Dec. 27, 1966 A. L. FINGERHUT 3,294,546

METHOD AND APPARATUS FOR POPPING CORN

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FIG. 1a

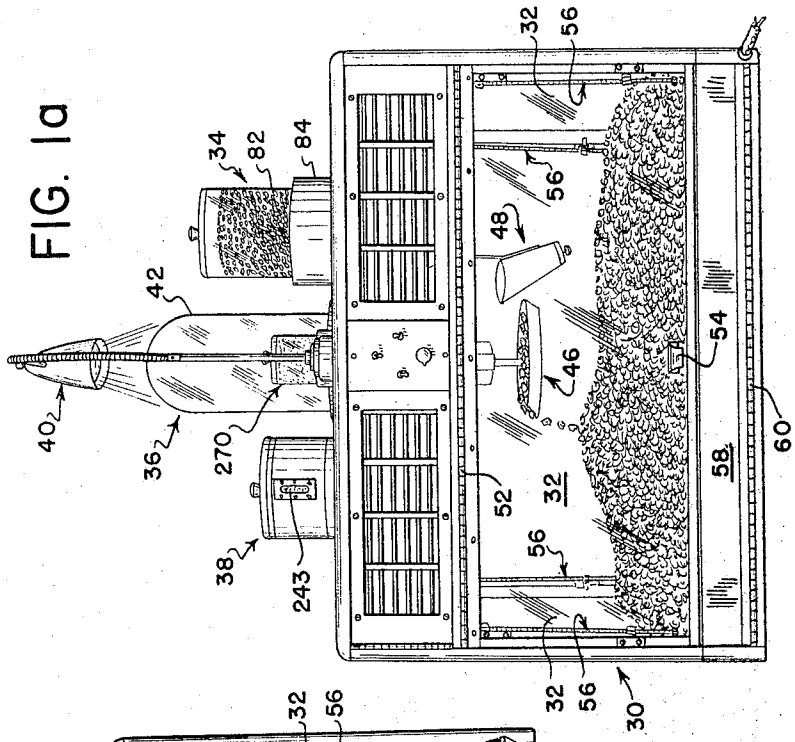
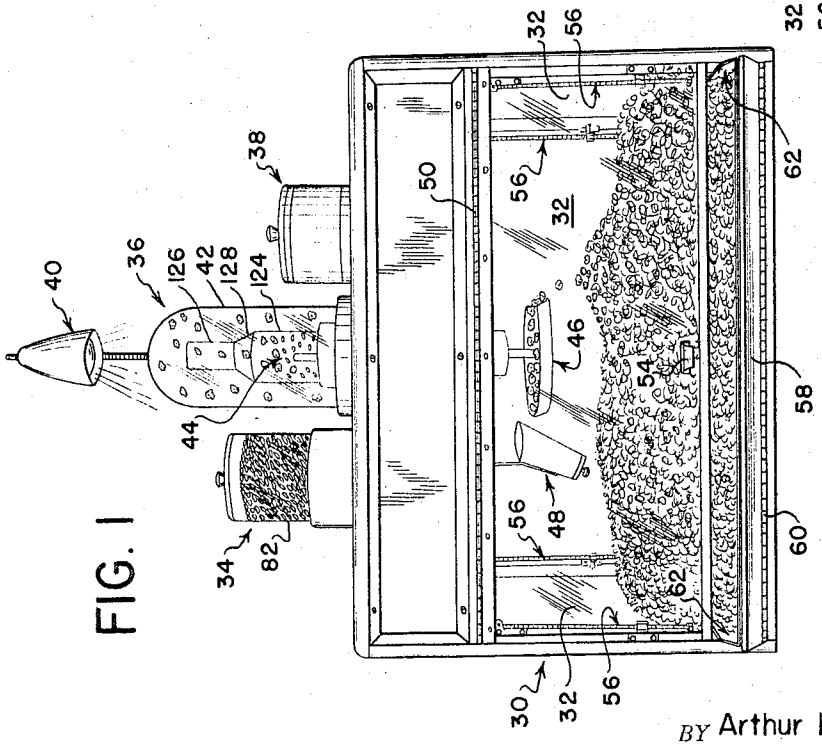


FIG. 1



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Dec. 27, 1966 A. L. FINGERHUT 3,294,546

METHOD AND APPARATUS FOR POPPING CORN

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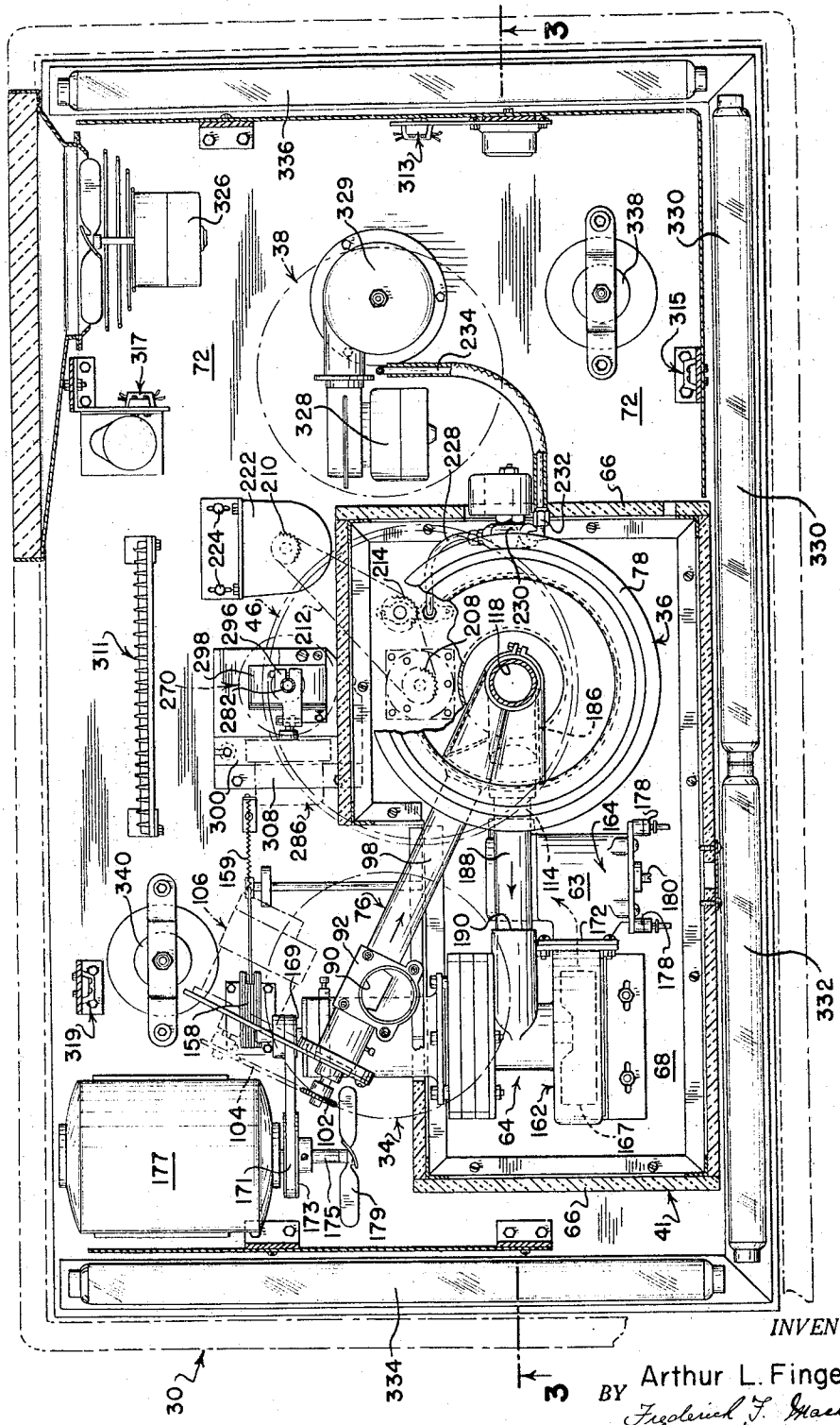
FIG. 2



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Dec. 27, 1966 A. L. FINGERHUT 3,294,546

METHOD AND APPARATUS FOR POPPING CORN

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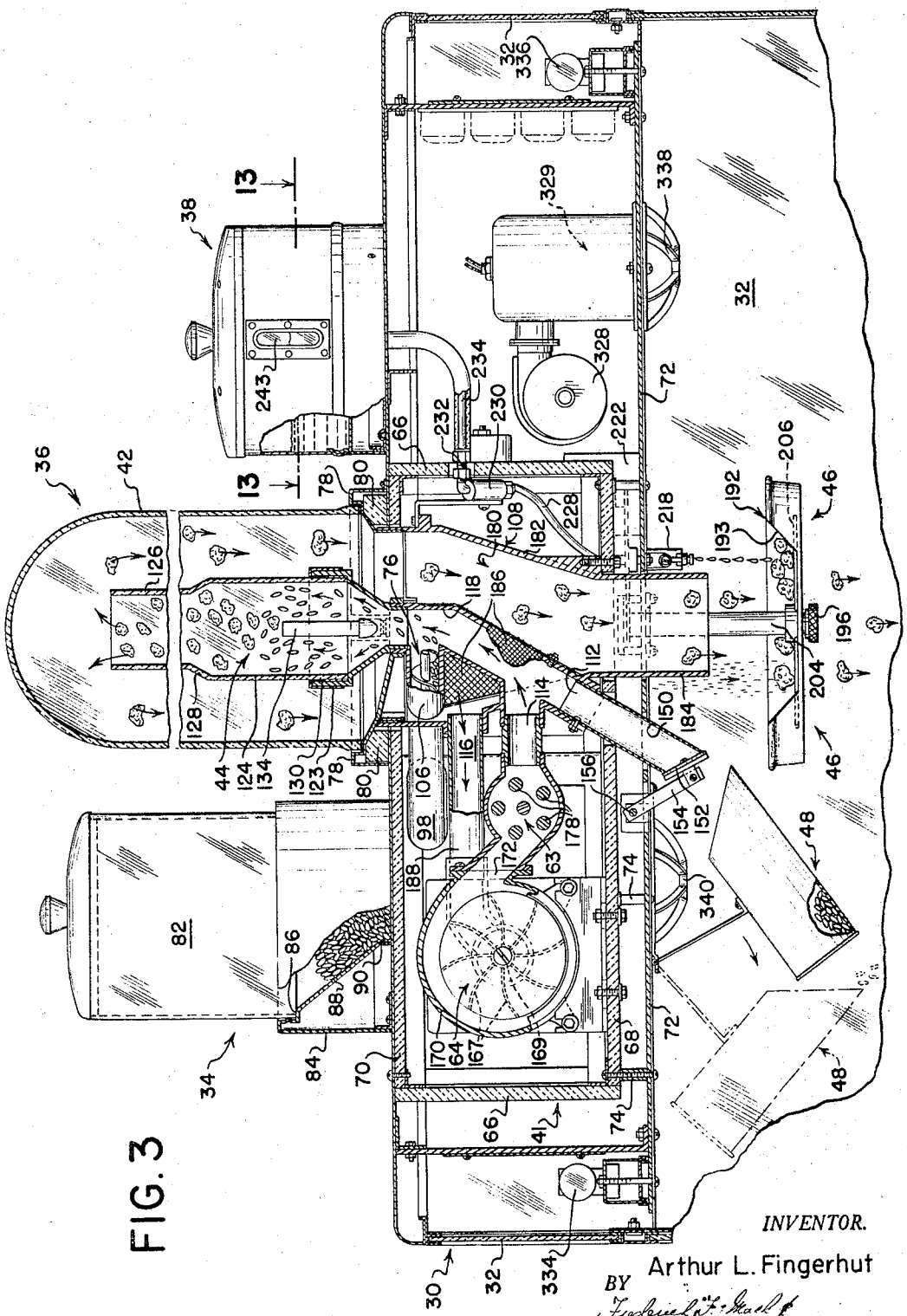

FIG. 3

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METHOD AND APPARATUS FOR POPPING CORN

