METHOD AND APPARATUS FOR TREATING MIXTURES TO MAKE OR BREAK EMULSIONS

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1 This invention relates to the centrifugal treatment of mixtures to break up small particles therein, to make or break emulsions, and the like. More particularly, the invention has reference to an improved method and apparatus for this purpose, in which centrifugal force is utilized to cause a vibrating action on the mixture as it discharges from the locus of centrifugal force.

Centrifugal force has been utilized heretofore in apparatus for making a more or less permanent mixture, generally called an emulsion, of two or more materials, such as water and oil. In such apparatus as commonly constructed, a rough mixture of the two materials is discharged by centrifugal force between plates revolving at high speed and arranged in close proximity to each other to provide a discharge orifice in the form of a narrow slit, which may be in the order of one-thousandth of an inch in width. An apparatus of this character is disclosed in U. S. Patent No. 1,145,670, issued to M. Leitch et al. on July 6, 1915. While this prior apparatus has been effective for emulsifying materials and has enjoyed considerable use, it has been found that small particles of the raw materials sometimes collect in the narrow discharge passages of the emulsifying elements and eventually tend to clog them and to stop the operation of the apparatus.

One object of the present invention, therefore, resides in the provision of an improved centrifugal method and apparatus for treating mixtures to break up small particles therein, to make or break emulsions, and the like, by which the mixture is discharged through a narrow outlet from the locus of centrifugal force without clogging the outlet.

Another object is to provide a method and apparatus of the character described, in which the discharge outlet from the locus of centrifugal force is alternately opened and closed with a pounding action to prevent clogging and also to break up particles of material discharging through the outlet, whereby the invention may be used to advantage for making emulsions and also for breaking emulsions by the pounding action on the suspended particles.

A further object is to provide a method and apparatus of the character described, in which the alternate expanding and contracting of the discharge outlet, with or without the accompanying pounding action on the discharging mixture, is effected rapidly and automatically under control of the centrifugal pressure of the mixture in the locus of centrifugal force.

Still another object is to provide an apparatus of the character described having automatic means for insuring that the mixture will be discharged only under a large hydrostatic pressure due to centrifugal force.

An additional object is to provide an apparatus of the character described having a deflecting wall against which the discharging material is sprayed at high velocity, thereby acting to break up particles in the mixture.

Another object is to provide a method and apparatus of the character described which are especially adapted for treating milk products to break cream emulsions of high fat content as a step in concentrating butter oil, to emulsify a mixture of milk ingredients for reconstituting cream, and the like.

According to the invention, the mixture to be treated, such as a mixture of oil and water, is fed into a locus of centrifugal force, or centrifugal chamber, where a body of the mixture is accumulated in the peripheral portion of the chamber adjacent a restricted discharge outlet. The outlet may be in the form of a narrow slit between two working surfaces of a pair of housing members defining the chamber, one of the members being reciprocable relative to the other to expand and contract the outlet. As the mixture accumulates in the chamber and builds up toward the axis of rotation, the action of centrifugal force causes it to exert an increasing pressure on the reciprocating housing members, and when this pressure attains a relatively high value, the outlet expands to permit discharge of the mixture by centrifugal force at a rate in excess of the rate of feed to the chamber. The centrifugal pressure of the mixture on the reciprocable member then decreases to a relatively low value to permit the reciprocating member to contract the outlet, whereby another body of mixture accumulates in the chamber and the cycle is repeated. The arrangement may be such that in this contraction of the outlet, the working surfaces of the housing members are brought together with a pounding action, thereby tending to disintegrate particles of material between these surfaces.

Thus, the expansion and contraction of the outlet, which may be accompanied by a pounding action on the discharging material, are effected automatically under control of the centrifugal pressure of the alternately accumulating and receding body of mixture in the chamber. Preferably, the reciprocable housing member is arranged to expand and contract the discharge outlet rapidly by changes in the centrifugal pres-
sure of the mixture on this member within a high pressure range, so that the mixture is discharged only under a large hydrostatic pressure due to centrifugal force, and the operating cycle is repeated at short intervals to effect a rapid vibration of the reciprocable members.

For a better understanding of the invention, reference may be had to the following detailed description taken in conjunction with the accompanying drawings, in which

Fig. 1 is a vertical sectional view of part of an apparatus made in accordance with the invention.

