July 2, 1940. B. DE H. MILLER 2,206,419

WORKING OF SOLIDIFIED PLASTIC MATERIALS

Filed Oct. 21, 1937

Fig. 1.

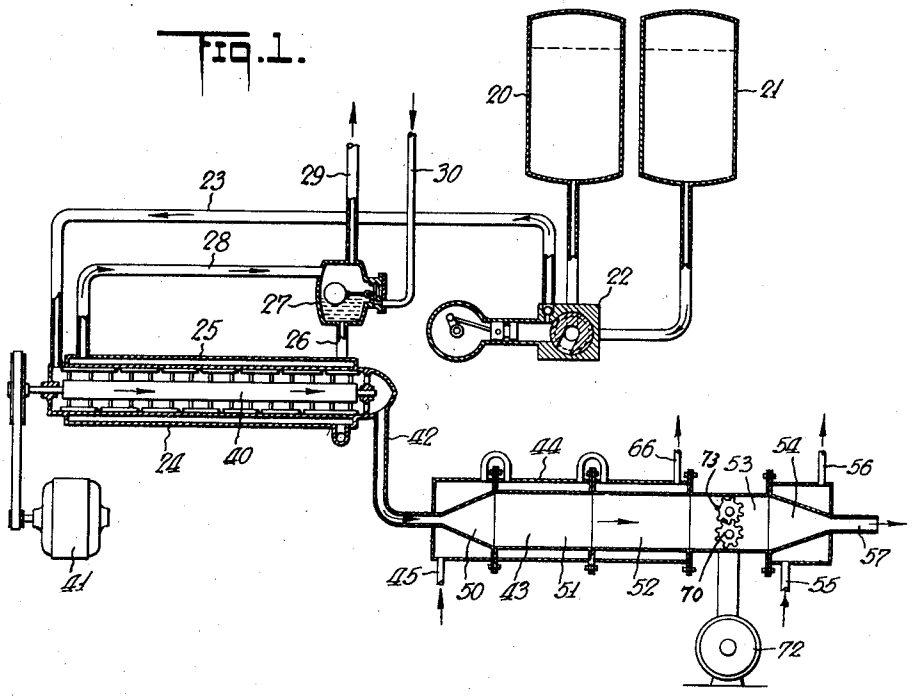


Fig. 2.

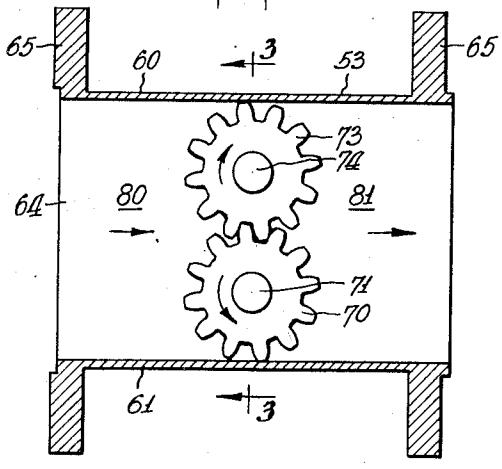
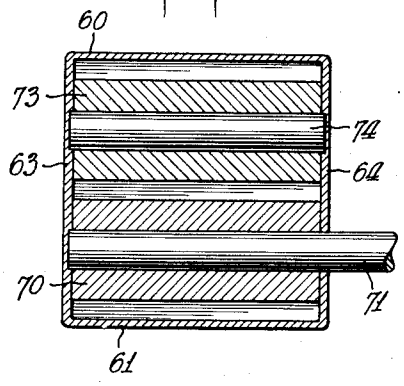


Fig. 3.



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WORKING OF SOLIDIFIED PLASTIC MATERIALS

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12 Claims. (Cl. 62—114)

This invention relates to an improved method and apparatus for treating materials following a change in the state of the materials from liquid condition into a semi-solid or solid condition. It also teaches a means for changing non-homogeneous materials of this type into a homogeneous product or for stabilizing any non-stable homogeneity of such material in order to prevent any subsequent change of the same into a non-homogeneous substance.

