Dec. 27, 1949 LE ROY. R. HAWK 2,492,635

METHOD AND APPARATUS FOR HEATING MILK

Filed Jan. 17, 1947

FIG_1_

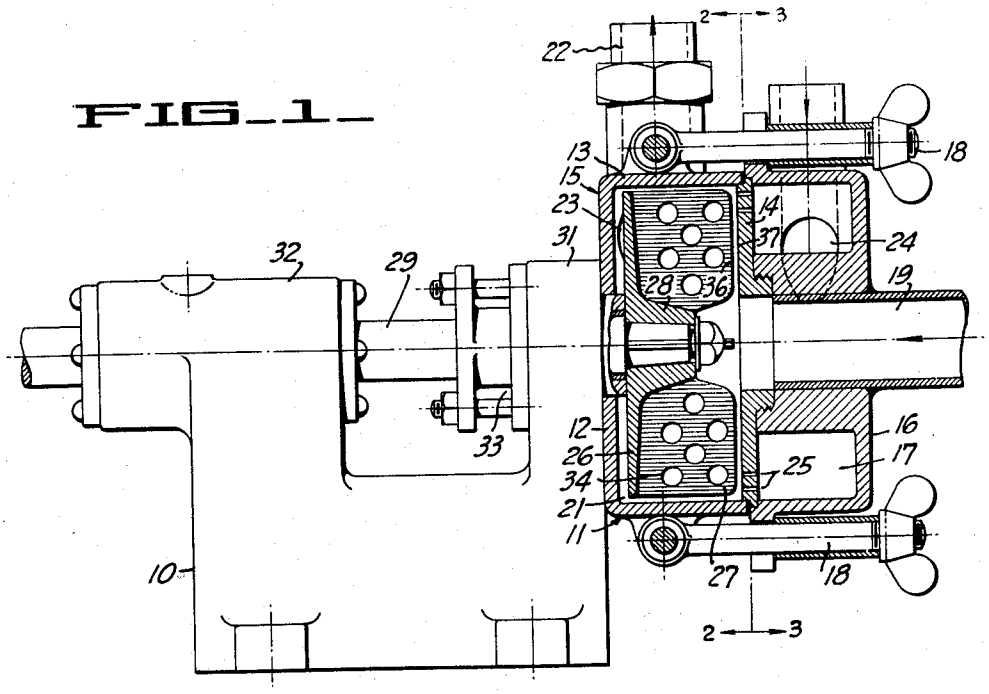


FIG_2_

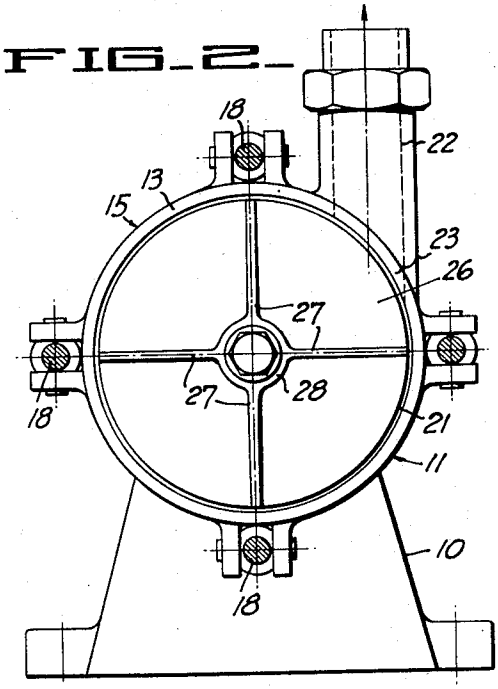
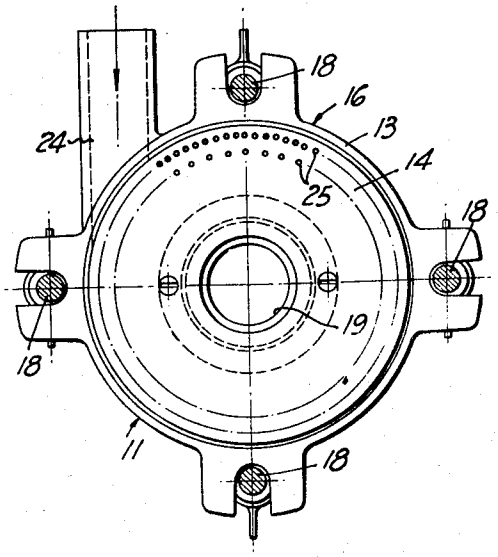