Fig. 2 is a horizontal sectional view on the line 2-2 in Fig. 1.

Fig. 3 is a vertical sectional view of part of a modified form of the apparatus, and

Fig. 4 is a horizontal sectional view on the line 4-4 in Fig. 3.

Referring to Figs. 1 and 2, the apparatus comprises a stationary frame 10 and a driving spindle 11 supported for rotation in the frame in suitable bearings (not shown). Mounted on the peripheral portion of the spindle is a housing assembly comprising three annular housing members 12, 13 and 14. The lower housing member 14 is fitted closely around the spindle and is seated on a shoulder 15 on the spindle. The member 14 is recessed to provide an annular feed chamber 16 which communicates with a bore in the upper end portion of the spindle through ports 17 in the spindle wall, the part of the spindle below the ports 17 being solid.

The intermediate housing member 13 has a central portion 13a projecting downwardly into the feed chamber 16 and having a close sliding fit with the outer wall of the feed chamber, as shown at 13b. The intermediate member 13 is spaced from the spindle, and the inner wall of its central portion 13a tapers upwardly to an inlet 18 between the feed chamber and a centrifugal chamber 19 defined by the housing members 12 and 13. The chamber 19 extends outwardly to a greater radius than feed chamber 16 and is formed by recessing the bottom of upper housing member 12 and the top of intermediate member 13. A nut 20 is screwed on the upper end of the spindle to clamp the housing member 13 against a shoulder on the spindle, the member 12 being also keyed to the spindle, as shown at 21.

At the peripheral portion of the centrifugal chamber 19, the housing members 12 and 13 have interengaging working surfaces 22 which define an outlet from the centrifugal chamber. The working surfaces 22 are urged together by an annular gasket 23 made of resilient material, such as rubber, and arranged near the sliding fit 13b. The gasket 23 is interposed between the bottom of feed chamber 16 and the lower end of the central portion 13a of the intermediate housing member and is held under compression so that it acts to close the outlet formed by the working surfaces 22. In this position of the intermediate member 13, there is a clearance at 22a between the upper end of the lower housing member 14 and the overlying surface of the intermediate member 13. This clearance being too small to be illustrated accurately but being, for example, in the order of one-hundredth of an inch. The intermediate housing member 13 is thus adapted to reciprocate axially between the upper and lower housing members 12 and 14, whereby the outlet 22 is alternately expanded and contracted.

The reciprocable housing member 13, as shown, is provided on its peripheral portion with an upwardly projecting lip 24 extending around the outside of outlet 22 in spaced relation thereto. A cover assembly 25 is mounted on the frame 19 around the rotating parts and forms a receiver 26 for collecting the material discharged through the outlet 22. The receiver 26 may be provided with a suitable discharge spout (not shown). On top of the cover assembly 25 is a hopper 27 for receiving the material to be treated, the hopper having a central bottom opening communicating with a stationary feed tube 28 extending down into the hollow spindle 11.

In the operation of the apparatus, the material to be treated, which may be a rough mixture of butter oil, water and milk powder to be emulsified for making cream, is fed continuously from the hopper 27 through feed tube 28 into the hollow spindle 11, the spindle being rotated at high speed, for example, 8,000 to 16,000 R. P. M., by a suitable motor (not shown). The resulting centrifugal force causes the mixture to flow outwardly from the interior of the spindle through ports 17 into the feed chamber 16 or first centrifugal locus 16. The mixture accumulates in the peripheral portion of chamber 16 and, due to centrifugal force, exerts an upward pressure on reciprocable member 13 acting to hold the surfaces 22 together and close the outlet. The mixture eventually overflows the inner edge of the central housing portion 13a and passes through inlet 18 into the second centrifugal chamber or locus 19. In the latter chamber, the mixture flows outwardly from inlet 18 under centrifugal force and accumulates in the peripheral portion of the chamber.