At the same time it serves to improve the texture and uniformity of such materials by eliminating or reducing the non-uniformities found in the material as a result of the previous processing to which the material has been subjected.

The invention can readily be utilized in the processing of many diversified materials in which a uniformly processed, homogeneous product is desired. Among the non-culinary materials which require such treatment in their preparation are paraffines, soaps and waxes, either alone or as mechanical mixtures or chemical compounds with other ingredients and having a definite melting point or different melting points within a limited range for different ingredients.

Among the commercial culinary products which require such treatment are oils, fats, lard, lard compounds, shortenings, vegetable oil compounds, margarine, greases, etc. Such materials are usually in a liquid state at some stage in the preparation, but are used commercially in solid or semi-solid form. They may or may not contain some water or other liquid having a solidifying temperature below that of the product as a whole.

As one illustration of a use of the invention, the treatment of margarine is taken for an example. In the manufacture of this product, it is necessary to emulsify two dissimilar liquids such as an edible oil and milk and to process this mixture in such a way that no separation of these liquids will later take place.

In the patent of Bottoms and Wood, No. 2,013,025, there is disclosed the processing of such a material by steps including supercooling the emulsified mixture coming from a pressure processing step and subsequently setting up or solidifying the mixture from a liquid to a solid state. The importance of some working of the solidified material to insure a homogeneous product is recognized by these patentees, the specific means they disclose being a simple screen through which the solidified material is slowly forced by the diminished processing pressure available.

It is thought that the solidification of a material of the nature described either with a supercooling as taught by Bottoms and Wood, or a mere chilling upon a refrigerated roll as taught by prior processes, involves the formation of a crystalline structure in the plastic material. The texture of the material is dependent upon the nature of the crystalline formation finally secured, and if a non-uniform formation is developed through improper heat treatment or improper application of mechanical forces, a non-homogeneous material will result. While the necessity for some type of working of the solidified material has long been recognized as being necessary to secure a homogeneous product, the danger in working the material excessively and so breaking down the crystalline formation as to result in a salvy, pasty structure has also been recognized. Should such breaking down of the crystalline structure take place without an opportunity for the crystals to re-form, an undesirable product would result, as set forth below.

It has also been found that other factors contribute to the formation of a non-homogeneous margarine product, and if such a product is packaged without having undergone a working or kneading treatment, the likelihood of a breaking down of the emulsion and the segregation of liquid particles must be considered. When this happens an excessvie amount of small globules of liquid derived from the water in the milk may appear on the surface of the printed block of margarine, whereas if the material has undergone an adequate working treatment those liquid particles would remain substantially dispersed in the kneaded block of crystalline material. Even when this segregation of liquid does not occur, it still is possible for the product to have a poor texture as a result of a non-uniform crystalline structure which may diminish its market value.

In the event that the emulsion is broken during the agitating step of the process, or in the event that a non-uniform removal of the heat of crystallization developed subsequent to the supercooling or ordinary chilling step should occur, a non-homogeneous margarine product may result. Moreover, in passing along the surface of the receiver a film of slippery material in which the crystals are broken down tends to develop, presumably due to friction of the margarine surface with the receiver surface plus the heat transfer resulting when the conventional means for preventing freezing is employed. Unless this slippery film is thoroughly mixed with the other portions of the mass the resulting print of margarine may have a slippery undesirable outer sur-

face. While all of these problems have been recognized heretofore, no provision has been made to so treat the material that a homogeneous, properly textured material may be secured.

This invention provides a solution to these and other problems and has as one object the production of a homogeneous solid material which will assume and retain a stable homogeneous condition even after a long period of time.

Another object is the provision of an effective and simple means for positively working and kneading solidified material following the setting up of the same into a solid condition either after a supercooling or an ordinary chilling step.

A further object is to secure a positive working of such material by means independent of the pressure exerted by the material.