FIG_3_



INVENTOR.
Le Roy R. Hawk
BY Paul D. Fleher
ATTORNEY

Patented Dec. 27, 1949 2,492,635

UNITED STATES PATENT OFFICE

2,492,635

METHOD AND APPARATUS FOR HEATING MILK

Le Roy R. Hawk, San Francisco, Calif., assignor to Golden State Company, Ltd., San Francisco, Calif., a corporation of Delaware

Application January 17, 1947, Serial No. 722,657

6 Claims. (Cl. 99—216)

1

This invention relates to the art of treating liquids to markedly raise their temperature almost instantaneously. More particularly it pertains to an apparatus and method for bringing coagulable liquid colloidal systems into contact with warming steam without deleterious effects. Still more particularly, it relates to rapid, relatively complete condensation of steam injected into milk and viscous milk concentrates whereby relatively efficient heat transfer is accomplished.

Many methods have been devised for injecting steam into a liquid to raise its temperature. All of these methods have some disadvantages although they do avoid the incrustation problem of the heat exchangers. The ordinary direct injection nozzle is acceptable for heating water but is not useful for viscous solutions since the suction of the injector is not strong enough to move viscous materials, for example, cold molasses or milk concentrates. Many patents have been issued which show steam issuing from a multiplicity of jets. These steam jets are usually directed through a thin layer of milk in a manner to cause the milk and steam to be driven through secondary jets into a low pressure receiving area. This method of sterilizing and heating milk requires a relatively large pressure differential between steam and receiving area, and high velocity of 1400 ft./sec. for efficient operations. This method also tends to "burn" the milk at the secondary jets and to impart an undesirable flavor. It creates heavy vibrational effects in the equipment and objectionable noise unless properly adjusted. For fairly efficient operation, such devices require that materials such as milk be preheated so that the "jump" temperature rise is not more than about 75 to 100° F.

Still another system which is sometimes used, is the introduction of steam through a nozzle in the periphery of a circular casing. This nozzle is positioned in the area where rotational speed is greatest so that the combination of static pressure plus pressure due to rotational velocity causes the liquid to exert a pressure only slightly less than the pressure of the steam. This pressure must be high enough so that it will exceed the vapor pressure of the liquid. Under these conditions flashing and cooling of the liquid is avoided. This device, like the others, has a limited effective "jump" or quick heating range. When it is operated at high liquid capacities the noise and vibrational effects common to steam jets is present. In addition this arrangement puts a hot metal surface on which lacteal liquids will

2

"burn" in the path of a stream of flowing liquid. It has long been known that use of velocity alone to sweep heated surfaces clean of burnt material is impractical. As viscosity and adhesive properties increase for the velocities previously employed, velocity alone becomes increasingly ineffective. Another disadvantage is that once burnt material adheres to a metal surface, the burnt material will continue to impart to any liquid coming in contact therewith a characteristic flavor.

The novel construction of the present invention provides a method of apparatus capable of overcoming all of the above disadvantages of quick heating devices used heretofore.

More explicitly, it is an object of this invention to provide an apparatus and method of almost instantaneously heating liquids, regardless of their viscosity, to a controlled temperature.

It is a further object of this invention to heat liquids without stratified and uneven heating.

