March 3, 1970 C. F. FISCHER 3,497,912
APPARATUS FOR CONTINOUS MIXING OF SOLID AND LIQUID MATERIAL
AND EXTRUSION OF THE MIXTURE
Filed Nov. 26, 1965 2 Sheets-Sheet 1

FIG. 1

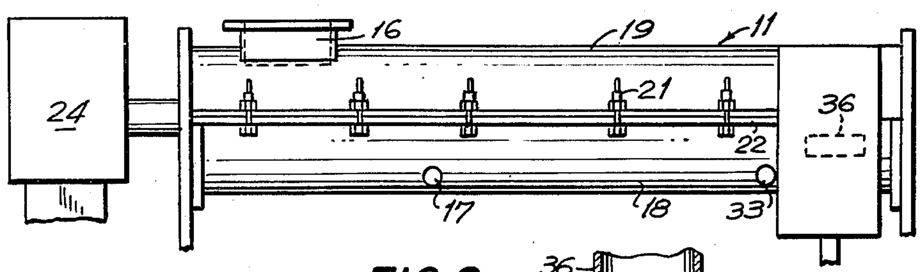


FIG. 2

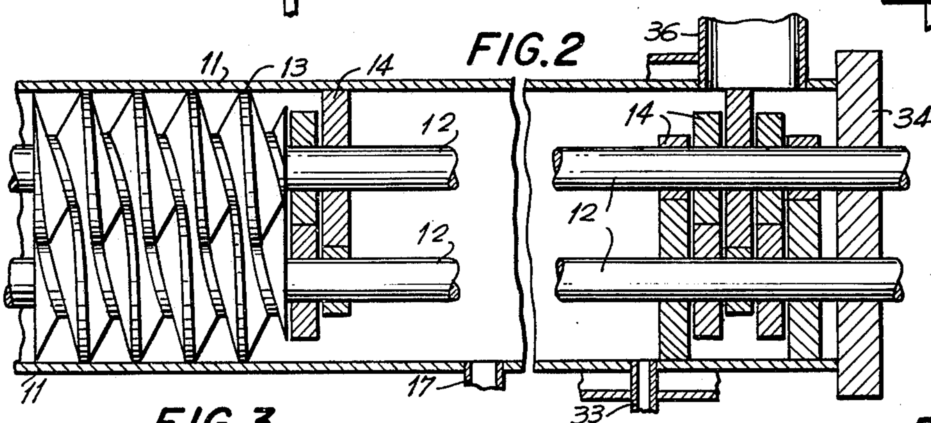


FIG. 3

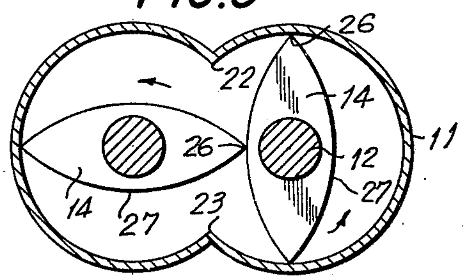


FIG. 4

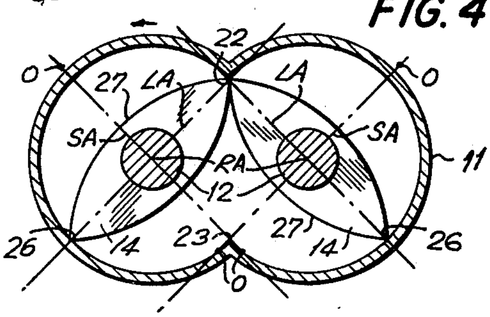


FIG. 5

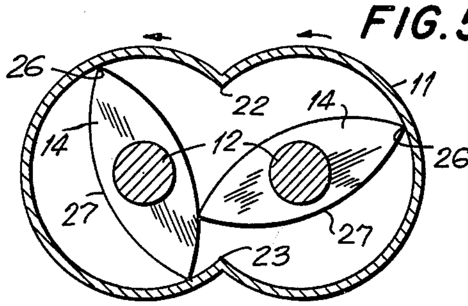


FIG. 6

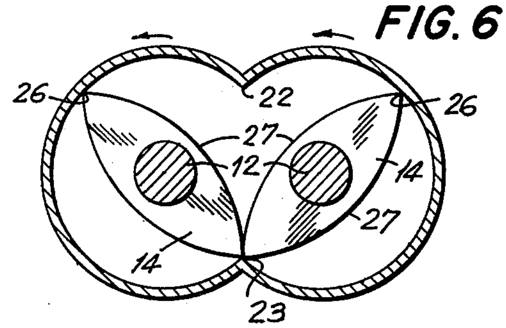
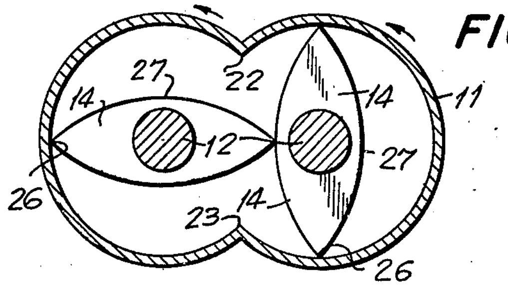