A further object is to provide an improved mulling or kneading means which may be removably located at any desired point in the receiver unit of the process, dependent upon the nature of the material being processed.

A further object is to provide means for simultaneously working a solidified plastic material and placing it under pressure sufficient to move the material to any further processing step.

A further object is to provide a sectional receiver unit for use in the processing of a solidified material.

Other objects and advantages of the invention will become more apparent when considered in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic view illustrating one arrangement of apparatus in which the process may be carried out in a confined system.

Fig. 2 is a sectional view corresponding to a portion of Fig. 1, but on a larger scale, and taken on line 2—2 of Fig. 3 and illustrating one form of means for positively working the material under process, and

Fig. 3 is a view taken on line 3—3 of Fig. 2, and showing the manner in which the working means may be assembled.

As shown in Fig. 1, a supply vessel **20** may be provided for supplying the liquid material which is to be processed. In the event that the final product is to consist of a mixture of more than one such liquid, a second tank **21** may be provided. Taking margarine as an illustration of the type of material which is to be processed, tank **20** may contain edible oil and tank **21** may contain cultured milk. These liquids, or any other fluids which are to be employed in making the product, would then be delivered into any suitable type of mixing pump **22** serving to mix such liquids in any desired and predetermined proportions, and to force them through pipe **23** into a suitable processing apparatus indicated generally at **24**. As will become apparent hereinafter, pump **22** is able to force the material being processed completely through the confined system and may serve either to deliver it from the system or to move it only up to the working means, after which said working means may then force the material out of the system.

Apparatus **24** may consist of any chilling or cooling unit **25** to which a refrigerant in liquid form may be delivered through pipe **26** after having passed through a suitable control unit such as an accumulator **27**. Gasified refrigerant after having served its heat exchange function returns to said control unit through a pipe **28** and thence back to a compressor, (not shown) through pipe **29**. The liquefied refrigerant is supplied to the control unit through pipe **30**. The specific type of processing unit **24**, however, is immaterial in the broader aspects of my invention, and it is contemplated that many equivalent structures may be used without departing from the scope or intent thereof.

A suitable agitating or conveying means **40** is housed within the processing unit **24** and is driven by any suitable source of power **41** at any desired speed. Such agitator **40** provides an open passage for the material which enters the apparatus **24** through pipe **23**, and which is moved in a continuous flow therethrough to the outlet **24** by means of the pressure exerted by pump **22**. During its passage through said apparatus **24** the mixture of liquids under pressure of pump **22** is subjected to a rapid extraction of heat and considerable agitation resulting in a complete emulsification of the liquid ingredients and a "supercooling." While it is found that this supercooling as taught by Bottoms and Wood results in a satisfactory operation, it is apparent that the invention may be used in installations in which a mere chilling of the material will take place. Such an adaptation is considered as being within the purview of the invention.

It has been found that this type of processing may result in the material leaving the apparatus **24** through pipe **42** in a liquid or semi-liquid state, although it has been chilled or supercooled to a temperature substantially below that at which it would normally set or solidify. When processing certain types of materials in which this solidification may abruptly take place, it has been found convenient to exert sufficient pressure by pump **22** so that the processed material entering pipe **42** will be in this liquid state. If this precaution is not taken there is a likelihood of frequent clogging or freezing of the apparatus **24**, due to the solidification of such material.

When the processed material in its emulsified and supercooled condition is brought out through pipe **42** in this liquid or semi-liquid state, a receiver means is provided, as shown in the Bottoms and Wood Patent No. 2,013,025, for permitting the liquid material to solidify and absorb its heat of crystallization raising the temperature from the supercooled condition. It has heretofore been considered advisable to permit this solidification to take place in an elongated unit **43** around which a jacket **44** is provided for circulating warm water to insure against a freezing of the supercooled material to the sides of the unit **43** and to avoid any stoppage of flow due to such freezing. It has been customary in the past to circulate water having a temperature of about 90° F.