It is a further object to almost instantaneously create pasteurizing and sterilizing temperatures in liquid under controlled conditions such that localized overheating and resultant "burning" is avoided.

It is a further object of this invention to provide a closed heating apparatus from which air may be excluded.

It is a further object of the invention to provide an apparatus and method for heating lacteal liquids to high temperatures without need for preheating.

It is a further object of the invention to provide an apparatus and method whereby hotter steam may be used and consequently higher emperatures may be imparted to food products such as milk than could be attained heretofore without localized overheating.

It is a further object of this invention to provide an apparatus and method whereby viscous, relatively non-flowing, colloidal suspensions can be efficiently heated to processing temperatures without deleterious effects or noisy operation.

It is a further object to produce a sanitary heating apparatus, capable of easy disassembly for rapid cleansing.

Further objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings wherein is set forth by way of illustration and example, one preferred embodiment of this invention.

Referring to the drawing:

Figure 1 is a side elevational view partly in sec-

tion illustrating apparatus incorporating the present invention.

Figure 2 is a cross-sectional detail taken along the line 2—2 of Figure 1.

Figure 3 is a cross-sectional detail taken along the line 3—3 of Figure 1.

When operating according to the preferred method of the instant invention, milk flows continuously through a chamber of small volume. Steam at relatively low velocity enters the milk in the form of a multiplicity of streams directed parallel to the axis of an agitator blade mounted in the chamber. These streams are broken into very small segments by the motor driven agitator, which makes, for example, 1750 R. P. M. The steam is thoroughly mixed with the milk by violent agitation. The steam is condensed without vibrational or pounding effects and the heat uniformly transferred to the milk by the time the liquid leaves the unit.

This invention is particularly useful in connection with the processing of highly viscous materials. Pumping such materials through heat exchangers as a preliminary to evaporation, etc., is inefficient because of the limited heat transfer through the coatings of viscous materials adhering to the exchanger walls. Secondly such apparatus has a limited temperature range of operation, within which undesirable heat effects such as burning can be avoided. The ideal procedure, therefore is one eliminating heating or heated surfaces. This requires a new satisfactory method and means of handling extremely viscous materials, and consequently the provision of the method and means of this invention constitutes an important and valuable contribution to this art.

Briefly, the aparatus of the present invention comprises a closed chamber. A high speed agitator or mixer capable of causing marked turbulence and mixing is mounted in the chamber. A multiplicity of relatively low velocity streams of steam are directed so that the streams are continuously and multitudinously segmented by the agitator.

The more preferable embodiment of the invention, because of its simplicity and limited number of parts, comprises a casing or housing having a central chamber of circular or volute formation termed the back wall member and fitted with a detachable specially designed face plate. Mounted in the housing chamber is an agitator or impeller unit composed of one or more blades whose length and width are such as to sweep substantially the entire chamber. This agitator is mounted on an axially aligned shaft preferably with small clearance from the steam injector face plate and is driven by suitable rotating means such as an electric motor or other prime mover capable of imparting high speed rotation.

Suitable means are provided for projecting into and removing from the housing, liquid being processed. Preferably this consists of an axial liquid inlet opening in the center of the removable face plate and an outlet flow means usually tangentially directed at the periphery of the central chamber. Each of the inlet and outlet openings may be provided with suitable sealing means whereby pipes or flexible conduits may be detachably connected thereto.

The specially designed face plate usually carries the liquid inlet aperture. Mounted on the external side of this face plate so as to cover the steam port area of the face plate is an annular shaped jacket. This jacket communicates with

the central chamber through a ring of ports having a predetermined minimum area. Preferably these apertures communicate with the central chamber along an area where there is marked agitation. Steam enters the jacket, preferably tangentially, and passes through the ports into the liquid being violently agitated by the impeller.