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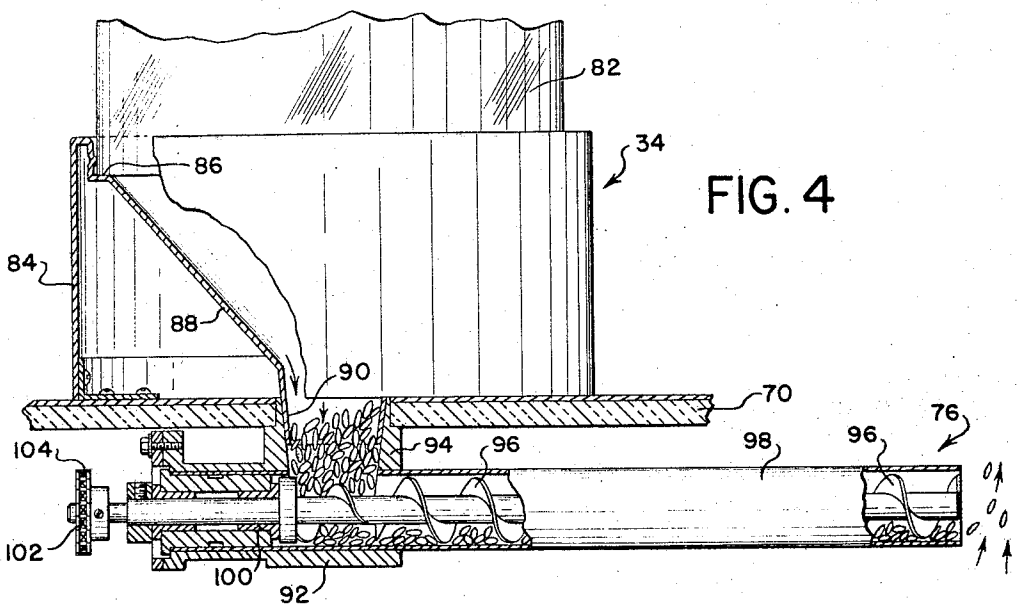


FIG. 4

FIG. 16

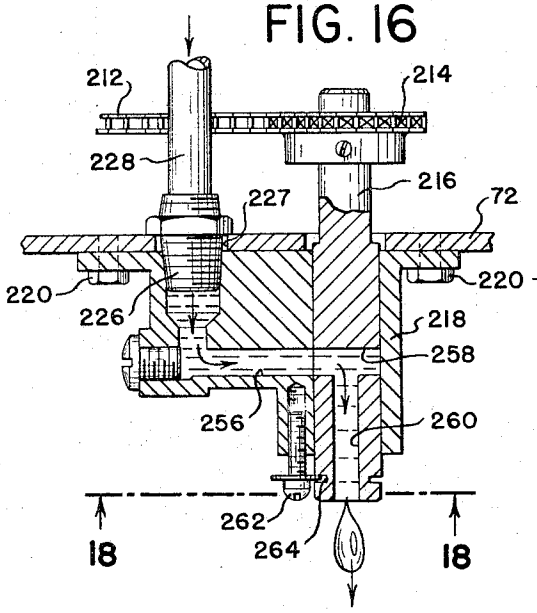
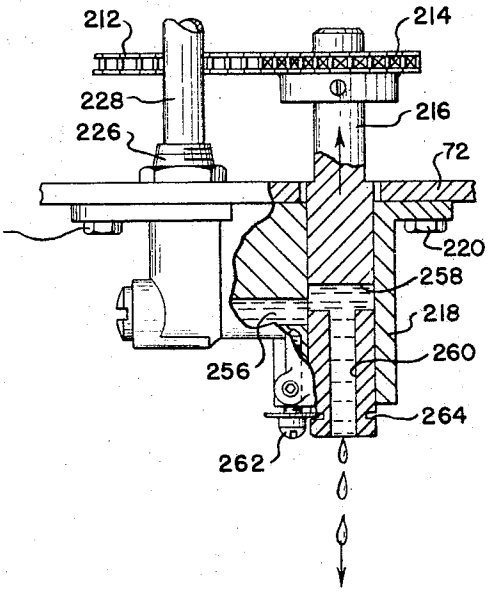


FIG. 17



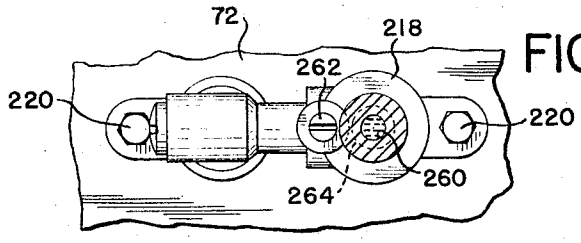


FIG. 18

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METHOD AND APPARATUS FOR POPPING CORN

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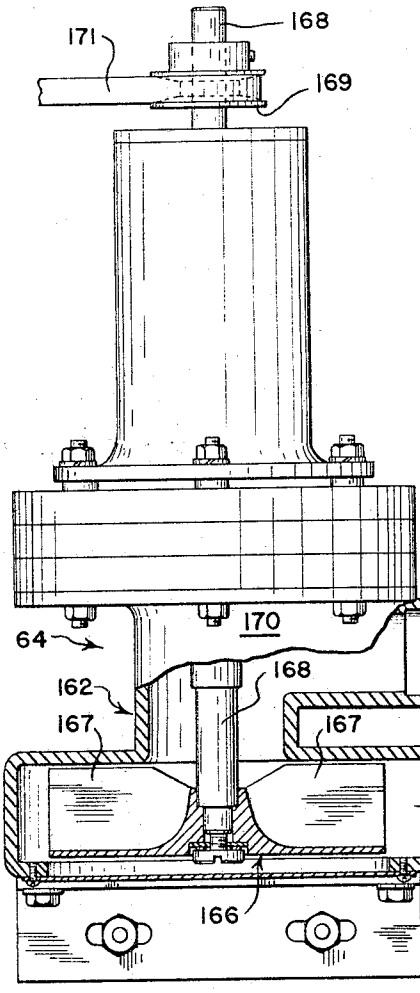


FIG. 5

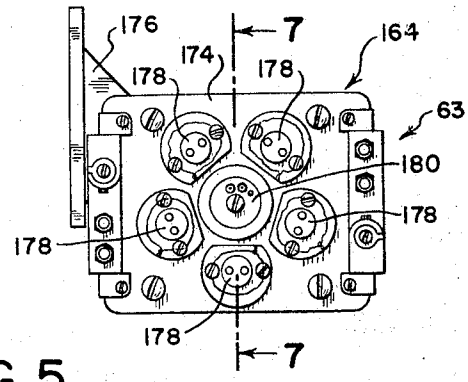
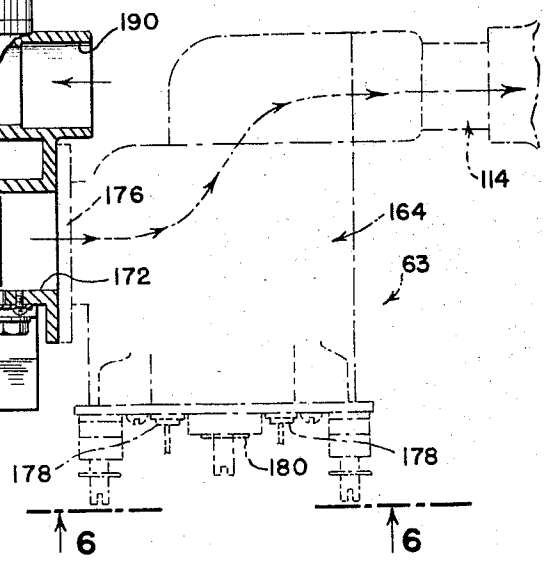


FIG. 6



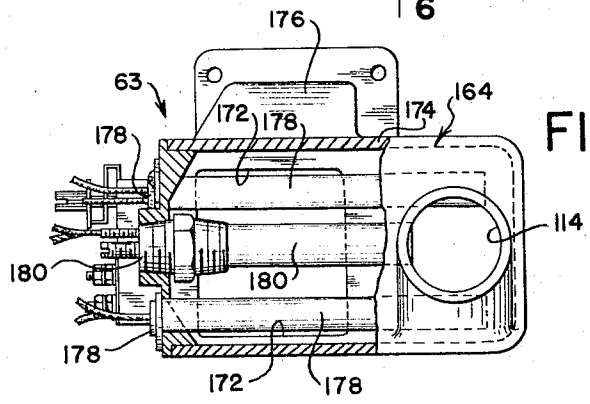


FIG. 7

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METHOD AND APPARATUS FOR POPPING CORN

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FIG. 8

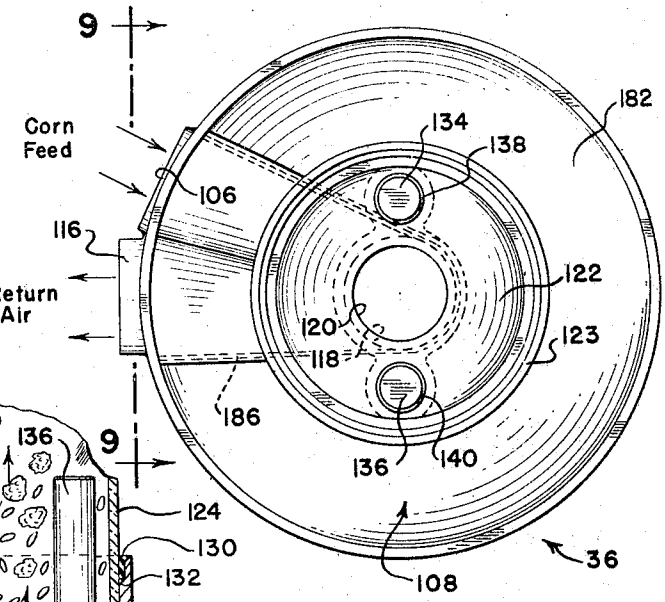
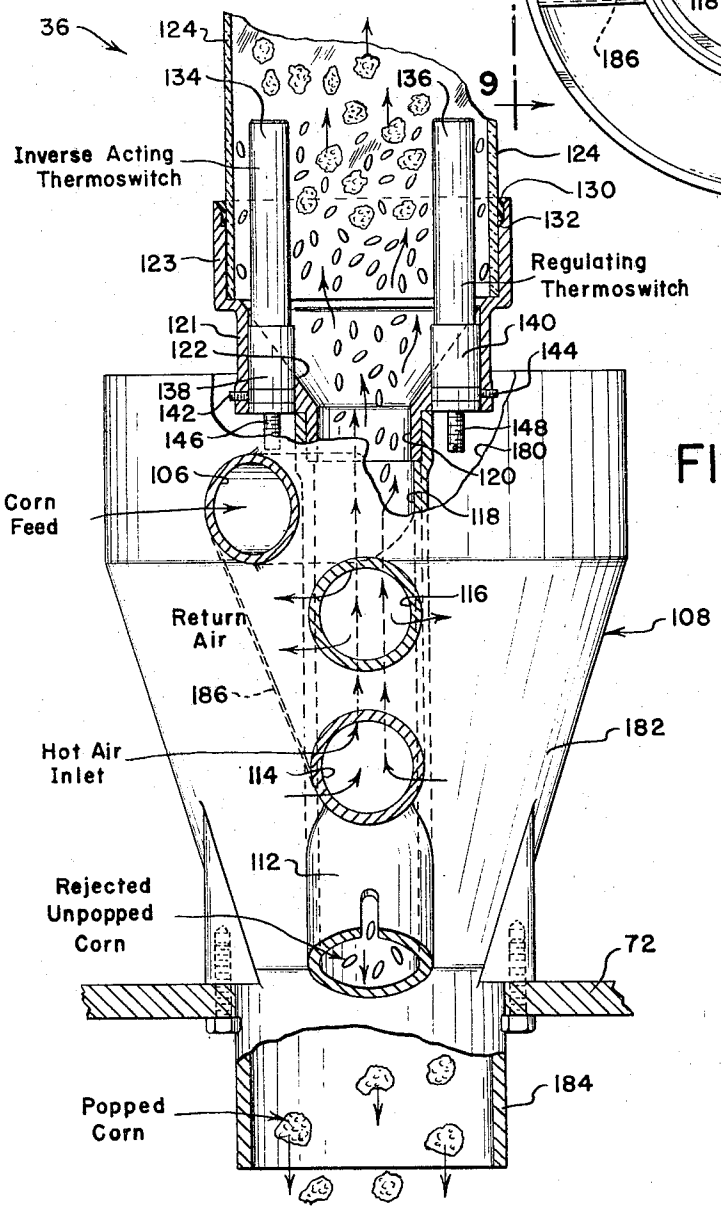


FIG. 9



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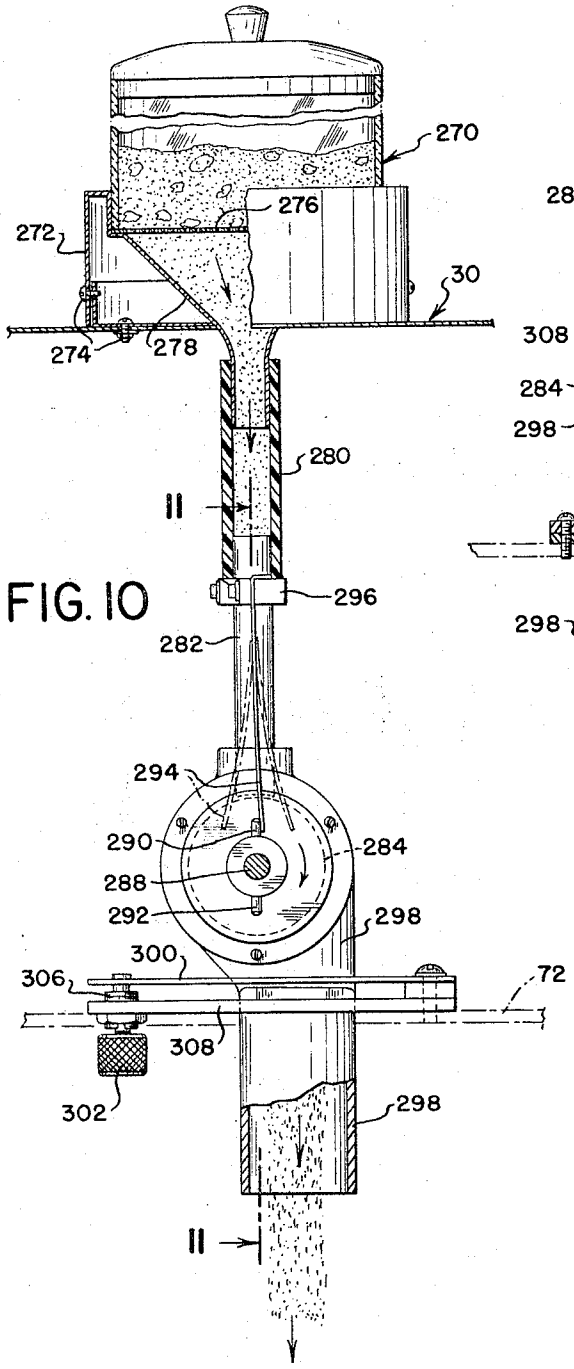