While the use of such a unit **43** and a warm water jacket **44** has insured against freezing up of this unit during the solidification of the material, it has been found that a film of slippery product sometimes appears along the surface of the material in contact with the jacket **44**. Moreover, since there is no agitation of the material in unit **43** and its solidification is taking place in a substantially quiescent state a non-homogeneous material sometimes results since a uniform liberation of the heat of crystallization from the interior particles of the mass of material is not always possible. Furthermore, since the pressure exerted by pump **22** is the only source of pressure available to force the solidified material into and along the unit **43**, insufficient working of such material is effected by screens or similar means placed within unit **43** and functioning

solely as a result of the reduced pressure from pump 22 upon the material at that point.

Since the capacity of chamber 43 is very large in comparison with the capacity of the processing unit 24, in order to have the material solidified in a substantially quiescent state, the result is that the material moves very slowly through the unit 43 as it solidifies and approaches atmospheric pressure as it reaches the extrusion end of unit 43. When dealing with pressures of this very low order the working of screens or the like has been found to be relatively ineffective.

The present invention avoids these disadvantages by providing a receiver unit 43 which may be built up from separate sections such as 50, 51, 52, 53 and 54. Sections 50, 51 and 52 for example, may provide a water jacket 44 comprising a group of water jackets in series on the separate sections and through which warm water may enter through pipe 45 and leave through pipe 66 for the purpose of preventing a freezing of the solidified non-homogeneous material to the sides of units 43. Unit 53 containing the means for positively working the solidified material may thus be positioned in the separable unit 43 at whatever point desired. The particular location of unit 53 will depend upon the nature of the material being processed and will be largely determined by the rapidity with which the material crystallizes into a solidified state. In the event that the working of such material in order to form a homogeneous final product should result in additional heat of friction, or in the event that part of the heat of crystallization remains in the thus worked material, a final water jacket element 54 having inlet pipe 55 and outlet pipe 56, through which cold water may be circulated, may be provided adjacent to the delivery end of working unit 53. After the working has taken place the recrystallization of the material and the heat developed by mechanical working may involve a release of heat which will then be carried away by this heat exchange element. This final unit 54 may have an extrusion nozzle means 57 serving to deliver the homogeneous solidified material under any desired pressure to a convenient source for slicing, packaging or storing the same.

As the material enters the relatively large receiver 43 the pressure exerted thereon by pump 22 is greatly diminished and may become barely sufficient to deliver the material through nozzle 57 without any appreciable propulsion. It is contemplated that in certain installations it may be desirable to have the completely processed product extruded with a positive and appreciable force so as to coordinate with the slicing, packaging and delivery phases of manufacture. The present invention makes provision for this in that the working or kneading unit 53 may exert a positive force derived from an external source of power and applied to the material simultaneously with the working thereof.

Referring now to Figure 2, it will be seen that the unit 53 comprises a member square in cross-section, and having top and bottom 60 and 61 and sides 63 and 64. Flange members 65 are provided for securing unit 53 into position with adjacent units of unit 43.

In the event that the cross-sectional area of unit 43 should be round, the necessary design of the adjacent units 52 and 54 may be made to accommodate a change from a round cross-section to and from the square cross section of the unit 53. Housed within the unit 53 is a mulling or kneading gear member 70 mounted upon the shaft 71 extending externally of the wall of unit 53, and driven from any suitable external source of power 72. Gear 70 is mounted within the square housing 53 in such a way that during its rotation the addendum circle passes in close proximity to the bottom wall of the unit 53 and prevents the by-passing of any of the material in space 80, since a small pressure differential exists between spaces 80 and 81. A second and similar gear 73 is mounted within the unit 53 upon a stub shaft 74 in such a way that it will be driven by the gear 70 and mesh therewith at all times. Gear 73 likewise has addendum circle passing in close proximity to the wall 60 of unit 53. The ends of both gears 70 and 73 rotate in close proximity to the end walls 63 and 64 of unit 53.

