said microwave chamber, said first microwave energy-absorbing jacket being immediately above said chamber, said second microwave energy-absorbing jacket being immediately below said chamber, and means for circulating a dielectric liquid into and through said microwave energy-absorbing jackets.

2. The apparatus in accordance with claim 1 wherein said first and second microwave energy-absorbing jackets are each provided with an inner wall formed of plastic impregnated with fiber glass and an outer wall formed of plastic impregnated with fiber glass and with aluminum powder to trap the microwave energy in said jackets.

3. A continuous process for cooking grain, by means of microwave energy, to produce gelatinization and disruption of the starches of the grain and sufficient softening of the kernels of the grain so that the grain may be subsequently rolled into cohesive, highly nutritional flakes, said process comprising the steps of providing a vertically positioned glass tube; continuously feeding grain into the top of said tube so that the grain falls therethrough by gravity; subjecting said grain glass said glass tube to microwave energy by injecting microwave energy into a chamber surrounding an intermediate portion of said glass tube whereby the temperature of the grain within said glass tube is raised to a temperature in the range of from about 130°–180° F. to produce gelatinization and disruption of the starches of the grain and softening of the kernels of the grain, continuously withdrawing said grain from the bottom of said tube while maintaining the rate of feed of said grain through said tube by controlling the rate of feed of said grain from said bottom of said tube, and containing microwave leakage from

said chamber by circulating a dielectric liquid through fluid-tight, microwave energy absorbing jackets positioned immediately above and below said microwave chamber.

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