FIG. 7



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APPARATUS FOR CONTINOUS MIXING OF SOLID AND LIQUID MATERIAL AND EXTRUSION OF THE MIXTURE

Filed Nov. 26, 1965 2 Sheets-Sheet 2

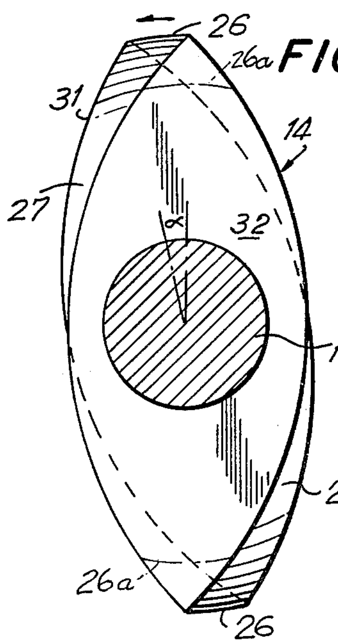


FIG. 8

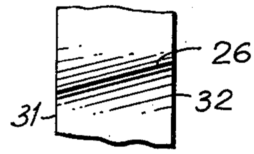


FIG. 9

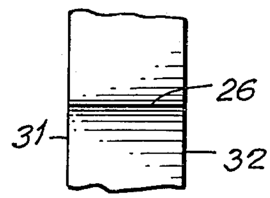


FIG. 10

FIG. 11

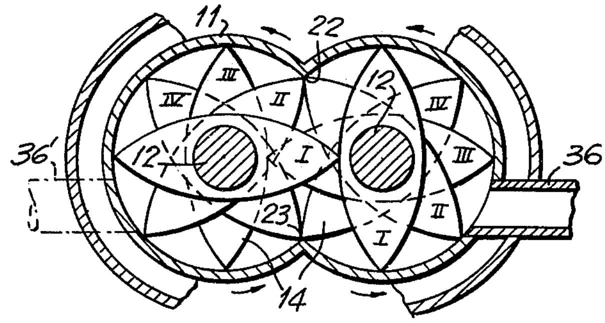


FIG. 12

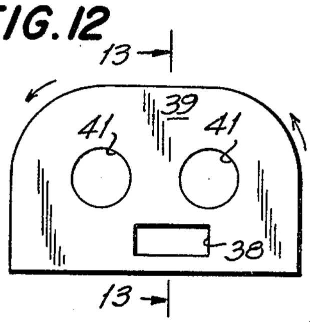
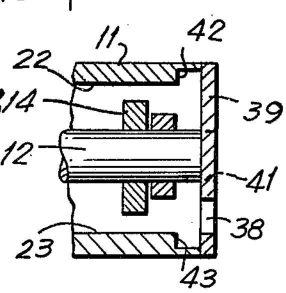


FIG. 13



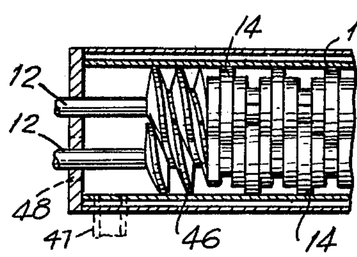
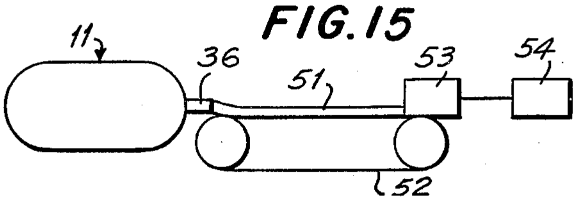


FIG. 14

FIG. 15



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United States Patent Office

3,497,912

Patented Mar. 3, 1970

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3,497,912
APPARATUS FOR CONTINUOUS MIXING OF SOLID AND LIQUID MATERIAL AND EXTRUSION OF THE MIXTURE

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Filed Nov. 26, 1965, Ser. No. 509,803
Int. Cl. B29f *3/02*
U.S. Cl. 18—2 7 Claims

ABSTRACT OF THE DISCLOSURE

Continuous formation of extruded built synthetic laundry detergent bar by mixing and shearing the ingredients in a zone having a series of successive counter-rotating paired paddles, mounted on two parallel horizontal shafts; and extruding the mixture from said zone. The apparatus may have an extrusion passageway offset from the central plane of the device.

This invention relates to a process for the production of synthetic detergent laundry bars and to machinery particularly suitable for producing such bars.