Referring to the detailed construction illustrated in Figures 1, 2 and 3, the preferred embodiment of the invention illustrated consists of a suitable supporting structure 10 which serves to mount the mixer assembly 11. The mixer assembly consists of a main body 15 which is circularly contoured and which includes the back wall 12 and the peripheral side wall 13. Extending across the front of this housing there is a face plate 14 which is likewise circularly contoured and in this instance substantially planar. Plate 14 is mounted upon one side of a body 16, which is formed to provide an inner steam space 17. For convenience plate 14 together with body 16 are assembled as one unit, which in turn is detachably clamped to one side of the body 15 by suitable means such as the hinged clamping bolts 18.

Passage 19 communicates through the central portion of plate 14 with the treatment chamber 21 within the main body 15. Milk to be treated is introduced through the passage 19, and after being treated within the chamber 21 is discharged through the outlet passage 22. The outlet passage preferably communicates tangentially with the interior of chamber 21 through the port 23.

Passage 24 serves as a steam inlet and is adapted to be connected to a suitable source of steam under pressure. This passage can likewise communicate tangentially with the steam space as illustrated.

The plate 14 is provided with a plurality of relatively small ports 25 by means of which steam passes from the space 17 into the treatment chamber 21. These ports are preferably distributed about the center of plate 14 and for convenience they can be arranged in two concentric circular rows as illustrated in Figure 3.

Within the treatment chamber 21 there is an impeller 26 consisting of one or more impeller blades 27 carried by a suitable hub 28. The hub is mounted upon one end of the rotatable shaft 29. As illustrated this shaft can be carried by the bearings 31 and 32, and leakage past the shaft can be prevented by use of a suitable packing gland 33. It is desirable that the blades 27 be provided with openings 34 as illustrated in order to provide a relatively great amount of turbulence during rotation. It will be noted that these blades and particularly edges 36 sweep relatively close to the adjacent face 37 of the plate 14 and relatively close to the points of communication of the ports 25 with the treatment chamber 21. It is, of course, to be understood that blade designs other than that shown can be used. Particularly effective are blades which have a thin knife like leading edge near the steam ports and which are curved in such a manner that material and steam tend to be impelled toward the opposite side of the chamber from the steam port plate.

The parts forming the passages 19, 22 and 24 are threaded or otherwise formed to facilitate coupling the same with associated piping.

Operation of the apparatus described above, and the steps of the present method, can be described as follows: The liquid material to be

heated is supplied to the inlet 19 at a suitable regulated rate. Steam is supplied to the steam inlet 24 at a suitable regulated pressure depending upon the temperature to which the liquid material is to be heated. Outlet 22 is connected with piping whereby the heated liquid is discharged to other equipment, generally for further processing. Shaft 29 is driven at a suitable rate by use of an electric motor or like source of power, as for example at a speed of 1750 R. P. M. There is continuous flow of relatively cold milk into the treatment chamber 21 through the inlet passage 19. Within the treatment chamber the milk is subjected to intense continuous turbulence and agitation. Steam is continuously admitted to the treatment chamber through the small ports 25 and as it is admitted the agitator immediately "bites off" and thoroughly intermingles the steam with the liquid. The steam is condensed substantially instantaneously without pounding or vibrational effects such as are usually encountered when steam jets are introduced into a body of cool liquid. Simultaneously with condensing of the steam the milk is flash heated to a predetermined temperature level. The liquid leaves the treatment chamber through outlet 22 at a pressure only slightly greater than the pressure of liquid entering the inlet 19 and at the desired elevated temperature.

Assuming it is desired to clean the operating parts, bolts 18 are removed to enable the face plate assembly to be removed from the housing, thus opening up the housing so that it can be thoroughly cleaned and sterilized.