As the body of mixture in chamber 19 builds up toward the axis of rotation, it exerts an increasing downward pressure on the pressure controlled surface 13c of the intermediate housing member 13, due to the centrifugal force acting on the mixture. Since the chamber 19 is of larger radius than feed chamber 16, this increasing pressure on surface 13c will ultimately overcome the biasing action of gasket 23 and the upward pressure of the mixture against member 13 in chamber 19, when upon the member 13 moves downwardly against the surface 22a of the lower housing member 14. Thus, the gasket 23 is compressed and the working surfaces 22 are separated so as to open the outlet which they define, for example, to a width of about one-hundredth of an inch.

In this lowestmost position of the reciprocating member 13, the mixture is discharged by centrifugal force from chamber 19 through outlet 22 at a maximum rate which exceeds the rate of feed of the mixture through inlet 18. Accordingly, the inner level of the mixture in chamber 19 recedes outwardly, with the result that the axial pressure on the surface 13c, due to centrifugal force on the mixture, is reduced. When this pressure is reduced to the point where it is overcome by the biasing action of gasket 23 and the upward pressure of the mixture on reciprocating member 13, the latter is forced upwardly compressing surfaces 22 together, thereby tending to pound and disintegrate any particles discharging through the outlet. At the same time, the resulting contraction of outlet 22 stops the discharge so that the mixture again accumulates in the peripheral portion of the centrifugal chamber 19 and the cycle is repeated.

By properly controlling the radial dimension of feed chamber 16, the rotational speed of spindle 11, the effective area of the part 13a influ-
enced by the mixture pressure in feed chamber 23, and the compression of gasket 22, the member 23 may be made to hold the discharge outlet open only as long as there is a large hydrostatic pressure of the mixture on surface 13c due to centrifugal force. Thus, the apparatus will insure that the mixture is discharged only under heavy pressure to enhance the mixing action and spray the discharge at high velocity against lip 24, so that a further breaking up and dispersion of particles is obtained. Also, by properly controlling the above operating factors in relation to the radial dimension of chamber 8, the member 13, the size of the particles of the emulsion or the component materials, and the discharge rate from chamber 19 (the maximum opening of outlet 22), the member 13 may be made to reciprocate at a rapid rate so that the working surfaces 22 open and close the outlet with a chattering action.

I have found that good results may be obtained by providing centrifugal hydrostatic pressures of several hundred to several thousand pounds per square inch of the mixture on surface 13c and reciprocating the member 13 at a rate of 15 pounds per second, when treating certain mixtures, as, for example, to break up particles in cheese mixes for obtaining a uniform mixture prior to separation of the curds, to make emulsions, as in reconstituting cream from butter oil, milk powder and water, and to break emulsions, as in the production of butter oil from cream.

The width of the working surfaces 22 and the vibration rate of member 13 may be such that a substantial part of the discharging mixture is wounded between the working surfaces. The lower working surface 22, as shown, serves also to accelerate the opening of the outlet to its maximum width, since the discharging mixture exerts an additional downward thrust on this surface when the outlet commences to open.

From the foregoing, it will be apparent that the apparatus is fully automatic in operation, the opening and closing of the discharge outlet 22 and the resulting pouding action on the discharging material being controlled by changes in the centrifugal pressure of the alternately accumulating and receding body of mixture on the pressure controlled surface 13c. The reciprocating means includes the pressure controlled surface 13c and also the surface of the part 13c subjected to the countereacting pressure of mixture in feed chamber 16, and the resilient gasket 23. The reciprocating action of the intermediate housing member 13 not only serves to prevent clogging of the outlet by particles of the discharging material but also tends to break up these particles and obtain an intamate and homogeneous mixture of the discharging material. Any disintegrated particles tending to adhere to the surfaces 22, after each pounding action thereof, are flushed from the surfaces by the next outflow of the mixture under heavy pressure and at maximum rate when the outlet is expanded.

The apparatus is of simple construction and is adapted to treat mixtures at a high throughput rate and can easily be disassembled for cleaning purposes by simply unscrewing the member 23 and removing the housing sections from the spindle.

For breaking emulsions, such as cream, and for homogenizing cheese mixes, I prefer to use a modified form of the apparatus in which the housing assembly also contains an outer chamber for receiving the mixture discharged from the outlet, to prevent aeration of the mixture and also to prevent it from going back into emulsion. The modified apparatus, as shown in Figs. 3 and 4, includes a pair of reciprocating housing members defining with a main housing member a pair of centrifugal chambers to which the mixture is fed.