One aspect of this invention relates to a modification of a twin-shaft paddle type mixing apparatus to enable the apparatus to be used not only as a mixing and intensive shearing apparatus, but also for a continuous mixing, shearing and extrusion operation in the manufacture of synthetic detergent laundry bars containing high proportions of builder salts. It has been found, in accordance with this aspect of the invention, that by providing a bar-discharge passageway which is offset with respect to the central plane between the twin shafts, it is possible to produce extrudates of smoother cross-section and closer grain and more uniform grain structure across the width of the extruded bar, and to make good products at high rates of production.

In one preferred embodiment of the invention the material is extruded from the apparatus in a direction transverse to the central plane between the shafts. In another preferred embodiment, the material is extruded in a direction parallel to the central plane, preferably through an opening which is adjacent to that side of the apparatus where the motion of the tips of the mixing and shearing paddles has a generally upward, rather than downward, component. It has been found, surprisingly, that the best extruded bars are obtained when the discharge opening is located at that side.

Certain preferred embodiments of the invention are illustrated in the accompanying drawing in which:

FIGURE 1 is an overall side view of the apparatus;

FIGURE 2 is a top view, in cross-section, with portions broken away, showing the arrangement of shafts, feed screw elements and paddles, and the position of a side discharge opening;

FIGURES 3 to 7 constitute a sequence of end views, partly in cross-section, showing successive positions of the paddles during the rotation of the shaft;

FIGURE 8 is an end view of an advancing paddle;

FIGURE 9 is a top view showing the tip edge of an advancing paddle;

FIGURE 10 is a top view showing the tip edge of a non-advancing paddle;

FIGURE 11 is an end view, partly in cross-section, illustrating the positions of adjacent paddles on their shafts;

FIGURE 12 is a view, in elevation, of an end plate, showing its eccentric discharge passageway;

FIGURE 13 is a side view, partly in section, showing

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the end plate of FIG. 12 in position on the end of the housing of the apparatus; and

FIGURE 14 is a top view, in cross-section, showing an arrangement in which screw flights are employed at the discharge end of the apparatus;

FIGURE 15 is a schematic end view showing the mixing and extrusion apparatus coupled with a conveying, cutting and pressing apparatus.

Referring now to FIG. 1 of the drawing, reference numeral **11** designates a jacketed housing within which there are mounted a pair of parallel rotatable shafts **12** (FIG. 2) each extending horizontally the full length of the housing and each having mounted thereon, for rotation therewith, feed screw elements **13** and agitator elements or paddles **14**. The longitudinal cavity within the housing is made up of two intersecting circular cylindrical zones (as can be seen from the end view in FIG. 3) each such cylindrical zone being coaxial with the rotatable shaft situated in said zone; there being a small radial clearance between the inner walls of the cavity and the outer peripheries of the paddles and feed screw elements. There is an opening or hopper **16** at one end of the housing, above the feed screw elements, for introducing, into the cavity of the housing, the solid materials to be processed. In one embodiment of the invention, these solid materials are finely divided builder salts together with finely divided synthetic anionic detergent; the water to be blended with the solid ingredients to form a pasty mass is introduced under pressure through an opening **17**.

To provide access to the interior of the housing, the latter is made in two sections, namely, a stationary lower half **18** and a removable upper half **19** which is firmly but detachably secured to the lower half in any suitable manner, as by means of bolts **21** passing through matching flanges **22** of these two halves of the housing. The upper half **19** has a downwardly depending ridge **22** (FIG. 3) conforming to the circular portions above their intersection, and the lower half has a similar upwardly projecting ridge **23**.

The two shafts are adapted to be driven in the same direction by a drive motor and gear arrangement **24** situated at one end of the housing. The feed screw elements on the shafts are of conventional helical type, suitably intermeshing in well-known fashion as the shafts rotate to advance the material, supplied through the hopper **16**, in an axial direction towards the paddles.

The paddles **14** are arranged in matching pairs, the design being such that a tip **26** (FIG. 3) of one paddle of each pair is always moving in wiping relationship to an edge **27** of the other paddle of the pair during the continuous co-rotation of the shafts. In one particularly advantageous construction, the paddles of any pair are identical with each other and mounted with their long axes LA (FIG. 4) at right angles, the edges **27** of each paddle being defined by equiradial symmetrical arcs whose centers O and O′ are symmetrically situated on the prolongations of the short axis SA of the paddle. These arcs are of greater radius than the radii of the cylindrical zones of the cavity in the housing. As will be seen from the sequence shown in FIGS. 3 to 7, during the co-rotation of the shafts about the rotational axes RA, one tip **26** of the left hand paddle follows along the edge of flank **27** of the right hand paddle, and then a tip of the right hand paddle moves in identical fashion along the edge of the left hand paddle. Thus, FIG. 4 is a view after a 45° rotation from the position shown in FIG. 3, and FIG. 5 shows the relationship after an additional 67½° of rotation. After a total rotation of 90° from the position shown in FIG. 4, the tip of the right hand paddle is adjacent to the other tip of the left paddle, as shown in FIG. 6. Thereafter, that tip of the left hand paddle moves in an identical fashion along an edge or flank of the right hand paddle; FIG. 7 shows the relationship after an additional 45° rotation. Thus, in a full 360° rotation, each edge of each paddle will be wiped once by a tip of its matching paddle. During this full 360° rotation, the internal walls of the housing will be wiped twice by the tips of the paddles.