The advantages of this invention are that effective heat exchange and temperature raising can be carried out with various viscous substances such as corn syrup, molasses, milk concentrates of high centiforce viscosity, as well as with free flowing liquids and the like. According to my method a mass of the material is subjected to direct injection of steam under conditions to prevent occurrence or formation of steam pockets of any appreciable size. More specifically my method is predicated upon the discovery that an agitator that can cause the steam streams to be multitudinously segmented and to be thoroughly mixed into the liquid, can contact the steam with sufficient material to cause rapid, substantially complete condensation of the steam.

The success of this invention is believed to be attributable to the fact that the high speed impeller cuts the steam streams up into small segments. This action coordinated with interrelated controls to maintain the steam velocity within proper limits prevents occurrence of large bubbles or envelopes of steam. Thus steam is given no opportunity to displace liquid rather than to mix with the liquid. As a result vibration and noise effects due to collapse of large steam bubbles encountered in devices utilized heretofore, are eliminated.

Starting temperature is relatively unimportant to the instant invention except as it determines the amount of steam that will be condensed to raise the liquid temperature to the desired level. This process does not have a limited "jump" temperature range within which it operates efficiently. Starting material may have a temperature, for example, of about 50° F. and be heated to 240° F. in one pass through the hereinafter described unit as readily as though the starting temperature were in the range of say 180° F. to 200° F.

The volume of liquid to be heated merely determines the size of the mixer unit. Any mixer unit can be operated at liquid capacities from almost zero to its maximum with proper balance of the other factors discussed herein.

Steam temperatures determine the quantity of steam input necessary to heat the desired quantities of milk to the desired temperatures. Since there is no hot metal surface, upon which liquid can remain and get so hot as to "burn" the liquid, and all heat is directly and quickly dispersed throughout the liquid, higher steam temperatures can be utilized than heretofore. This results in steam condensate dilution being materially reduced. For example, heretofore use of higher than 300° F. steam has been considered impractical even when desiring to heat a liquid to the 240° F. to 260° F. temperature range. Now it has been found possible to utilize for example, 350° F. to 400° F. temperature steam without deleterious effect.

The critical and interrelated factors governing the efficiency of heat exchange in operations performed in accordance with applicants' inventions are turbulence, rotor speed proximity of agitator approach to steam inlet ports, and the difference between the liquid and steam pressures.

Turbulence governs the efficiency of mixing and the extent to which the steam comes in contact with liquid which will absorb heat from the steam and cause relatively complete condensation of the steam in a short period of time. Highly turbulent flow is desired in the mixer casing and is promoted by the ports 34.

The proximity of the rotor blades to the steam inlet ports 25 determines the size of segments of the steam stream being turbulently mixed into the liquid if the rotor speed remains constant and the difference in pressure between the liquid and the steam remains constant. If the rotor rotates within a few thousandth's of an inch clearance there is no opportunity for large bubbles of steam to form displacing liquid rather than being mixed into the liquid. For effective steam stream segmentation it has been found that unsatisfactory operation results when the rotor blades are set more than ½ inch from the steam ports for normal speeds in the range of 1000 to 2000 R. P. M.

The rotor speed must be such that the jets of steam are cut into numerous small segments which can be intimately mixed into the liquid being heated. Another factor in rotor speed is the number of blades of the rotor. For any rotor speed, the larger the number of rotor blades, the greater the number of steam jet segments formed. For two and four blade rotors, the desirable rotor speeds are generally in the range of 1000 to 2000 revolutions per minute.

The last factor is the difference in pressure between the liquid and the steam. This pressure difference makes itself felt in two ways. If the steam pressure is too high, steam bubbles of too great size are "driven" by their velocity into the mass of liquid being heated. These have an unbalancing effect upon the rotor and the collapse of big bubbles gives rise to the vibrational and noise effects discussed above. Secondly, if the steam pressure is too high the steam will displace liquid and take the path of least resistance which usually has the effect of steam flashing back up the liquid inlet line stopping liquid flow. While there may be varying combinations of pressure differentials and temperature levels depending upon the material being heated, it has been found desirable usually to limit the pressure difference to between about 2 to 20 lbs. per square