Referring to Figs. 3 and 4, the apparatus there shown comprises a frame 30 in which a vertical driving spindle 31 is supported in suitable bearings (not shown). The upper portion of the spindle is recessed to form a feed space which is open at the top. A flanged collar 32 closely surrounds the spindle and is seated on a shoulder 32a, the collar in turn supporting a ring 33 fitted closely around the collar and secured thereto in any suitable manner, as by welding. A main housing made up of two annular, complementary sections 34 and 34a is mounted on and rotates with the spindle 31. The outer portion of the main housing 34, 34a is enlarged and rests upon the ring 33, while the inner portion 35 of the housing is reduced and rests upon a gasket 35 on the flanged end of collar 32. A nut 37 is screwed on the top of the spindle and serves to clamp the main housing on the collar 32 and ring 33. The reduced portion 35 of the housing forms an annular feed passage 38 communicating at its inner end with the interior of the spindle and at its outer end with the interior of the enlarged portion of the housing through restricted openings 39.

Within the outer or enlarged portion of the main housing 34, 34a are two annular reciprocating housing members 41, 41a which are generally trough-shaped in cross section, the upper member 41 being inverted so that its open end is 42 adjacent the open end of the lower member 41a. The main housing 34, 34a is internally recessed at the top and bottom and defines with the housing members 41 and 41a two annular centrifugal chambers 42 and 42a, respectively. At the outer peripheries of these chambers, the main housing and the reciprocable members 41 and 41a have interengageable working surfaces 43 and 43a, respectively, providing outlets which open and close in the reciprocation of the members. The surfaces 43 and 43a are normally urged together to close the outlets, by biasing means in the form of flexible sealing rings 45 and 45a, respectively, backed by substantially solid rings 46 and 46a, respectively, the washers extending inwardly between the members 41 and 41a and between the housing sections 34 and 34a, and being seated at their inner edges against the periphery of the spindle. The outer edge portions of washers 44 and 44a are slightly curved in diverging relation and make sliding contact against the outer walls of the reciprocable members 41 and 41a, respectively. The sealing rings 45 and 45a are interposed between the outer edge portions of the washers and the closed ends of the reciprocable members 41 and 41a, respectively, the sealing rings also bearing against the outer walls of the reciprocable members.

A small clearance, for example, about .001" to .001" or more, is provided between the inner walls of members 41 and 41a and the adjacent faces of washers 44 and 44a, respectively, so as to allow free reciprocating motion of the members 41, 41a.

The washers 44 and 44a and their respective housing members 41 and 41a and rings 45, 45a define separate annular feed chambers communicating through restricted inlets 47 and 47a, at the inner ends of the feed chambers, with the centrifugal chambers 42 and 42a, the latter extend-
ing outward to the outlets 43 and 43a at a substantially greater radius than the feed chambers. The feed chambers also communicate with feed passage 38 on opposite sides of the washers, through spaces between the housing members 41, 41a and the washers and through the openings 39, it being understood that these spaces and openings are formed by notching the edges of housing members 41, 41a and housing sections 34, 34a adjacent the washers. Thus, the centrifugal chambers 42 and 42a are in constant communication with feed passage 38 during reciprocation of members 41 and 41a. The inner portions of the washers may be provided with openings 44b connecting the upper and lower sections into which the feed passage 38 is divided by the washers.

At the outer periphery of the main housing the joint between the two sections 34, 34a, is sealed by a thin annular insert 48 which is T-shaped in cross-section, the head of the insert being seated against the inner face of the outer wall of the housing. This wall, together with the outer walls of the reciprocable housing members 41, 41a, forms an outer chamber 45 for receiving the mixture discharged through outlets 43, 43a. The chamber 45 has peripheral outlets 50 near the insert 48 and offset axially from outlets 43, 43a.

The frame 50 supports a cover assembly 52 forming a chamber 53 for collecting the mixture discharged through outlets 50, the collecting chamber 53 having a bottom outlet communicating with a discharge spout 54. The cover assembly 52 in turn supports a stationary axial feed tube 55 extending into the open end of the hollow spindle.