As a result of this construction the inner meshed gears 70 and 73 when rotating in the direction as shown by the arrows in Fig. 2, provide a barrier to the flow of solidified material entering the unit 53 and all such material passing through unit 53 is therefore compelled to move into contact with said gears. When rotating, the space between adjacent teeth of the gears 73 and 70 is filled with the solidified material occupying the space 80 as the teeth move out of mesh. As will be apparent, the speed of rotation of gears 70 and 73 is adjusted so that the amount of material metered out by these gears will be equal to the amount of material constantly entering space 80. As the gears thus rotate they will carry with them between their teeth successive portions of the material in space 80 which may be of a non-homogeneous nature as a result of the reasons heretofore given.

As the gears continue to rotate with this material lodged between their teeth, they again become in engagement with one another and in so engaging the material held by the teeth is mulled and kneaded while being forced out from between such teeth. This positive working action will result in the material being mulled into layers which are constantly forced into space 81 at the outlet end of unit 53 and form a mass of uniformly mulled and kneaded material. All material thus forced into space 81 and thereafter removed through nozzle 57 and having been subjected to this positive mulling and kneading action will have all slippery particles or improperly cooled particles thoroughly intermixed with the main body of the material. By properly adjusting the speed of these gear members, no breaking of the emulsion in the solidified material will take place and subsequent segregation of liquids in the processed material will be avoided, since all liquid particles will be uniformly dispersed into the mass of material as a result of the thorough intermixing which takes place. Moreover, by exerting sufficient force upon the gears by means of the power unit 72 and by controlling the speed of rotation in coordination with the operation of pump 22 by any suitable control means (not shown) the material passing through unit 53 may have a pressure imposed thereon which will be sufficient to extrude it through nozzle 57, regardless of the stiffness or hardness thereof.

By reason of the flexibility of the process thus disclosed the operator has a greater control over the nature of the final product. Not only may the working take place either during the normal solidification period of the material or subsequent to that solidification period, but also external

heat transfer may be employed in order to produce a homogeneous product with the degree of plasticity desired. In general, mechanical working of a material after its solidification without subsequent heat transfer breaks up the agglomerated groups of crystals and results in a softer, more plastic material. For example, if a homogeneous shortening product in a relatively soft condition is desired, the operator may locate section 53 in the receiver at such a point that the working takes place after the solidification of the shortening has been substantially completed. The worked product would then be in a relatively soft state due to the breaking up of the agglomerated group of crystals and in order to avoid a subsequent coalescing of the crystals of the worked material resulting in a stiffening of that material, the cooling unit 54 may be omitted.

If a stiffer final product is desired, the working unit may be transposed to a point in the receiver where the normal solidification is not substantially complete. In this case a minor solidification and coalescing of crystals would take place following the working step and result in a product of intermediate stiffness or hardness which would not be as hard as when no working is employed, but would be harder than if the working had taken place after normal solidification. The use of heating jackets prior to the working step and the use of cooling jackets subsequent to that step may likewise be varied in accordance with the stiffness desired in the final product. The final cooling jacket 54 will normally be used when a stiffer product is desired, and will normally be omitted when a soft, plastic product is desired.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In combination, means for supercooling a material in a liquid state, a receptacle connected to said processing means and providing a space in which the supercooled material may set under pressure into an unworked solid state, and externally actuated muller means connected to said receptacle and receiving the set material therefrom and uniformly breaking up the solidifying formation of the masses of said material.

2. A process for treating material, which includes the steps of supercooling the liquid under pressure to a temperature substantially below its normal solidifying point, while maintaining it in liquid or semi-liquid condition, delivering the supercooled material to a receiver, retaining said supercooled liquid or semi-liquid material in such receiver as it solidifies and is advanced under diminished pressure, and then increasing the pressure while positively working said solidified material and uniformly breaking up the solidifying formation to produce a homogeneous mass of such solidified material and facilitate the movement of the material to a point of discharge.