FIG. 10

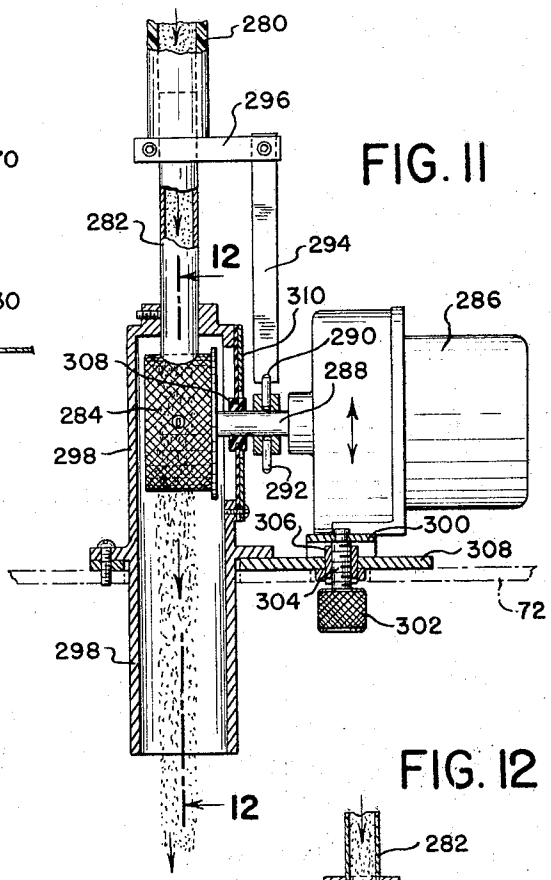
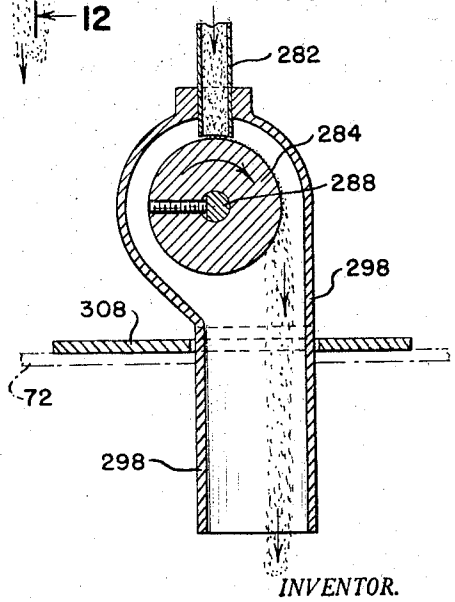


FIG. 11

FIG. 12



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Dec. 27, 1966 A. L. FINGERHUT 3,294,546

METHOD AND APPARATUS FOR POPPING CORN

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FIG. 13

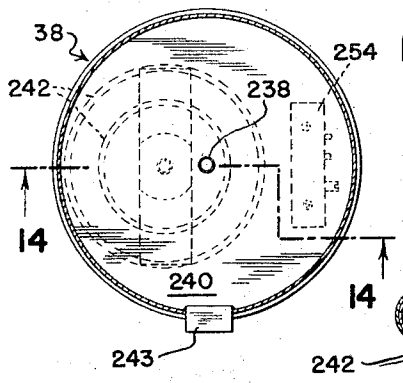
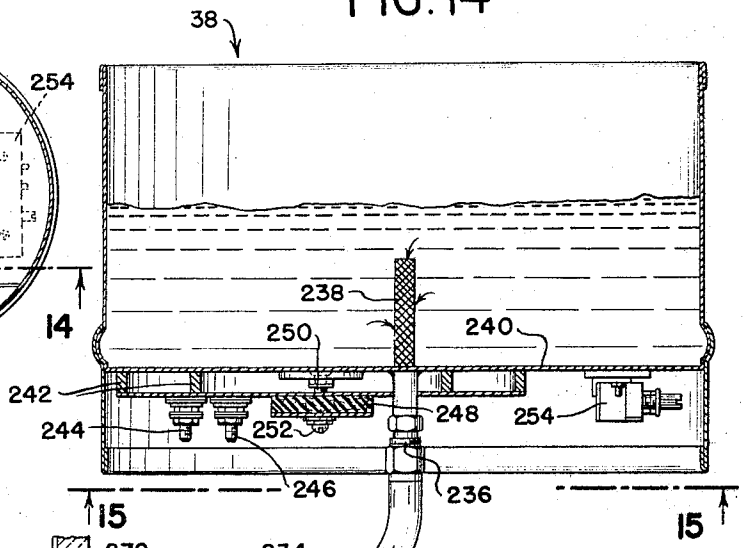


FIG. 14



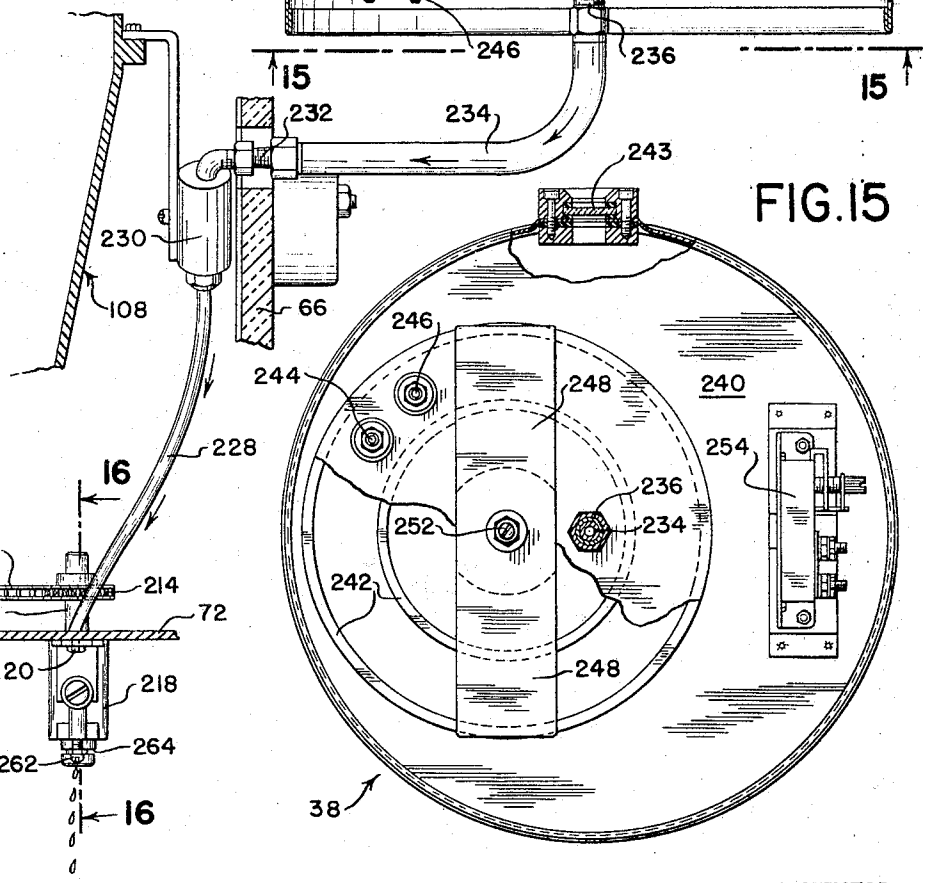


FIG. 15

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METHOD AND APPARATUS FOR POPPING CORN

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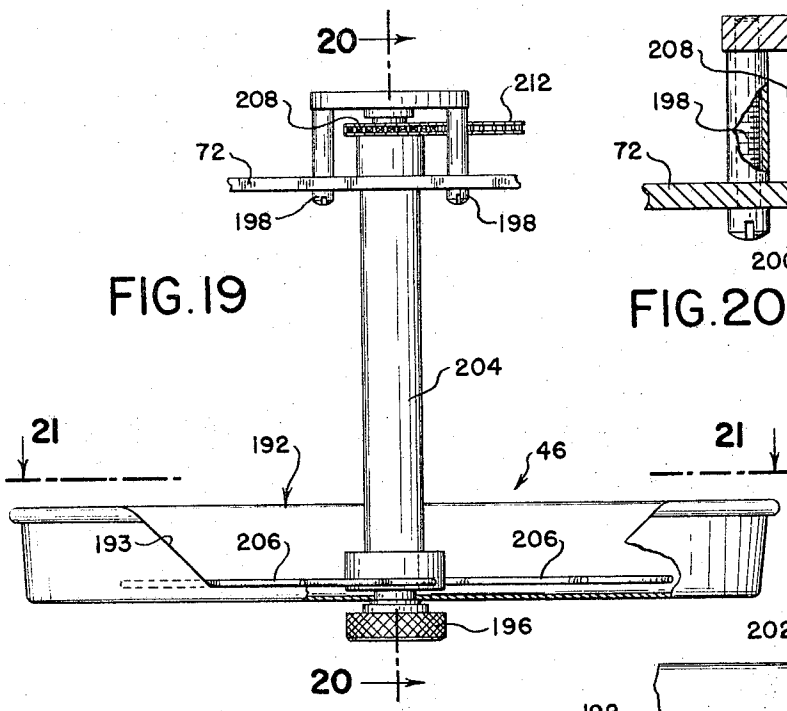


FIG. 19

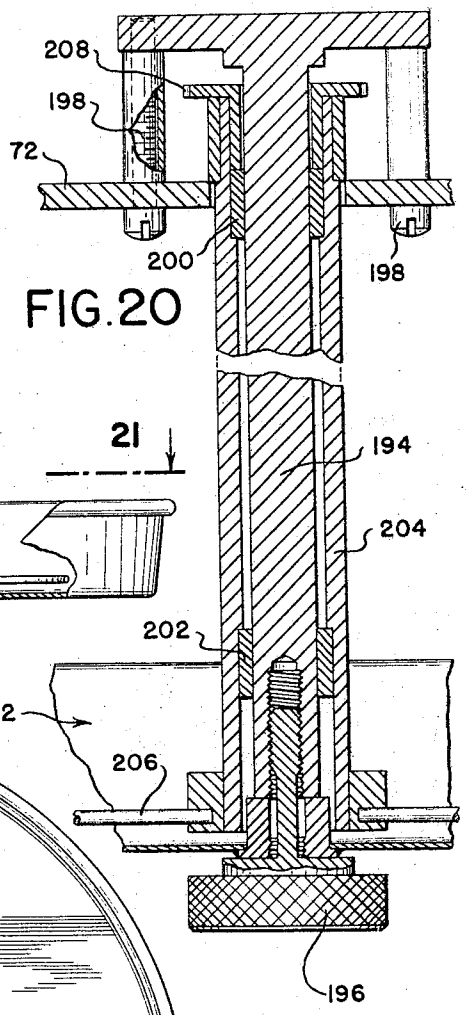
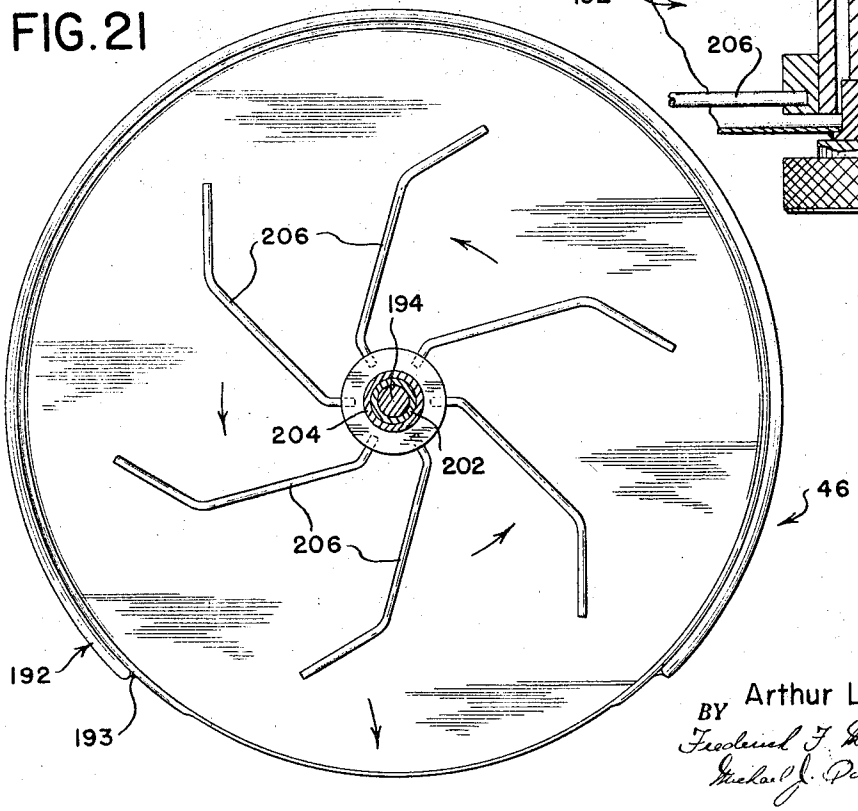