inch absolute and preferably to between 5 and 10 lbs. per square inch. In this way, the back pressure is high enough to limit the velocity of the steam to between 200 and 800 feet per second. Of course, the velocity of steam will be dependent also upon steam orifice area. The above steam velocities are predicated upon proper design of orifices to allow relatively free flow of steam. It will be recognized that 400° F. steam will have a pressure of approximately 250 lbs. per square inch absolute. In order to utilize 400° F. steam for my purpose, it is necessary to pass the steam through an expansion valve placed relatively close to the steam inlet passage 22. In this way steam enters the mixing unit at a pressure in the range above stated and still has a high temperature, provided the superheat has not been dissipated. However in some cases, depending upon the material being heated, desuperheating of the steam may be desirable.

For purposes of illustration, the following specific examples of actual runs carried out in accordance with this invention will now be given.

Example I

1000 gallons of whole dairy milk at a temperature of about 60° F. was heated in a heater unit made from a standard 1½ inch connection centrifugal pump. This pump was modified so as to operate and be within the above description. The milk entered the unit under pump suction at the rate of 20 gallons per minute and consequently had an internal pumping pressure of about 15 pounds under these operating conditions. Steam entered the unit through a ported face plate having 150 ports each of 3/64'' diameter giving the entering steam a total port area that resulted in a steam velocity of approximately 700 feet per second, at a temperature of about 230° F. or at about 20 pounds per square inch. The heated milk leaving the pump was at a temperature of approximately 160° F. This milk was conveyed to a vacuum chamber where it was flash cooled, then refrigerated and stored at about 40° F.

Example II

1000 gallons of whole milk at 40° F. was pumped under approximately 55 pounds pressure to the same heating unit as in Example 1, operating at a rate of 20 gallons per minute as before.

Steam entered the unit at a temperature of approximately 300° F. corresponding to approximately 65 pounds per square inch steam pressure.

The heated liquid leaving the unit was at a temperature of approximately 240° F. and was then conveyed to vacuum evaporators for concentration.

Example III

The approximately 200 gallons of heavy viscous concentrate of approximately 40% solids content from the evaporators of Example II was withdrawn from storage at 50° F. by a centrifugal pump and pumped under a pressure of about 70 pounds per square inch to the heater unit of Example I operating as follows: Another positive displacement pump was placed in the line after the heater and was driven at a fixed speed to pass the viscous concentrate through the heater at a predetermined rate of approximately 6½ to 7½ gallons per minute. Steam entered the heater through a pressure reducing valve set in the steam line close to the unit so that 150 lb. pressure (360° F.) was reduced to 80 pounds per square inch at the inlet ports without a marked drop in temperature.

The heated milk concentrate was withdrawn from the heater through a third positive displacement pump at a temperature of approximately 240° F. and subsequently processed.

In all three runs, operation was quiet, the mixer making no noise audible above the hum of the motor. The liquids were heated uniformly so that there was an outlet temperature seldom varying more than ±2 degrees from the desired temperature in the higher ranges and having even less variation at lower temperatures. The milk concentrate had no "burnt" flavor even after having been contacted with 360° F. steam.

In subsequent runs, milk concentrates of 25 to 50% solids content were heated in units which operated continuously for 6 hours, at the rate of 600 gallons per hour with 360° F. steam. At the end of these runs the heating unit showed no evidence of "burning" on the face plate whereas when operating with previous heating devices of the jet variety it was necessary to stop operating every 20 minutes, the time necessary to run only 200 gallons. After each 200 gallons run, it was necessary to withdraw the steam jet unit from its shell to remove "burnt" material adhering to the jet unit.