3. A process for treating material, which includes the steps of supercooling the liquid to a temperature substantially below its normal solidifying point, while maintaining it in motion in liquid or semi-liquid condition, delivering the supercooled liquid or semi-liquid material to a receiver, retaining said supercooled material in such receiver until it adopts a solidifying formation, and then mixing material from adjacent walls of said receiver with the body of the material and working said material to break up the solidifying formation and produce a homogeneous mass.

4. The process of treating a material normally solid at ordinary room temperatures and readily liquefiable, which includes forcing the liquefied material under pressure through a confined space, agitating the material in said space and simultaneously supercooling it, maintaining the supercooled material in liquid or semi-liquid condition within said confined space, delivering the supercooled material into a separate space in order to permit it to assume solidifying formation while being maintained under diminished pressure, increasing the pressure on said solidified material and simultaneously positively working the solidified material in order to uniformly break up the solidifying formation thereof to form a homogeneous mass of solid material and to facilitate the movement of the material to a point of discharge.

5. A process for treating mixtures of materials having different melting points, one or more of the ingredients of such mixture being normally solid at ordinary room temperatures, said process including supercooling the material in liquid condition under pressure to a temperature substantially below the melting point of said normally solid constituent, delivering the supercooled mixture of materials into a separate space in order to permit the same to assume a solidifying formation under lower pressure, increasing the pressure on the mixture to remove it from the separate space and simultaneously working the solidified materials in order to uniformly break up the solidifying formation thereof and to form a homogeneous mass of solidified material.

6. A sectional receiver for supercooled liquid material under pressure, having a relatively small inlet through which the material is delivered, whereby the material may assume a substantially quiescent state under pressure in said receiver and thereby solidify during relatively slow flow through the receiver, said receiver having a plurality of interchangeable sections and means for joining said sections, one sectional unit of the receiver having a positive means for working the material contained therein and actuated from an external source of power, whereby the solidified material may be positively kneaded and discharged from the receiver.

7. The process of changing a material from a liquid to a homogeneous solid condition, including advancing the material under pressure in a confined stream, agitating the material and subjecting it to a temperature lowering medium while in said stream, advancing the cooled material in a substantially quiescent state by means of pressure through a confined passage wherein the material may adopt a solidified formation in which non-homogeneous conditions may result, positively working the solidified material by means actuated independently of the source of pressure upon the material, and breaking up the solidifying formation thereof whereby the solidified material may be delivered from the confined system in a homogeneous, solid condition.

8. An apparatus for treatment of a readily solidifiable liquid, including a receiver through which the liquid may move in a substantially quiescent condition and solidify, a pair of intermeshing rotatable gears in said receiver in the path of movement of said solid material, means to warm the receiver in advance of said gears, and means to cool said receiver beyond said gears.

9. An apparatus for treatment of a readily solidifiable liquid, including a receiver through which the liquid may move in a substantially quiescent condition and solidify, a pair of inter-

meshing rotatable gears in said receiver in the path of movement of said solid material, and means to warm the receiver in advance of said gears.

10. The method of processing oleaginous material in a liquid state, which includes supercooling and agitating the material, solidifying the supercooled material in a quiescent state to form relatively soft surface portions and harder internal portions, and thereafter uniformly mixing said surface portions with the mass of material by the application of external force sufficient to break up said harder portions.

11. The method of processing oleaginous material in a liquid state, which includes simultaneously agitating and supercooling the liquid under pressure, delivering the supercooled liquid to a receiver, permitting solidification in said receiver in a substantially quiescent state and under diminished pressure, uniformly mixing the softer surface portions of the material in said receiver with the harder internal portions and to render the material homogeneous, while increasing the pressure on the material to extrude it from the receiver.

12. The method of processing oleaginous material in a liquid state, which includes simultaneously agitating and supercooling the material, moving the material at a relatively slow rate in a quiescent state through a receiver, and working the material by intermeshing gears substantially contacting opposite walls of the receiver, whereby the softer surface portions adjacent to the walls of the receiver are intermixed with the harder internal portions and said harder portions are broken up to render the mass homogeneous.

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