FIG. 20

FIG. 21



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METHOD AND APPARATUS FOR POPPING CORN

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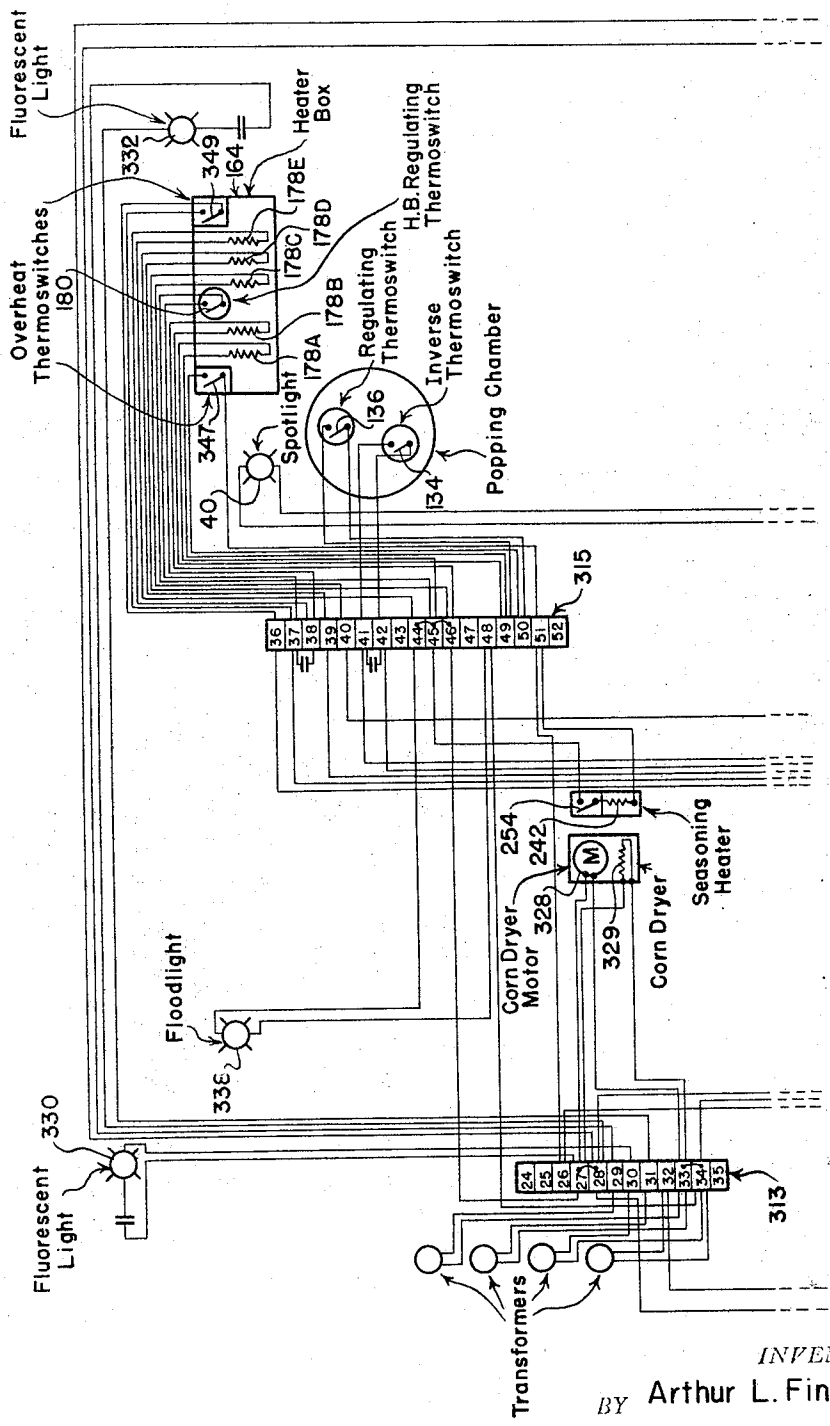

FIG. 22a

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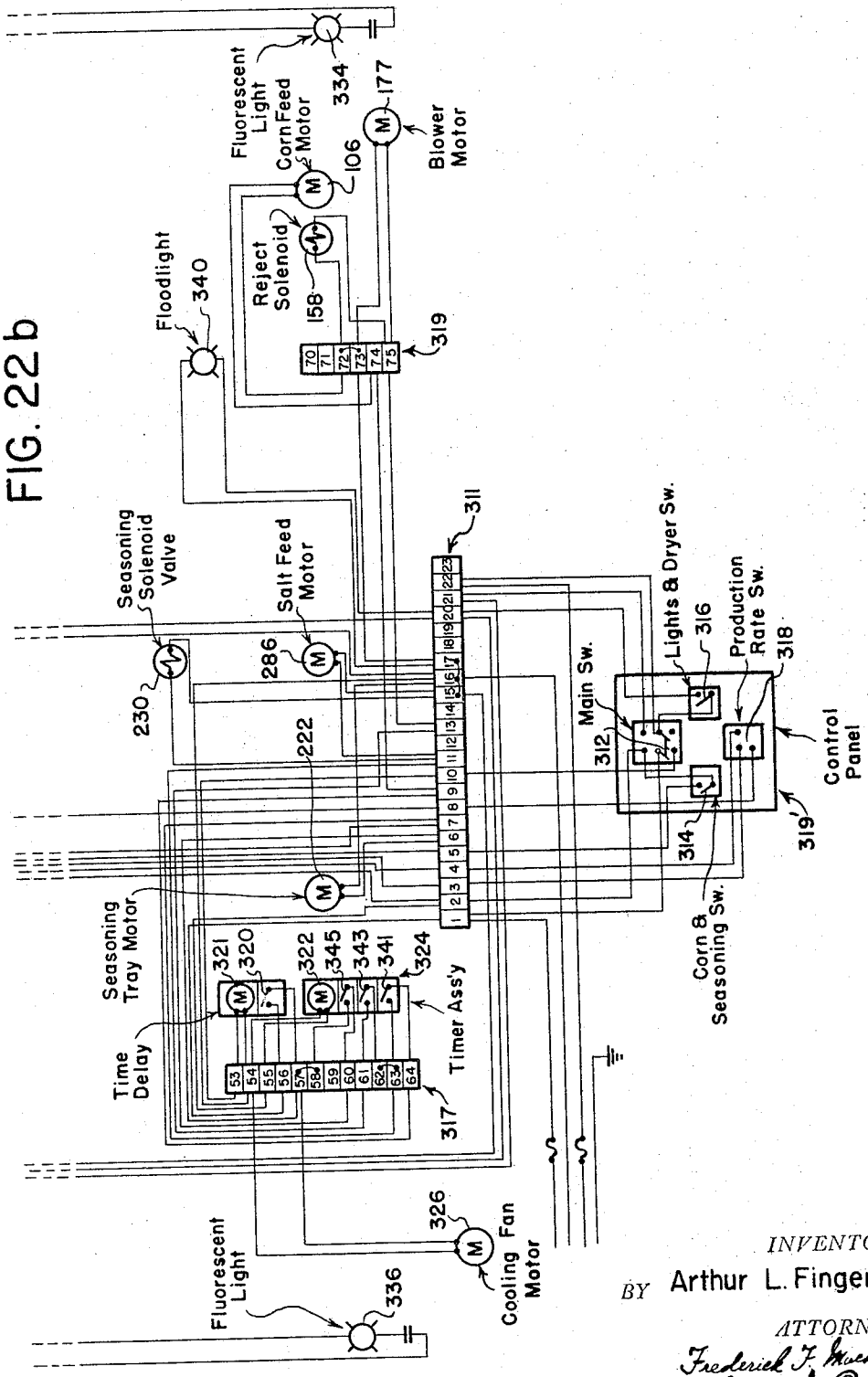
FIG. 22b



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United States Patent Office

3,294,546

Patented Dec. 27, 1966

3,294,546

METHOD AND APPARATUS FOR POPPING CORN

Arthur L. Fingerhut, Livingston, N.J., assignor to General Foods Corporation, White Plains, N.Y., a corporation of Delaware

Filed Mar. 27, 1962, Ser. No. 186,581
18 Claims. (Cl. 99—81)

This application is a continuation-in-part of my prior application, Serial No. 729,924, filed April 21, 1958, now abandoned.

This invention relates to an improved method and apparatus for popping corn that are especially adapted for use in public or semi-public locations and embody automatic features which allow the corn to be popped in a continuous manner requiring a minimum of an operator's time while providing increased operating efficiency and an improved yield of quality product.

U.S. Patent No. 2,922,355, granted to Julius Green on an application Serial No. 717,346 filed February 25, 1958, which was copending with the aforesaid application Serial No. 729,924, and also the applications of said Julius Green, Serial No. 801,682 filed March 12, 1959 (now abandoned) and Serial No. 53,722 filed September 2, 1960, all propose to pop corn in a continuous manner by disposing a substantially tubular popping zone vertically and centrally within a transparent housing and blowing hot gas into the lower end of and upwardly through the popping zone and out its open upper end. Raw kernels of corn are fed into the popping zone at a point near its lower end but above the point of introduction of the hot gas, the velocity of which is initially sufficient to air-vey the raw kernels upwardly into the popping zone but is then reduced to suspend them in the popping zone as a floating bed until they pop, whereupon the popped kernels are carried out of the open upper end of the zone. A collector is located at the bottom of the popping zone to collect "old maids," i.e., unpoppable corn kernels, and a dome-like housing around the popping zone and above its open upper end deflects the stream of hot gases and popped kernels from said upper end radially outwardly from and then downwardly around the popping zone.

Thus the circulating gases exit from the popping zone after having lost heat to the suspended kernels and at a velocity lower than said initial velocity. Accordingly the hot gas is withdrawn separately from the popped kernels, and before being recycled to the lower end of the popping zone, its initial velocity is restored by the blowing means and heat is added to make up for that absorbed by the kernels, etc.

While the apparatus and processes described in said Green patent and application represent significant advances in the corn popping art, the above stated continuous features of the popping operation introduce new problems in maintaining continuity, in terms of over-all operating efficiency and quality of the popped kernels produced, and especially in maintaining an approximately constant popping temperature.

It has been found that in the operation of a system of the type described above, best results as to quality of product are secured when the temperature of the gas-kernel mixture in the floating bed is maintained at an approximately constant value, usually about 375° F.

Within these limits, and assuming raw kernel inlet temperatures within a normal range, the kernels will absorb sufficient heat to cause popping in a relatively short time consistent with efficient operation of the apparatus and especially with the production of a product of uniform high quality. Should the temperature fall materially below the desired value, the time that the kernels must remain suspended in the circulating gases is unduly increased and also the quality of the product suffers objectionably. On the other hand, if the temperature of the circulating gases substantially exceeds the desired value, the kernels may become overheated particularly at the surface, a condition which also interferes with popping and results in a product of lower quality. Theoretically it should be possible in such a system to establish approximate equilibrium conditions in which the amount of heat supplied to the circulating gases is just sufficient to compensate for any heat loss and in addition to supply the amount of popping heat absorbed by the kernels when fed at an equivalent rate and at an approximately constant temperature. Under such ideal conditions, the temperature of the circulating gases in the popping zone would remain substantially constant and the time of suspension of the kernels in the hot gas before popping would also be substantially constant. It has been found, however, such desirable conditions cannot be maintained by temperature-responsive control of the gas heating means as indicated in the Green patent, because of the peculiar if not unique operation of a corn popping system of the type described.