Although the present invention has been described in relation to the illustrated preferred form of apparatus, it should be understood that the present invention is not limited to the apparatus described, but refers to such modifications and equivalents as are obvious to one versed in the art. For example, the ports in the face plate may be staggered instead of being in one concentric ring. Also cavitation behind the impeller blades may be avoided by various means such as having one or more small holes in the impeller blade, to mention only one. Also various types of impellers and impeller mountings may be substituted for the impeller described, etc.

It will be seen from the foregoing that an instantaneous heater has been provided which is capable of handling liquids of wide variations of viscosity, i. e. from water to the most viscous liquids having centerpoise viscosities in the thousands, with equal facility.

Further it will be seen that this apparatus, because it has positive agitation instead of induced agitation, is capable of heating liquids such as whey concentrates which become thick and viscous upon heating, despite the condensed steam dilution, as well as liquids that are or become free flowing upon heating.

Further, it will be seen that apparatus has been provided that can handle two or more ingredients for simultaneous mixing and heating. For example, as well as mixing two liquids, the following may also be accomplished. Milk or milk concentrate having solid pieces of butterfat may be fed to such a unit, the butterfat becoming melted upon heating with steam and the butterfat thoroughly dispersed.

Further, it will be seen that this apparatus requires no auxiliary heating equipment such as preheaters.

Heater units constructed according to the present invention are particularly useful for preheating food products in their flow to evaporators and dryers.

I claim:

1. In heating apparatus of the character described, a casing forming a chamber of relatively small capacity having liquid inlet and out-

let apertures, a series of small ports in said casing, an agitation member mounted in said chamber to sweep in close proximity to said ports, means for imparting motion to said agitating member, a source of steam controlled temperature and pressure connected with said ports for introduction of steam into said chamber.

2. In heating apparatus of the character described, a casing forming a circular contoured chamber having a liquid inlet aperture and an outlet aperture, a series of small ports in said casing, a rotatable member mounted at the axis of said chamber to sweep in close proximity to said ports, means for imparting rotation to said rotatable member, a steam jacket exteriorly mounted on said casing in communication with said ports.

3. In heating apparatus of the character described, a casing comprising a back member and a removable face plate member forming a circular contoured chamber having a liquid inlet adjacent its axis, a rotatable agitation member mounted at the axis of said chamber to sweep in close proximity to the face plate, means for imparting rotation to said rotatable member, an outlet aperture in the peripheral wall of said chamber, an annular steam jacket exteriorly mounted on said face plate member, a concentric ring of ports in said face plate member establishing communication between said steam jacket and the chamber and serving to introduce steam.

4. In heating apparatus of the character described, a casing comprising a back member and a removable face plate member forming a circular contoured chamber having a liquid inlet aperture in the peripheral wall, a rotatable member mounted at the axis of said chamber to sweep in close proximity to the face plate, an outlet aperture adjacent the axis of said chamber, a

steam jacket exteriorly mounted on the casing and a series of ports in said face plate member establishing communication between said steam jacket and the chamber serving to introduce steam.

5. In heating apparatus of the character described, the combination of the mixer of claim 1 and a pump for introduction of viscous liquid into said mixer and a pump for removal of heated liquid which is capable of maintaining a pressure in the mixer outlet line slightly in excess of the steam pressure.

6. The method of rapidly heating a continuous stream of viscous liquid comprising introducing the liquid into a closed chamber of small capacity, relative to the volume passing, introducing steam in a plurality of streams, segmenting said streams of steam by the sweep of the edge of a high speed mixer blade in close proximity to the steam inlets, mixing said steam segments into said liquid and removing the heated liquid from the chamber under conditions to maintain pressure within the chamber slightly in excess of the steam pressure.

LE ROY R. HAWK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
939,481	Dickson	Nov. 9, 1909
1,063,294	Seaver, Jr.	June 3, 1913
1,342,135	Schmidt	June 1, 1920
1,838,721	Venske	Dec. 29, 1931
2,020,309	Grindrod	Nov. 12, 1935
2,077,227	Bethune	Apr. 13, 1937