The operation is similar in general to that of the apparatus shown in Figs. 1 and 2. The mixture flows into the rotating spindle from feed tube 55 and is thrown outwardly through feed passage 38 and openings 39 into the feed chambers in housing members 41, 41a. There the mixture accumulates in the peripheral portions of the feed chambers and finally overflows through inlets 47, 47a into the centrifugal chambers 42, 42a, where the mixture again accumulates in the peripheral portions of the outlets 43, 43a being held closed by the biasing action of the flexible rings 46, 46a and the liquid pressure in the feed chambers containing these rings. As the mixture accumulates in the chambers 42, 42a toward the axis of rotation, the action of centrifugal force causes it to exert an increasing pressure on the adjacent pressure-controlled surfaces of members 41, 41a, and when this pressure exceeds the countereating force of the rings 46, 46a and the liquid pressure in the feed chambers containing the rings, the resulting movement of members 41, 41a opens the outlets 43 and 43a, the minimum desired width for example, about .01". The mixture then discharges through the outlets under high pressure due to centrifugal force, until the bodies of mixture in chambers 42, 42a recede outwardly to the point where their centrifugal pressure on members 41, 41a is overcome by the countereating biasing pressure, whereupon the members 41, 41a return to their initial positions to close outlets 43 and 43a and at the same time pound any particles of the mixture between the surfaces defining the outlets. Thus, the members 41 and 41a are reciprocated rhythmically.

The mixture discharged through outlets 43 and 43a strikes the outer wall of the main housing 34, 34a at high velocity and then passes toward the central portion of outer chamber 49, from which it is discharged through outlets 56 into the stationary collecting chamber 55. The outer centrifugal chamber 45 acts to prevent emulsification of the mixtures of the outlets 42 and 42a and to prevent re-emulsifying of the mixture when it is desired to break an emulsion, as might otherwise occur if the mixture were sprayed directly from the outlets 43 and 43a into the collecting chamber 53.

It will be understood that the washers 44, 44a, instead of being rigid, could be made flexible with a spring action and arranged so that their outer edges move with the reciprocating members 41, 41a, in which case the biasing action on the members 41, 41a tending to close the outlets would be obtained entirely from the spring action of the washers. The latter construction, however, has the disadvantage that its operation would be impaired by mechanical failure of the spring washers. Also, it will be understood that while I have shown only two sets of reciprocating members and associated parts, a larger number may be employed if desired, preferably by arranging the parts in tiered fashion.

I have found that by the practice of my invention, dairy cream may be concentrated to as high as 99 percent of butterfat or higher, more readily than has hitherto been the case with prior practices. In centrifuging ordinary cream in the usual types of centrifugal apparatus, it is generally impossible to obtain a butterfat concentration substantially in excess of 50 percent, unless some other means are used to release the fat occluded by the curd or proteins. Prior methods for releasing the fat are rather involved, time-consuming and expensive. However, with the present invention, the cream may be concentrated in an ordinary centrifuge to a butterfat content of 78 to 80 percent, and then passed directly into an apparatus such as that shown in Figs. 3 and 4, where the extrusion of the steam through outlets 43 and 43a under high centrifugal pressures, preferably with a rapid and intense pounding action of the working surfaces defining these outlets, serves to rupture the membranes containing the fat globules and thereby break the emulsion. The material may then be readily concentrated, by recentrifuging, to a fat content of 99 percent or greater.

I have also found that the present invention lends itself admirably to reconstituting cream from butterfat, skim milk powder and water. As an example, 8 pounds of butterfat are melted and heated to about 110° F., and 2.8 pounds of milk powder are added to 39.2 pounds of water and heated to about 110° F. The melted butterfat and the milk solution are mixed together and agitated and then fed at a temperature of about 105° F. into the apparatus, which may be of the form shown in Figs. 3 and 4. There the material is intimately mixed and emulsified by the pounding and extruding action under high centrifugal pressures, and is discharged from the apparatus in the form of cream.

The mechanics of the reciprocating movement of the apparatus are largely dependent upon the size of the particles of the components of the emulsion or other material being treated, and upon the size of the narrow slit opening (22 or 43, 43a). Usually, the size of these particles will vary. For instance, they may vary from .001" to .002". If the slit opening is .006", then this opening will allow all smaller particles to go through but will hold back the larger particles. This will gradually clog up the slit opening and result in increasing the level in the chamber.
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(19 or 42, 42a), so that the pressure exerted by this increasing level will act to expand the slit opening and cause the larger particles to start rushing through the opening. However, as these particles rush through the opening, the level in the chamber decreases and the opening tends to close. This action is continuous and may result in a vibration in the order of 15 cycles per second, or the vibration rate may decrease to as low as 5 cycles per second or increase to an even higher order per second than 15.