In particular, major difficulties in maintaining continuous uniform operation arise from the fact that the circulating gas has several functions, namely, that it not only serves to convey heat from the heating means and impart it to the kernel, supply heat to the ductwork and housings, but it must also air-vey the raw kernels to the popping zone and maintain a controlled stationary floating bed of unpopped kernels in suspension therein. As an illustration of the problems arising from this fact, it will be evident that variations will inadvertently occur from time to time in the amount of heat required for popping. For example, if abnormally cold raw kernels are fed to the popping zone at a desired constant rate which would under normal or ideal conditions be commensurate with a desired constant heat supply, the kernels will have to remain suspended for a longer time before they heat up to popping temperature and hence the volume and weight of the stationary floating bed will increase, while the output of popped kernels decreases. Also the effect will be to take less heat out of the circulating gases with the result that the temperature in the floating bed itself tends to decrease, further aggravating the conditions just described.

Such density increases in the floating bed could be partially compensated by increasing the heat supply, but temperature-responsive controls located in the air passages are not effective because, when the amount of corn in the floating bed increases and more heat is needed, the effect of the increased amount of corn is to decrease the amount of circulating gas so that its temperature tends to rise and heat controls sensing this rise would then reduce the supply of heat. In any event the amount of compensation available by way of increasing the heat supply is limited since both the maximum velocity and

the maximum temperature of the circulating gas must be limited. For all of the above reasons, the popping zone in a system of the type described tends to become overloaded at times, with the result that the time required for kernels to pop may become excessive, and the floating bed may even become so heavy that it will fall into the ductwork, and result in failure of the machine.

In first starting the machine, moreover, the parts are cold and in the interest of maximum capacity, it is desirable to heat these parts substantially to operating tem perature before feeding corn to the popping zone. Although apparatus may be designed wherein the corn is fed at a low enough constant rate to allow the available heat to pop the kernels in the popping zone before an undue accumulation of unpopped kernels occurs therein, even in the initial stages, this is an inefficient and undesirable operating principle because later on when the machine parts have reached an equilibrium temperature, there will be heat available for popping more kernels than there are kernels to be popped, and because the decrease in the popping rate will be reflected visually in the reduced rate at which popped kernels issue from the popping zone.

In addition, it is important that ancillary cooperating means such as salt metering means and seasoning (i.e., butter and the like) metering means also operate at a rate which is commensurate with the rate of actual production of popped kernels of corn so that the product will not be either over-seasoned or salted or under-seasoned or salted, despite variations in said rate for reasons already indicated.

Accordingly, it is among the objects of the present invention to provide a continuous kernel popping apparatus having improved operating efficiency wherein kernels of corn are popped with uniform quality.

A specific object of the invention is to provide a continuous popping apparatus wherein the kernel feeding means and the kernel heating means will operate in a compatible manner such that the kernels will be fed at a rate commensurate with the rate at which they can absorb enough heat from the circulating gases to cause popping.

Another specific object of the invention is to control and synchronize the operation of kernel feeding means and kernel heating means such that ancillary means employed to salt and season popped kernels of corn will operate in a manner comparable to the rate at which popped corn is produced.

It has been found that the above objects can be accomplished most effectively and most simply by maintaining an approximately constant supply of heat to the circulating gases during the continuous operation of the machine under normal conditions, while maintaining the desired approximately constant temperature in the popping zone itself by regulating the rate of feed of raw kernels thereto in response to variations in the temperature of the gas-kernel mixture of the floating bed itself. Thermostatic regulation of the heat supply is necessary only to control the heat input under abnormal conditions and to prevent excessive temperatures which might damage the corn, or the machine itself, during standby and this can be attained by thermostatic means responsive to the temperature of the circulating gases. Such a control is effective during the initial warm-up period and also during the reject cycle as hereinafter described, in addition to providing a safety factor at all times. For normal operation, however, the popping temperature in the floating bed of kernels is maintained at the desired approximately constant value by regulating the rate of feed of the raw kernels in response to any deviation from said value of the temperature of the gas-kernel mixture. Should the temperature increase above the normal approximately constant value for any reason, the supply of an extra amount of cold raw kernels to the floating bed and the increased amount of heat absorbed by these kernels from the circulating gases will bring the temperature in the bed back down to the desired value. On the other hand, should the temperature in the floating bed drop for any reason, a reduction in the amount of raw kernels fed thereto will have the opposite effect of reducing the amount of heat absorbed from the circulating gases and this causes the popping temperature in the bed to rise again. It has been found that this method of control is capable of maintaining the temperature in the floating bed within very narrow limits, with high efficiency and production of a product of uniform high quality, while preventing undue accumulations in the bed which might unduly restrict air flow and cause an excessive rise of temperature.

The popping apparatus, apart from the controls embodying the present invention, may be similar to that disclosed in the aforesaid Green patent. Thus it may comprise a housing having a popping device therein in the form of a vertically disposed duct having an open upper end, and means for blowing hot gas into the lower end of and upwardly through the duct. Means are also provided for feeding raw kernels into the duct downstream from the gas blowing means. The gas blowing means are operated to produce gas velocity sufficient to suspend and agitate unpopped kernels out of its open upper end, and gas heating means are provided between the blowing means and the popping zone to replenish the heat content of the circulating gases.

Unlike the Green patent, however, the output of the gas heating means is subject only to reduction by thermostatic control, and this only in the abnormal case where the temperature of the circulating gases reaches a predetermined maximum value. Normally any such increase is prevented by controlling the feed of raw kernels to the popping zone as already stated, this being preferably accomplished by locating temperature-responsive means in the bed itself for sensing the temperature of the gas-kernel mixture therein, that is, in the confined area where the kernels are maintained in the suspended and agitated condition by the hot gas coursing upwardly therethrough. Such temperature sensing means can control either the rate of operation or the period of operation of the kernel feeding means.

Not only is unsatisfactory operation avoided by reason of the prevention of overloading in the popping chamber, but also various ancillary metering means such as salt metering means or seasoning metering means are also controlled in accordance with the temperature of the gas-kernel mixture and will salt and flavor the popped corn in accordance with its rate of production.

Thermostatic control of the heat supply is therefore necessary only to prevent "run away" or overheating conditions, and this requires only overheat sensing means which serve to break electrical circuitry preferably communicating with the gas heating means. In normal operation, this will occur when the feed of kernels is terminated at the end of a cycle as described hereinafter, during standby conditions, these means may also be effective under abnormal conditions such as during initial warm-up. The overheat sensing means are located so as to respond to increases in the temperature of the circulating gases and are operative to limit their maximum temperature by controlling the output of the gas heating means when the feed of kernels is terminated and the temperature sensing means controlling said feeding means is not in operation.

The invention will now be described in more specific detail with reference to the accompanying drawings wherein:

FIG. 1 is a frontal view of a preferred form of the kernel popping apparatus;

FIG. 1*a* is an elevation of the apparatus in FIG. 1 from the back side thereof;

FIG. 2 is a top plan view of the device with parts of the top thereof removed and other parts broken away to better reveal portions of the device;

FIG. 3 is a side elevation of the device taken along line 3—3 in FIG. 2;

FIG. 4 is an enlarged view partly in elevation and partly in section of the unpopped kernel feeding means;

FIG. 5 is an enlarged top plan view partly in section showing the hot gas blowing means, with the gas heating means being shown in phantom;

FIG. 6 is an elevation taken along line 6—6 in FIG. 5 and showing the gas heating means;

FIG. 7 is an elevation partly in section taken along line 7—7 in FIG. 6;

FIG. 8 is an enlarged top plan view and FIG. 9 is a side elevation taken along line 9—9 in FIG. 8 of the popper manifold;

FIG. 10 is an enlarged view partly in section and partly in elevation of a salt reservoir and a salt metering device;

FIG. 11 is a sectional view taken along line 11—11 in FIG. 10;

FIG. 12 is a sectional view taken along line 12—12 in FIG. 11;

FIG. 13 is a sectional view of a seasoning reservoir taken along line 13—13 of FIG. 3;

FIG. 14 is an enlarged sectional view of the seasoning reservoir taken along line 14—14 in FIG. 13 and also illustrating seasoning metering means;

FIG. 15 is a bottom plan view of the seasoning reservoir taken along line 15—15 of FIG. 14;

FIG. 16 is an enlarged sectional view of the seasoning metering means taken along line 16—16 of FIG. 14;

FIG. 17 is a view similar to FIG. 16 showing the adjustable features of the seasoning metering means;

FIG. 18 is a bottom plan view of the seasoning metering means taken along line 18—18 in FIG. 16;

FIG. 19 is an enlarged side elevation of a popped corn mixing means in which popped corn is mixed with salt and seasoning supplied from the salt metering means and the seasoning metering means;

FIG. 20 is an enlarged sectional view taken along line 20—20 of FIG. 19;

FIG. 21 is a plan view taken along line 21—21 of the mixing means in FIG. 19; and

FIGS. 22*a* and 22*b* are wiring diagrams of the control circuitry for operating the apparatus.

Referring to FIGS. 1 and 1*a* it will be seen that the apparatus generally comprises a display case **30** adapted to exhibit corn kernels through windows **32** mounted on the front, sides and back of the display case. Mounted on top of the display case **30** is kernel hopper means **34**, a popping device generally designated as **36**, and a seasoning device generally designated as **38** and a salt metering device **270**. Also mounted on the top of display case **30** is a spotlight **40** adapted to shine down upon the domed glass jar **42** of popping device **36** to highlight and dramatize the showering effect of corn as it is popped and conveyed by the circulating heating gas out of the duct shown as **44** in FIG. 1. As seen in FIGS. 1 and 1*a*, spider means **46** and "old maid" collecting means **48** are viewable through the windows **32** of display case **30**.

The front and back windows **32** are each hingedly connected at **50** and **52** and are adapted to fold upwardly by gripping handles **54** located at the lower extremity of the respective windows. Means generally designated as **56** are located at the sides of front and back windows **32** which are adapted to maintain the windows either in a closed position relative to display case **30** or to maintain them folded upwardly. Elongated doors or partitions **58** are located in the lower extremities of the front and back of the display case **30** and are hingedly connected thereto as at **60**, the doors being adapted to swing outwardly to increase the capacity of the display case and allow additional working area. The lower marginal edges of the front and back windows **32** close against the respective doors **58** when the latter are closed and thereby serve to confine the popped corn within the display case. As seen in FIG. 1, door **58** on the front of the machine may

be arranged to occupy an inclined position so that it and suitable end wings **62** form a sort of bin permitting the popped corn to be scooped out below the lower edge of the front window **32**.

The over-all internal operating components of the machine will now more fully be described by referring to FIGS. 2 and 3. Gas heating means **63** and gas blowing means **64** are mounted beneath the top of display case **30** within the side, bottom and top (insulated) walls **66**, **68** and **70**, respectively, of the insulating housing box **41**, the box being suitably mounted on an upper floor **72** of the display case through intermediation of spacer legs **74**, the floor **72** extending as a horizontal panel upon which other operating parts of the apparatus are mounted and being itself suitably affixed to the sides of display case **30**.

Communicating with the kernel hopper means **34** is kernel feeding means designated generally as **76**, and which in turn communicate with the lower extremity of duct **44**. Duct **44** has open upper and lower ends and is mounted centrally within jar **42** which is mounted on the top of display case **30** by means of annular bracket **78** which also serves to retain a heat insulating ring **80**.

The remaining features of the apparatus will be described in greater detail hereinafter together with the specifically detailed operating descriptions of the principal parts of the apparatus. Referring to FIG. 4 showing the details of the kernel hopper means **34**, a tubular transparent corn kernel reservoir or container **82** is mounted within a cylindrical support **84** having a seat portion **86** upon which the container **82** rests. Integral within the support **86** is a funnel shaped chamber **88** which introduces raw unpopped kernels to the kernel feeding means **76** through a discharge port **90**, which in turn is seated within an opening in the top of display case **30**. Bolted (by suitable means not shown) to the top of display case **30** is a housing **92** which receives the discharge port **90** in complementary fashion at **94**. Mounted in housing **92** is a horizontal auger or screw conveyor **96** which fits compatibly within auger sleeve **98** and is mounted for rotation within sleeve **98** by bearings **100**. Mounted at the end of the auger shaft is a sprocket **102** adapted to be driven by chain **104**. Chain **104** is driven by a corn feed motor drive generally shown in phantom in FIG. 2 as **106**. Corn feed motor **106** is a constant speed motor adapted to be intermittently operated under the control of temperature sensing means located within the popping device **44** as will be described hereinafter and thereby control the rate at which raw unpopped kernels are fed by the auger **96** through auger sleeve **98**. Although an intermittent feed of raw unpopped kernels may be provided by the motor drive **106**, a variable speed motor may alternatively be employed in which case the motor drive will also be operated in accordance with signals from the temperature sensing means.

Kernels issuing from the kernel feeding means are introduced into a substantially vertical duct of a manifold shown in detail in FIGS. 8 and 9. Auger sleeve **98** fits complementarily within corn feed port **107** of a manifold housing generally designated as **108** for the kernel popping means. Manifold housing **108** has a number of ports besides the corn feed port **107**, viz.: corn reject port **112**, hot air inlet port **114**, return air outlet port **116**. The ports **107** **112**, **114**, and **116** all communicate with a vertical duct **118** adapted to convey hot gas (air) upwardly past the corn feed port **107**. Here the hot gas entrains raw unpopped corn kernels and transports them upwardly through the duct **118** into the popping chamber defined. This duct snugly receives a lower cylindrical section **120** of an integral thermoswitch housing **121**, having a frusto-conical upwardly flaring inner surface **122**, which in turn communicates integrally with a larger diameter cylindrical sleeve **123**, receiving the lower extremity of a tubular transparent glass elongated wall portion **124**.