It will be understood that the invention may be used for other purposes than those described, and that the centrifugal pressures at which the mixture is discharged, the rate and intensity of the pounding action, and the maximum width to which the narrow discharge outlets are opened may be varied to suit requirements. Also, while I described the outlets 22 and 43, 43a as closing completely during each operating cycle, it will be understood that their closing need not be complete, whereby the mixture will be discharged continuously at a varying rate.

I claim:

1. A method for reconstituting milk or cream from butterfat, milk powder and water, which comprises heating and mixing the butterfat, milk powder and water, feeding the heated mixture to a locus of centrifugal force, in periodic sequence accumulating a body of the mixture in the peripheral portion of the locus to increase the mixture pressure therein due to centrifugal force, discharging the mixture by centrifugal force in a closely confined stream from the peripheral portion of the locus at a relatively high rate in excess of said feeder to decrease the mixture pressure in the locus due to centrifugal force, and cutting down the discharge rate from the locus to less than said feed rate to thereby accumulate another body of mixture in the peripheral portion thereof, and controlling the variations in the discharge rate by said changes in the centrifugal pressure of the mixture in the locus, said discharge at a relatively high rate and said cutting down of the discharge rate being repeated alternately to effect a rapid vibrating action on the mixture.

2. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from said axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, means including said pressure controlled surface and operable automatically by changes in the centrifugal pressure of mixture in the chamber to reciprocate said first member for alternately expanding the outlet and said mixture at a maximum rate and then contracting the outlet to reduce the discharge rate through the outlet, a third rotary housing member having a sliding fit with said first member and defining therewith a feed chamber communicating with said inlet, the reciprocating means including a compressible gasket between said first and third housing members for sealing the sliding fit and urging said working surfaces together, and means including said feed chamber for feeding the mixture through the inlet at a rate less than said maximum discharge rate when the outlet is expanded but greater than said reduced discharge rate when the outlet is contracted, whereby the mixture alternately accumulates and recedes in the chamber to vary the centrifugal pressure of the mixture on said pressure controlled surface, said second chamber being coaxial with the first chamber and having a surface forming part of the reciprocating means and said pressure controlled surface under centrifugal force in the second chamber to bias the reciprocable member toward the other member and contract the outlet.

3. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from the axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, means including said pressure controlled surface and operable automatically by changes in the centrifugal pressure of mixture in the chamber to reciprocate said first member for alternately expanding the outlet and said mixture at a maximum rate and then contracting the outlet to reduce the discharge rate through the outlet, a third rotary housing member having a sliding fit with said first member and defining therewith a feed chamber communicating with said inlet, the reciprocating means including a compressible gasket between said first and third housing members for sealing the sliding fit and urging said working surfaces together, and means including said feed chamber for feeding the mixture through the inlet at a rate less than said maximum discharge rate when the outlet is expanded but greater than said reduced discharge rate when the outlet is contracted, whereby the mixture alternately accumulates and recedes in the chamber to vary the centrifugal pressure of the mixture on said pressure controlled surface.

4. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from the axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, means including said pressure controlled surface and operable automatically by changes in the centrifugal pressure of mixture in the chamber to reciprocate said first member for alternately expanding the outlet and said mixture at a maximum rate and then contracting the outlet to reduce the discharge rate through the outlet, a hollow axial spindle for supporting and rotating the housing members, said members being of generally annular form and said first member being concentric with but spaced from the spindle, the other member being concentric.
with the spindle and mounted thereon, a third annular housing member mounted on the spindle and at least partly defining a feed chamber communicating with the interior of the spindle and with the inlet, said first housing member having a portion partly defining said inlet and extending into the feed chamber with a sliding fit with said third member, the reciprocating means including an annular compressible gasket disposed between said first and third housing members in position to seal the sliding fit, and means including the spindle and said feed chamber for feeding the mixture through the inlet at a rate less than said maximum discharge rate when the outlet is expanded but greater than said reduced discharge rate when the outlet is contracted, whereby the mixture alternately accumulates and recedes in the chamber to vary the centrifugal pressure of the mixture on said pressure controlled surface.

5. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from the axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, the second housing member containing said reciprocable members and at least partly defining therewith an outer chamber for receiving mixture discharged through said outlet from the first chamber, said outer chamber having a peripheral outlet for discharging mixture therefrom and displaced axially from said first outlet.

6. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from the axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, means including said pressure controlled surface and operable automatically by changes in the centrifugal pressure of mixture in the chamber to reciprocate said first member for alternately expanding the outlet to discharge the mixture at a maximum rate and then contracting the outlet to reduce the discharge rate through the outlet, a third rotary housing member reciprocable relative to the other housing members and defining with said second member a second centrifugal chamber having near said axis a restricted inlet for the mixture, said third member having a pressure controlled surface partly defining the second chamber and disposed at a greater radius from said axis than the second inlet, the second and third members having working surfaces disposed at a greater radius from the axis than said second pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of the third member, the second housing member containing said reciprocable members and at least partly defining therewith an outer chamber for receiving the discharge from said outlets, the outer chamber having a peripheral outlet for discharging mixture therefrom and displaced axially from said first outlets, the reciprocating means being operable to reciprocate both reciprocable members and including said pressure controlled surfaces and a pair of superimposed spring elements acting to bias the reciprocable members toward said second member to contract the outlet and providing displacement of the outlet by changes in the centrifugal pressure of the mixture on said pressure controlled surface. 8. A method for treating mixtures to break

7. Apparatus for treating mixtures to make or break emulsions, and the like, which comprises a housing member rotatable about an axis, a second housing member rotatable about the axis and defining with the first member a centrifugal chamber having near said axis a restricted inlet for the mixture, the first housing member being reciprocable relative to the other and having a pressure controlled surface partly defining the chamber and disposed at a greater radius from said axis than the inlet, the members having working surfaces disposed at a greater radius from the axis than said pressure controlled surface and providing an outlet which expands and contracts in the reciprocation of said first member, a spring element defining with one of the reciprocable members a feed chamber communicating with the inlet to the adjacent centrifugal chamber, and means including said feed chambers for feeding the mixture through the inlets at a rate less than said maximum discharge rate when the variable outlets are expanded but greater than said reduced discharge rate when the variable outlets are contracted.

8. A method for treating mixtures to break
up small particles therein, to make or break emulsions, and the like, which comprises feeding the mixture to a locus of centrifugal force, in periodic sequence accumulating a body of the mixture in the peripheral portion of the locus to increase the mixture pressure therein due to centrifugal force, discharging the mixture by centrifugal force in a closely confined stream from the peripheral portion of the locus at a relatively high rate in excess of the rate of said feed, to decrease the mixture pressure in the locus due to centrifugal force, and cutting down the rate of discharge from the locus to less than said rate of feed to thereby accumulate another body of mixture in the peripheral portion thereof, controlling the periodic variations in the discharge rate by said changes in the centrifugal pressure of the mixture in the locus, and pounding the discharging mixture periodically and simultaneously with cutting down the rate of discharge from the locus.

9. A method for treating mixtures to break up small particles therein, to make or break emulsions, and the like, which comprises feeding the mixture to a locus of centrifugal force, in periodic sequence accumulating a body of the mixture in the peripheral portion of the locus to increase the mixture pressure therein due to centrifugal force, discharging the mixture by centrifugal force in a closely confined stream from the peripheral portion of the locus at a relatively high rate in excess of the rate of said feed, to decrease the mixture pressure in the locus due to centrifugal force, and cutting down the rate of discharge from the locus to less than said rate of feed to thereby accumulate another body of mixture in the peripheral portion thereof, controlling the periodic variations in the discharge rate by said changes in the centrifugal pressure of the mixture in the locus, feeding the mixture to a second locus of centrifugal force before feeding the mixture to said first locus, and utilizing the centrifugal pressure of the mixture in said second locus to cut down the discharge rate from the first locus.

GEORGE J. STREZYNSKI.

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<td>Cornell</td>
<td>Feb. 24, 1942</td>
</tr>
</tbody>
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