The cylindrical inner surface of the tubular wall portion **124** defines the major region wherein the corn kernels are suspended and agitated under the influence of hot air coursing upwardly through the duct **118**. A tubular glass section **126** of reduced diameter (ref. FIG. 3) communicates integrally with cylindrical section **124** through neck portion **128**. To mount and seal the cylindrical section **124** within the cylindrical sleeve **123**, a resilient sealing ring **130** is deposited in seat **132** and retained by a suitable annular retaining collar.

It is important in regulating and controlling the movement of the air or gas to make sure that it meets certain definite and distinct requirements. First, the raw or unpopped kernels are delivered into a first transporting zone (viz, duct **118**) in which the velocity of the air stream must be sufficient to insure the positive elevation of the kernels to a superposed heated popping zone. The air velocity necessary to accomplish this transportation is readily determinable according to the knowledge and experience of the art of pneumatic conveyors. The flotation velocity is a function of the diameter and specific gravity of the kernels and the transportation velocity ordinarily should be at least twice the flotation velocity. It can be provided, according to the general formula $Q=AV$, by regulation of gas blowing means **64** or other circulation device to supply a quantity of air Q, and by confining the moving body of air in a stream the area A (duct **118**) of which bears such a relation to the quantity Q as to provide the desired velocity V, the raw kernels being conveyed into this moving current by any appropriate mechanical means such as kernel feeding means **76**.

It is very desirable that the aforesaid transporting velocity V be maintained up close to the entrance of the popping zone (section **124**), not only to insure delivery of the raw kernels to the popping zone, but also to make sure that unpopped kernels are suspended and agitated therein and are not blown back down and out of the zone as explained below. On the other hand, in order to insure that the kernels remain in the popping zone long enough to be heated and popped, the exit velocity V_1 from this zone preferably is somewhat less than the flotation velocity for the unpopped kernels. It will be evident that the popping explosion of a kernel may impart sudden upward or downward accelerations to neighboring individual unpopped kernels. To prevent such downwardly accelerated unpopped kernels from leaving the popping zone, the velocity V at the entrance to this zone must provide an upward thrust or pressure against the kernels which is great enough to resist and overcome such downward accelerations and therefore should be substantially greater than the flotation velocity to insure the results described above. To prevent upwardly accelerated kernels from leaving the zone, the exit velocity V_1 is less than the flotation velocity for a sufficient height that the upward acceleration is dissipated before the kernels pass out of the popping zone and accordingly they fall back into the heated zone.

The reduction in velocity from V to V_1 may be provided by independent control of the air circulation in the two zones, but preferably by slowing down the rapidly moving inlet air stream due to either one or both of two causes. The heat required for popping may be provided in any suitable manner, but where it is supplied by heating the inlet air, the cooling effect of the raw corn produces a substantial temperature drop by the time the air has moved into the popping zone, so that its velocity is decreased correspondingly. In addition the drop in velocity is accomplished by substantial enlargement of the cross section of the stream passing from duct **118** through the popping zone (section **124**), the velocity being reduced thereby according to the general formula $Q=AV$.

It is desirable that the suspended bed or mass of kernels in the popping zone be maintained in a turbulent condition. This condition is secured by using the relatively small diameter, high velocity, inlet air stream somewhat like a jet, blowing it into or near the bottom of the popping zone and allowing it to lose velocity as it expands in eddies and whorls, thus maintaining the mass of suspended kernels in a state of turbulent agitation. This condition insures uniform heating and popping as the kernels are suspended and agitated. If the popping zone is of sufficient height, however, there will be a fairly steady stream of air leaving the upper end of this zone at the exit velocity V_1 so as to minimize the risk of carryover of unpopped kernels as the result of the aforesaid turbulent agitation. This exit zone may also contain some unpopped kernels which have been "kicked" upwardly by the popping explosions of neighboring kernels, but the exit zone is made high enough to provide for the dissipation without carryover of upward accelerations. Of course, the air stream leaving the exit zone tends naturally to expand its cross section, and if permitted such expansion will result in a further reduction in velocity to a value below V_1 and consequent added protection against carryover of unpopped kernels.

When a kernel pops at any point in the popping zone, it suddenly acquires a size many times larger than the unpopped kernel and a correspondingly decreased density. The velocity V_1 is ample to displace these popped kernels out of the popping zone, but in some cases it may be desirable to move the popped kernels away from the heating zone rapidly to avoid overheating and possible parching or other undesirable effects, however, and to this end the cross section of the stream above the popping zone may be constricted by the use of tubular glass section **126** with the result of increasing the air velocity above V_1 and removing the popped kernels more quickly.

On inverse acting theremoswitch **134** and a regulating thermoswitch **136** are mounted vertically in complementary cylindrical seats **138** and **140**, respectively, of housing **121** by means of set screws **142** and **144**, each of the thermoswitches having adjusting screws **146** and **148**. A substantial portion of the length of inverse acting thermoswitch **134** occupies the major region of the popping zone. This inverse acting thermoswitch functions to sense the temperature of the mixture of hot air and corn in the popping chamber. By sensing this temperature the switch energizes and thereby regulates corn feed motor **106** which in turn controls the rate of feed of corn to the popping zone. This in turn adjusts and thereby controls the temperature of the air-kernel mixture in the popping zone. Thus, if the temperature of the heated gas and corn mixture in the popping zone rises, the inverse acting thermoswitch will close its contacts and energize motor drive **106** which in turn feeds new corn into the popping zone by means of kernel feeding means **76**. This new supply of corn enters the duct **118**, is transported to the popping zone and serves to lower the temperature of the mixture to a point where the contacts of inverse thermoswitch **134** will open and stop corn feed. In this way the temperature of the air-corn mixture in the popping zone is automatically regulated.

The regulating thermoswitch **136** controls the maximum temperature of heat supplied to the popping zone. As will be explained hereinafter, in the later stages of the operating cycle of the present apparatus a timing switch stops operation of the kernel feeding means **76** so that further introduction of raw unpopped kernels to the duct **118** is terminated. Consequently, since no additional corn is being introduced to the popping zone and since corn is continually being popped therein and removed from the popping zone the tendency is for the temperature of the gas-corn mixture therein to rise. The regulating thermoswitch **136** serves as a means for regulating maximum temperature during this later part of the cycle and thereby assures quality popped corn. This is accomplished by the regulating switch **136** opening contacts to a part of the gas heating means.

As will be apparent hereinafter the popping operation is not prolonged but rather is interrupted at intervals by a short period during which rejects or "old maids" accumulating in the popping zone can be discharged through the duct **118** into a reject tube **150** fitting into a reject port **112** of housing **108**. A flapper gate **152** is carried by an arm **154** on a shaft **156** which is adapted to be rocked under the control of solenoid **158** connected eccentrically to the shaft **156** in any suitable way, which serves to open the flapper gate against the tension of spring **159** and allow discharge of unpopped corn kernels into a reject container **48**.

The gas heating means **63** and the gas blowing means **64** are shown in greater detail in FIGS. 5, 6 and 7. These means generally comprise an air blower **162** and an air heater **164**. The blower **162** may be of any suitable design but preferably comprises an impeller fan **166** having vanes **167** driven by means of shaft **168** in a blower housing **170**. At the opposite end of the blower shaft is a pulley **169** continuously driven at a constant rate by means of endless belt **171** which in turn is driven by pulley **173** mounted on drive shaft **175** of a constant speed motor **177** (ref., FIG. 2). Also mounted on the drive shaft **175** is a fan **179** which serves to circulate air and cool machine elements outside the insulated housing box **41**. The blower housing has an outlet port **172** which communicates with a heater box housing **174** through plate **176**. Mounted in the housing **174** are five resistance-type cartridge heaters **178**, which in the wiring diagram of FIG. 22*a* are identified as **178A**, **178B**, **178C**, **178D** and **178E**. Heaters **178B** and C operate under the control of regulating thermoswitch **136**; and heating element **178E** operates under the control of regulating thermoswitch **180**, as will be described hereinafter. The remaining heating elements **178A** and D are adapted to be energized by a production rate switch to be hereinafter described.

Although the inverse acting thermoswitch **134** will normally prevent undue increase of the temperature of the mixture of air and corn in the popping zone by signaling for the addition of raw corn which will cool said mixture, abnormal conditions sometimes occur in which the load of corn kernels in the popping zone will increase unduly and thereby dampen or restrict the air flow through the popping zone. This may happen for example during the initial warm-up period as already stated, the consequent reduction of air flow can in turn bring about an increase in the inlet air temperature to the gas-kernel mixture, by increasing the proportion of heat supplied to the circulating gases relative to the amount of the circulating gases. The quality of the product would then suffer due to reduced agitation and mixing of the product, consequent poor heat transfer, and extension of the required popping cycle. This coupled with the rise in inlet air temperature could occasion drying out of the kernels before they are popped and this in turn would cause the temperature of the mixture to rise with a reduced rate of popping. Also, the temperature rise could further burden the popping chamber and cause self-aggravation and malfunctioning of the operation.

To prevent the occurrence of such abnormal deleterious effects, the overheat sensing means mentioned above are provided. These means may for example comprise a regulating thermoswitch **180** which deenergizes resistance heater **178E** should the inlet air temperature tend to become too high, and thus reduces the inlet air temperature which causes the inverse-acting thermoswitch **134** to terminate the feed of kernels and maintain proper equilibrium between kernels and heat thereby maintaining high quality of product. In this way overloading of the popping chamber with raw corn kernels is avoided.

As already described, the regulating thermoswitch **136** located in the popping zone provides another means for preventing overheating by breaking the circuit energizing the resistance heaters **178B** and C. When both such overheat sensing means are employed, the thermoswitch **180** can be made responsive to the temperature of the circulating gases, and the regulating thermoswitch **136** is preferably set at a temperature higher than the setting of the inverse thermoswitch **134** located in the popping tube in order to control the maximum temperature of the air-kernel mixture in the popping zone near the end of a cycle when feeding of raw kernels is terminated automatically or stopped by the operator at the latter's election. Thus, when the kernel feeding means **76** are inoperative the corn kernels can no longer be employed to cool the hot air introduced to the popping zone so that the inverse acting thermoswitch **134** will no longer be effective in controlling the maximum temperature of the gas-air mixture in the popping zone. At this point, therefore, the regulating thermoswitch **136**, sensing the increase in temperature which will occur due to the diminishing quantity of suspended and agitating corn in the popping zone, will break the resistance heaters **178B** and C from circuit and thereby limit the temperature to a predetermined setting.

As the popped kernels are conveyed upwardly through the cylindrical sections **124** and **126** and are deflected radially outwardly and downwardly by the domed jar **42** they descend downwardly through the manifold **108** by means of a chute **181** defined between the manifold duct **118** and a frusto-conical manifold wall portion **182** which communicates integrally with a cylindrical section **184** passing through the insulated bottom **68** of the insulated housing box **41** and the floor **72** of the display case **30**. The popped kernels falling downwardly through the manifold eventually drop onto a mixing tray (FIGS. 19, 20 and 21) adapted to mix salt and/or seasoning with the popped corn. The heated air circulating upwardly through the popping zone is also deflected radially and downwardly by the domed jar **42** and is separated by means of a screen **186** (FIG. 3) mounted in the manifold **108** as shown in FIGS. 8 and 9 upstream from the return air port **116**. Inserted in return air port **116** is a duct **188** which connects the return air port **116** with port **190** of impeller fan **162** thereby providing means for continuous recirculation of heated air through the gas blowing means **64** the gas heating means **63** and the popping chamber.

The mixing tray **192** is fixedly mounted on a stationary post **195** by means of a captive screw **196** as shown in FIG. 20. The post **194** in turn is mounted through anchor bolts **198** to floor **72** of the display case and serves to journal at **200** and **202** a rotatable hollow shaft **204** at the lower extremity of which is mounted a mixing spider **206** (ref., FIG. 21). At the upper extremity of the spider shaft **204** is a sprocket **208** driven by a sprocket **210** through intermediation of chain **212** (ref., FIG. 2).

The chain **212** also serves to drive sprocket **214** mounted on an oil (seasoning) metering shaft **216** (ref., FIGS. 16–18) housed within oil metering housing **218** mounted on floor **72** by bolts **220**. Thus the chain **212** drives the mixing spider **206** and the oil metering shaft **216** and is in turn driven through intermediation of sprocket **210** by constant speed motor **222** mounted on display case floor **72** by bolts **224**.

The oil metering housing **218** (ref., FIG. 16) is connected by fitting **226** passing through a hole **227** in the display case floor **72** to pipe **228** which in turn connects to a solenoid valve **230** controlling the flow of seasoning oil to the oil metering means. The solenoid valve in turn is connected by means of a fitting **232** passing through the side wall **66** of the insulated housing box **41** with a tube **234** which in turn connects with fitting **236** in the floor of reservoir or tank **38** (ref., FIGS. 13, 14 and 15). The fitting **236** is connected to a cylindrical filter screen **238** mounted in the floor **240** of the seasoning reservoir. Mounted on the underface of this floor **240** is an electrical ring heater **242** having terminals **244, 246** and which is

resiliently mounted by a supporting member **248** through intermediation of bolt **250** and screw **252**. Also mounted on the floor **240** of the reservoir is a regulating thermoswitch **254** which serves to control the temperature of the seasoning oil by regulating the temperature of ring heater **242**. As the seasoning melts (this can be observed through window **243** in reservoir **38**) it passes through the cylindrical filter **238**, the floor of reservoir **240** and the tube **234** to the solenoid valve **230** which is operated under the control of the inverse thermoswitch **134**. When switch **134** senses an elevated temperature in the popping chamber and operates to deliver corn by the kernel feeding means **76**, the solenoid valve **230** is simultaneously energized and opened to allow said seasoning oil to flow through the pipe **228** to the seasoning metering housing **218**.

The housing **218** has a lateral port **256** which is adapted to intermittently register with a transverse port **258** in metering shaft **216** as the latter rotates. A vertical discharge port **260** is also provided in the lower extremity of metering shaft **216** and is preferably centrally located therein. This discharge port **260** intersects with transfer port **258** to accept and deliver seasoning oil as it is intermittently fed to rotating port **258** by port **256**. Oil metering shaft **216** can be displaced upwardly or downwardly in its housing **218** by means of an adjusting screw **262** seated in an annular recess **264** at the end of shaft **216**. By adjusting the height of the port **258** in relation to the port **256** as shown in FIG. 17, the amount of seasoning oil receivable within the rotating port **258** is regulated and in that way the rate at which the oil is discharged onto the mixing tray **192** can be further controlled.

The salt metering means are shown more fully in FIGS. 10–12. A transparent salt box **270** filled with salt rests within and is supported on salt box support **272** which is anchored to the top of the display case **30** by suitable means shown at **274**. The bottom of the salt box consists of a screen **276** through which finer particles of salt pass. The salt passes through screen **276** and falls into funnel **278** which is seated within flexible tube **280**. The flexible tube in turn has seated therein a complementary metering tube **282** which receives the salt and guides it onto knurled metering wheel **284**. The lower extremity of metering tube **282** is shaped arcuately so as to evenly surround a segment of the metering wheel **284** which is driven by motor **286** through intermediation of horizontal shaft **288**. Mounted on shaft **288** are a pair of pins **290**, **292** which are adapted to engage and deflect leaf spring **294** fixedly attached to bracket **296** embracing metering tube **282**.

As in the case of the solenoid valve **230**, when the inverse acting thermoswitch **134** operates corn kernel feeding means **76**, the salt metering motor **286** drives shaft **288** to deflect leaf spring **294** by means of pins **290** and **292** and thereby vibrates flexible tube **280** through intermediation of bracket **296** to promote supply of salt through metering tube **282** onto knurled metering wheel **284**, whereon any lumps of salt passing screen **276** are broken up. The knurled wheel **284** then conveys the salt particles into a position where they will fall freely within salt metering housing **298** through the floor **72** of the display case and onto the mixing tray **192**. The gap between the metering tube **282** and the metering wheel **284** can be adjusted by adjusting the elevation of the metering shaft **288** and motor **286** which is mounted on bracket **300**, which in turn is adapted to be moved up or down by adjusting screw **302**. This is accomplished by fixedly mounting on bracket **300** a screw **304** which is threaded into bushing **306** mounted on plate **308** and attached to floor **72**. As the screw **304** is rotated to displace the bracket **300** upwardly and in turn close the gap between wheel **284** and tube **282**, the head of set screw **302** will abut the lower face of bushing **306**. To widen the gap between the wheel **284** and the tube **282**, screw **304** is rotated in an opposite direction until the bracket **300** abuts the upper extremity of bushing **306**. In this way stalling of motor **286** by too close a gap between the wheel **284** and the tube **282**, or overflow of salt by too wide a gap therebetween is prevented.

To accommodate for the minor adjustment occasioned by vertical displacement of shaft **288** and also provide a moisture-proof gland or packing at the point of entry of the shaft into metering housing **298**, a flexible grommet **308** surrounds shaft **288** and is mounted on housing **298** by means of plate **310**.

The operation of the corn popping apparatus will now be described, in the course of which description reference will be made to FIGS. 22*a* and 22*b* comprising a wiring diagram for the apparatus. The control circuitry can be oriented with respect to the mechanical features of the apparatus by reference to terminal board **311** (terminals **1–23**), terminal board **313** (terminals **24–35**), terminal board **315** (terminals **36–52**), terminal board **317** (terminals **53–64**), and terminal board **319** (terminals **70–75**), which are seen to be mounted on floor **72** in FIG. 2. The operator places main switch **312**, corn and seasoning switch **314**, and lights and dryer switch **316** to the "On" position, and places the production rate switch **318** to the "High" position to obtain a maximum rate of warm-up; these switches are located on control panel **319**. In closing the switches **312**, **314** and **316** and placing switch **318** in the "High" position, the seasoning heater **242** is energized through thermoswitch **254**, all heaters **178A**, **178B**, **178C**, **178D**, **178E** in heater box **164** are energized, time delay motor **321** is de-energized closing normally closed switch **320**, the timer motor **322** of timer assembly **324** is energized, the cooling fan motor **326** mounted on the back panel of display case **30** (ref., FIG. 2) is energized, the constant speed motor **222** driving the spider **206** and the oil metering shaft **216** is energized, the gas blower drive motor **177** is energized, the reject solenoid **158** is energized to close the flapper gate **152** against the tension of spring **159**, corn dryer motor **328** and dryer-heater **329** are energized, fluorescent lights **330**, **332**, **334**, **336**, the spot light **40**, and the flood lights **338**, **340** are energized.

After approximately a ten minute interval, during which hot air is circulated through the heater box **164** and the popping chamber and recirculated therethrough, the temperature in the popping chamber will reach a pre-selected temperature corresponding to the temperature setting of the inverse acting thermoswitch **134**, at which time the contacts of switch **134** close energizing the following: corn feed motor **106**, salt feed motor **286**, and seasoning solenoid valve **230**. Thereupon kernel feeding means **76** introduces raw, unpopped corn kernels into the stream of upwardly moving hot air in duct **118** air-veying the kernels into the popping chamber where they are suspended and agitated for a period of time sufficient to heat and pop them, whereafter they are air-veyed up through and out of cylindrical section **124** into dome jar **42** and are deflected radially and thence downwardly by the jar **42** onto the mixing tray **192**, the popped corn being prevented from entering the gas blowing and gas heating means by screen **186**. After being deposited upon the mixing tray **192**, the popped kernels are mixed by means of rotating spider **206** with the seasoning and salt deposited thereon by the salt metering means and the seasoning metering means. After a period of mixing, the seasoned and salted popped corn is then displaced from the stationary tray **192** through the cut-out gap provided in the cylindrical wall portion thereof **193**. The salted and seasoned popped corn then falls into the display case from which it can be scooped as described above. During this popping operation, unpoppable corn kernels will continue to collect in the popping zone.

Simultaneous with the aforesaid corn kernel feeding and air-veying operation, the temperature of the air-kernel mixture in the popping chamber will drop by virtue

of the addition of raw corn until the temperature is reduced to a point where it causes the inverse thermoswitch **134** to open and to de-energize the corn feed motor **106**, the salt feed motor **286** and the seasoning solenoid valve **230**. The aforesaid conditions are thereafter repeated, during which time corn is continuously popped, salted, seasoned and dropped into the display case **30**. At this point it should be understood that the operating cycle can be terminated at any time simply by throwing the main switch **312** to the "Off" position, at which point time delay means to be hereinafter described function for a time to continue popping corn in the popping chamber. Furthermore, the starting of the machine may also take place at any point during the cycle consisting of fifteen minutes in this particular case.

After a number of intermittent feedings which provide a continuous and appetizing fountain-like shower of popped corn in the transparent spotlighted jar **42**, a point of time is eventually reached when it becomes desirable to automatically reject those unpoppable corn kernels which accumulate and are suspended in the popping chamber, burden the popping capacity of the unit, prolong the mean popping time for the kernels, and affect the quality of the poppable corn. To terminate the operating cycle, the time cycle motor **322** de-energizes the corn feed motor **106** by means of a cam (not shown) which opens switch **341** of timer assembly **324**. Thereafter corn is no longer fed into the duct **118**. During this period, the seasoning solenoid valve **230**, the salt feed motor **286** and the various heaters **178** in heater box **174** continue to operate. After a period of about a minute, the salt feed motor **286** and the seasoning solenoid valve **230** are de-energized by means of timer motor **322** opening switch **343** in the manner in which switch **341** is opened, thereby terminating the metering of seasoning and salt for a period of about two minutes. After the salt feed motor **286** and the seasoning solenoid valve **238** are de-energized about an additional forty-five seconds transpire to pop the residual load of corn in the popping zone. Thereafter the reject solenoid **158** and the blower motor **177** are simultaneously de-energized by timer motor **322**, which in turn opens switch **345**; the de-energizing of blower motor **177** and reject solenoid **158** brings about opening of flapper gate **152** and allows unpopped kernels or "old maids" to drop through the duct **118** into reject collecting container **46**, as seen in FIG. 2. Thereafter timing motor **322** while still energized or closes switch **345** which energizes blower motor **177** and reject solenoid **158** to allow flapper gate **152** to close under tension of spring **159**. A slight delay of about fifteen seconds takes place after which time the time cycle motor **322** closes switch **341** to re-energize corn feed motor **106**. Thereupon the operation of the corn feed motor **106** is again controlled by the operation of the inverse acting thermoswitch **134** in the popping chamber.

From the point of time that the corn feed motor **106** is re-energized about one minute transpires before timing motor **322** closes switch **343** to operate seasoning solenoid valve **230** and salt feed motor **286** to resume the seasoning and salting of popped corn. This description completes a typical warm-up cycle. The second, third, fourth, etc. cycles will consist of fifteen minute cycles in this particular operation. Upon reaching about the fourth cycle, equilibrium conditions and normal control operations will be achieved. Normal operating cycles will be substantially like that of the aforesaid warm-up cycle except for the ten-minute warm-up period.

Of course, either the warm-up cycle or any subsequent cycle may be modified by operation of the control thermoswitches **136** and/or **180** as already described. For example, if during a normal or "equilibrium" operating cycle, a build-up of unpopped corn kernels should occur in the popping chamber and cause restriction of air flow and increase in the air temperature, the regulating thermoswitch **180** will sense this elevation in temperature and open at a predetermined setting to de-energize heater **178E**. This may also occur during the warm-up cycle. By de-energizing the heater **178E**, the maximum temperature of the heated air introduced to the popping zone is limited so as to avoid poor quality popped corn.

As described above, the thermoswitch **136** in the popping chamber serves to reduce the rapid increase of air temperature and usually is set so as to be effective during that portion of the cycle when kernel feed is terminated. However, it also prevents excessive temperatures of the air-corn mixture in the popping chamber stemming from any other cause such as an accumulated burden of unpopped corn kernels therein; and with a suitable setting, this thermoswitch **136** functions in substantially the same manner as switch **180**, cooperating with the switch **134** in maintaining the proper relationship between the kernels and the heat necessary to pop them. Such regulation is achieved by switch **136**, whatever its setting, by de-energizing heaters **178B** and **178C** at the predetermined temperature.

In the event of failure of blower motor **177**, overheat thermoswitches **347** and **349** are provided in order to break the circuit energizing all of the heaters contained in the heater box, to wit, heaters **178A, B, C, D** and **E**.

Should the operator desire to alter the production rate from a high rate to a medium or low rate, the production rate switch **318** is placed in the medium or low position. Thus, at a low production rate two of the five heaters **178** are disconnected electrically, and in the case of a medium production rate, one heater is disconnected, thereby reducing the supply of heat to the air-corn mixture in the popping chamber, which, in turn, reduces the rate at which corn is being fed intermittently to the duct **118** under the control of the inverse acting thermoswitch; and since the inverse thermoswitch for the most part controls the rate of seasoning and salting through seasoning solenoid valve **230** and salt feed motor **286**, respectively, the rate at which popped corn is seasoned and salted is correspondingly reduced resulting in a controlled proportion of seasoning and salt to popped corn at all operating production rates.

If the demand for popped corn will not be so great as to require continuous operation of the machine throughout the day, the operator may wish to suspend the corn popping operation temporarily, that is, interrupt the feed of raw kernels of corn, salt and seasoning; however, the operator may wish to maintain the machine in a warm, ready-to-run condition. This is done by throwing the corn and seasoning switch **314** to the "Off" position which de-energizes the salt feed motor **286** and the seasoning solenoid valve **230** as well as corn feed motor **106**. It will be noted that the switch **312** during this period is in the "On" position so that the various heaters **178** in heater box **164** will be operable in accordance with the setting of production rate switch **318** and with the temperature settings of the respective thermoswitches **180** and **136**; of course, any popping occurring of residual corn kernels during this shutdown period will remain under the control of the thermoswitches **136** and **180**.

To terminate the operation of the machine at any chosen time, the operator simply throws the main switch **312** to the "Off" position. This de-energizes the seasoning solenoid valve **230**, the salt feed motor **286**, the corn feed motor **106**, the heaters **178** in heater box **164**, and the seasoning heater **242**. Placing the main switch **312** in the "Off" position also energizes the time delay motor **321**, which, in turn, opens time delay switch **320** approximately 90 seconds later. Upon the opening of switch **320**, the blower motor **177** is de-energized as is the reject solenoid **158** (to disperse "old maids" as aforesaid) and the seasoning tray motor **222**. At the option of the operator, the corn drier motor **328** and the various lights such as the spotlight **40** and the various fluorescent lights as well as the floodlights can be turned off simply by placing the switch **316** in the "Off" position.

A preferred embodiment of the corn popping apparatus of the present invention and its mode of operation has now been fully described. While the invention has been explained by reference to one preferred embodiment, it will be understood that other means may be employed to accomplish the same result and yet will be embraced by the spirit of the invention. Thus, instead of the various constant speed motors which operate intermittently, to wit, the corn feed motor **106** and the salt feed motor **286**, variable speed motors may also be substituted therefor, all of such motor means being employed to control the respective rates of operation. Likewise, in lieu of the seasoning solenoid valve **230** which operates intermittently under the control of signals from the inverse acting thermoswitch **134**, an equivalent adjustable valve mechanism operating more or less continuously may be substituted therefor.

Furthermore, the invention should be understood in its broadest aspect as embracing novel means for continuously regulating the rate at which heat is supplied to popcorn kernels; more specifically, in its broadest aspects, the invention incorporates into a continuous kernel popping apparatus means for regulating the temperature of heated gas, e.g., air, in accordance with the rate at which kernels of corn are introduced to the popping operation. The invention has been described in detail in terms of novel means for sensing the temperature of the gas-kernel mixture in the popping chamber and thereby regulating the feed of corn kernels to the popping chamber, this being accomplished through the control exercised by the inverse acting thermoswitch **134** over the corn feed motor. The location of this sensing means in the floating bed itself, as well as its use to regulate corn feed instead of heat supply, are important features of the invention for reasons set forth above.

While the present invention has been described with particular reference to specific examples, it is not to be limited thereby, but reference is to be had to the appended claims for a definition of its scope.

What is claimed is:

1. Kernel popping apparatus comprising a housing, a popping device including a duct disposed vertically within said housing and having an open upper end, means for blowing hot gas into the lower end of and upwardly through said device, means for recycling said hot gas to said blowing means, means for feeding raw kernels into said device down stream from said blowing means, said blowing means producing a gas velocity sufficient to maintain continuously in said device a bed of unpopped kernels through which gas is circulated to maintain the individual kernels in suspension and agitation while supplying unpopped kernels to said bed and carrying popped kernels out of the open upper end of said device, means upstream from said device for supplying to said circulating gas a quantity of heat normally sufficient to pop suspended kernels at substantially the rate at which unpopped kernels are delivered to said bed, means responsive to the temperature in said bed for increasing said rate of delivery when the temperature in said bed exceeds a predetermined minimum value and for decreasing said rate of delivery when the temperature in said bed is below a predetermined minimum value, said heating means including a plurality of heating units, and means for deenergizing certain of said units thereby decreasing the amount of heat supplied to said gas and decreasing the temperature in said bed below said predetermined minimum value to decrease the production rate of the apparatus.

2. Kernel popping apparatus comprising a housing, a popping device including a duct disposed vertically within said housing having an open upper end, means for blowing hot gas into the lower end of and upwardly through said device, means for recycling said hot gas to said blowing means, means for heating said gas prior to its return to said device, means for feeding raw kernels into said device down stream from said blowing means, said blowing means producing a gas velocity sufficient to maintain continuously in said device a bed of unpopped kernels through which said gas is circulated to maintain the individual kernels in suspension and agitation while supplying unpopped kernels to said bed and carrying popped kernels out of said open upper end, said heating means supplying to said gas a quantity of heat normally sufficient to pop suspended kernels at substantially the rate at which unpopped kernels are delivered to said bed, means responsive to the temperature in said bed for regulating said heating means to prevent the temperature of the gas blown into said device from exceeding a predetermined temperature, means responsive to the temperature in said bed for varying the quantity of unpopped kernels fed to said device and thereby compensating for fluctuations of the popping temperature in said bed, said last named means increasing the rate of feed of said kernels when the temperature in said bed exceeds a predetermined minimum value and decreasing said rate of feed when the temperature in said bed is below a predetermined minimum value, said heating means including a plurality of heating units, and means for deenergizing certain of said units thereby decreasing the amount of heat supplied to said gas and decreasing the temperature in said bed below said predetermined minimum value to decrease the production rate of the apparatus.

3. Kernel popping apparatus as defined in claim **2**, said predetermined temperature being greater than said predetermined minimum temperature.

4. Kernel popping apparatus comprising a housing, a popping device including a duct disposed vertically within said housing and having an open upper end, means for blowing hot gas into the lower end of and upwardly through said device, means for recycling said hot gas to said blowing means, means for heating said gas prior to its return to said device, means for feeding raw kernels into said device down stream from said blowing means, said blowing means producing a gas velocity sufficient to maintain continuously in said device a bed of unpopped kernels through which said gas is circulated to maintain the individual kernels in suspension and agitation while supplying unpopped kernels to said bed and carrying popped kernels out of said open upper end, said heating means supplying to said gas a quantity of heat normally sufficient to pop suspended kernels at substantially the rate at which unpopped kernels are delivered to said bed, means sensing the temperature of the gas in said heating means and regulating the same to maintain the temperature of the gas blown into said device below a predetermined temperature, means sensing the temperature of the gas-kernel bed in said device and increasing the rate at which kernels are fed thereto when the temperature in said bed reaches a predetermined minimum value and decreasing said rate when said temperature is below a predetermined minimum value, said heating means including a plurality of heating units, and means for deenergizing certain of said units thereby decreasing the amount of heat supplied to said gas and decreasing the temperature in said bed below said predetermined minimum value to decrease the production rate of the apparatus.

5. Kernel popping apparatus comprising a housing, a popping device including a duct disposed vertically within said housing and having an open upper end, means for blowing hot gas into the lower end of and upwardly through said device, means for recycling said hot gas to said blowing means, means for feeding raw kernels into said device down stream from said blowing means, said blowing means producing a gas velocity sufficient to maintain continuously in said device a bed of unpopped kernels through which said gas is circulated to maintain the individual kernels in suspension and agitation while supplying unpopped kernels to said bed and carrying popped kernels out of said open upper end, means up-

stream from said device for supplying to said circulating gas a quantity of heat normally sufficient to pop suspended kernels at substantially the rate at which unpopped kernels are delivered to said bed, means sensing the temperature of the gas-kernel mixture in said bed for varying the quantity of kernels fed to said bed to thereby compensate for fluctuations of the popping temperature in said bed, said last named means increasing the rate of feed of said kernels when the temperature in said bed exceeds a predetermined maximum value and decreasing said rate of feed when the temperature in said bed is below a predetermined minimum value, said heating means including a plurality of heating units, means for de-energizing certain of said units thereby decreasing the amount of heat supplied to said gas and decreasing the temperature in said bed below said predetermined minimum value to decrease the production rate of the apparatus, and means for supplying flavoring material to said popped kernels, said flavor supplying means also being controlled by said sensing means to supply flavoring material to said popped kernels in accordance with the rate at which unpopped kernels are fed to said device.

6. Kernel popping apparatus as claimed in claim 5, said flavor supplying means comprising means for delivering measured quantities of salt to the popped kernels.

7. Kernel popping apparatus as defined in claim 5, said flavor supplying means comprising means for delivering measured quantities of liquid seasoning to the popped kernels.

8. Kernel popping apparatus comprising a housing, a popping device including a duct disposed vertically within said housing and having an open upper end, means for blowing hot gas into the lower end of and upwardly through said device, means for heating and recycling said hot gas to said blowing means, means for feeding raw kernels into said device down stream from said blowing means, said blowing means producing a gas velocity sufficient to maintain continuously in said device a bed of unpopped kernels through which said gas circulates to maintain the individual kernels in suspension and agitation while supplying unpopped kernels to said bed and carrying popped kernels out of said open upper end, said heating means supplying to said gas a quantity of heat normally sufficient to pop suspended kernels at substantially the rate at which unpopped kernels are delivered to said bed, means responsive to the temperature in said bed for increasing said rate of delivery of unpopped kernels thereto when the temperature in said bed exceeds a predetermined minimum value and for decreasing said rate of delivery when the temperature in said bed is below a predetermined minimum value, said heating means including a plurality of heating units, means for deenergizing certain of said units thereby decreasing the amount of heat supplied to said gas and decreasing the temperature in said bed below said predetermined minimum value to decrease the production rate of the apparatus, means terminating operation of said feeding means while said blowing means continue to operate, and second means responsive to the temperature in said bed and operative at a predetermined temperature higher than said minimum value to control the amount of heat supplied by said heating means during the kernel feed termination period.

9. Kernel popping apparatus comprising means forming a closed circulating path for heating gases, a popping device forming a vertically disposed part of said path whereat popped kernels are separated from unpopped kernels, means for delivering raw unpopped kernels to said path upstream from said device at a variable rate, gas blowing means in said path for circulating the gases through said device at a velocity sufficient to maintain a bed of said unpopped kernels in suspension and agitation in said device, said gases passing upwardly past the point of delivery of said kernels and upwardly through said device, means in said path further upstream from said device than said point of delivery for supplying heat to said circulating gases, and temperature-responsive means located in said bed in said device to control said kernel delivery means to vary said rate of delivery directly proportional to variations of temperature in said bed, popped kernels being carried upwardly away from said bed by said upwardly circulating gases.

10. Kernel popping apparatus as defined in claim 9, including temperature-responsive means exposed to the temperature of said circulating gases in said bed and operatively connected with said heat supplying means for reducing the supply of heat to said gases whenever their temperature reaches a predetermined maximum.

11. Kernel popping apparatus as defined in claim 10, including timing means for interrupting operation of said kernel delivery means after a predetermined period of popping and for a predetermined interval.

12. Kernel popping apparatus as defined in claim 11, said timing means being also operable to interrupt the operation of said gas blowing means after a portion of said interval has elapsed, thereby permitting discharge of remaining unpopped kernels by gravity from said popping device.

13. Kernel popping apparatus as defined in claim 9, including means for delivering flavoring material to said popped kernels, said flavor delivering means being controlled by said temperature-responsive means.

14. A method of popping kernels continuously which comprises circulating hot gas upwardly through a vertically disposed popping zone in a recirculation path at a velocity sufficient to maintain a bed of unpopped kernels in suspension in said zone while air-veying popped kernels upwardly away from said bed in said zone, removing the popped kernels from said gas and recirculating the gas to said zone at said velocity while adding heat thereto from a heat source upstream from said zone at a constant rate normally equal to the heat losses therefrom, maintaining the temperature of the gas-kernel mixture in said bed at an approximately constant value by delivering raw unpopped kernels into said path upstream from said zone and downstream from said heat source at an average rate varying directly with the temperature of said gas-kernel mixture in said bed, and limiting the temperature of said circulating gases to a predetermined maximum by reducing said rate of heat supply in response to increase of the circulating gas temperature substantially above said approximately constant value.

15. A method of continuously popping kernels which comprises continuously recirculating hot gases in a closed path including a heat supply zone and a vertically disposed popping zone downstream from said heat supply zone at a normally substantially constant velocity sufficient to maintain a bed of unpopped kernels in suspension in said popping zone while air-veying popped kernels therefrom, supplying heat to said circulating gases in said heat supply zone at a constant rate, replenishing said bed by delivering raw unpopped kernels into said path upstream from said popping zone and downstream from said heat supply zone, regulating the rate of delivery of said unpopped kernels in response to the temperature in said bed to vary said rate directly with said temperature and maintain an approximately constant popping temperature in said bed, popped kernels being removed from the circulating gases prior to their return to the popping zone.

16. A method as defined in claim 15, including the steps of supplying flavoring materials to the popped kernels and controlling the rate of supply thereof in response to the temperature in said bed and in predetermined proportion to said rate of delivery of unpopped kernels to said bed.

17. A method as defined in claim 15, including the step of discontinuing the delivery of unpopped kernels to said bed at the end of a predetermined period of operation and continuing the circulation of said hot gases for a predetermined interval thereafter.

18. A method as defined in claim 17, including the steps of discharging unpopped kernels remaining in suspension after said interval to waste and thereafter resuming the delivery of raw unpopped kernels to the popping zone to reform said bed.

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