Certain paddles **14** (hereinafter called "advancing paddles") are designed to advance the material longitudinally of the shafts. To this end, the profile of the rear face **31** (FIG. 8) of the advancing paddle is offset by a slight angle α (about the axis of rotation) from the profile of its front face **32**. For example, for a paddle having its long axis 4⅞ inches long and its short axis 2 inches long, and having a thickness of 1 inch, the two faces may be offset by an angle of 12½°. The other paddle of the same pair has the profiles of its faces similarly offset by the identical angle, the design being such that the edge of each paddle will be wiped by the tip of its paired paddle, as previously described. Thus, in any cross section through the pair of paddles, at right angles to the axis of rotation, the relationship of the cross-sectional profiles will be the same as that shown in FIGS. 3 to 7. To advance the material from the hopper end of the housing toward its opposite end, the profile at the rear face of the paddle (that is the face nearest the hopper end) is preferably offset (from the profile at its front face) in the same direction as the direction of rotation of the paddles illustrated by the arrows in FIG. 8. It will be appreciated that while the tips are shown as being relatively sharp in the drawings, they may be relatively blunt, for example having arcuate tips as indicated by the broken lines **26*a*** on FIG. 8, the dimensions being adjusted so that the tips, though blunt, still are in close wiping relationship with the inner walls of the housing and with the edges of the matching paddle.

To continue the longitudinal advance of the material, in a more or less helical path, the long axes of each successive pair of paddles may be offset, by an arcuate angle, from the long axes of the pair previously engaged by the material being treated. FIG. 11 (in which the arrows indicate the direction of rotation of the shafts) illustrates various positions of the front faces of successive paddles, the paddle designated as I being nearer to the discharge end of the machine than the other paddles; the paddle II being next, then the paddle III and then the paddle IV which is furthest from the discharge end, there being a 45° angle between the long axes of successive paddles. This offsetting of the long axes of adjacent paddles also aids in the mixing action of the apparatus. As will be seen from FIG. 11, when the paddles are in the position designated as II, for example, their further movement acts to compress the material between the edges of flanks of the paddles and the walls of the housing, forcing the material into the paths of the movement of adjacent pairs of paddles.

The front and rear faces **32, 31** (FIGS. 9 and 10) of the paddles are advantageously flat and, when the paddles are mounted on the shafts, are situated in planes perpendicular to said shafts; the faces of adjacent paddles are preferably close to each other; thus the clearance between the front face of one paddle and the rear face of the next paddle may be on the order of about 0.03 inch. The clearances between the tips of the paddles and the inner walls of the housing may be, for example, about 0.03–0.04 inch; the clearances between the tip of the paddles and the edges of the paired paddles which they wipe may be about the same, e.g. about 0.03 inch.

It has been found advantageous to utilize, simultaneously, both the advancing paddles (i.e. paddles whose front and rear faces are offset, as described previously) and the nonadvancing paddles (i.e. paddles whose front and rear profiles are aligned, not offset).

In one typical arrangement, illustrated schematically in FIG. 2, after a series of four full helices (on each shaft) of the feed screw elements **13**, there are a sequence of five pairs of advancing paddles (of the dimensions previously described) followed by one pair of otherwise identical non-advancing paddles, then three pairs of advancing paddles, this one-and-three arrangement being repeated three times more, followed by one pair of non-advancing paddles and five pairs of advancing paddles. In this arrangement, the long axis of the front face of each paddle is offset 45° (in the direction of rotation of the shaft) from the long axis of the front face of the next, downstream, paddle. Slightly rearward of the end wall **34** of the housing is a rectangular horizontal discharge tube **36** (see also FIG. 11), having an internal width of about 2 inches, an internal height of about 1 inch and a length of about 6 inches. This discharge tube is advantageously located at that side of the housing which corresponds to the side where the motion of the paddle tip has a generally upward, rather than downward, component; alternatively, but less desirably, it may be located at the opposite side, as indicated by the broken lines, at **36′** (FIG. 11). While good results have been obtained with a discharge tube having a substantially uniform cross-section along its length, the discharge tube may be tapered, narrowing toward its exit. In another discharge arrangement, found particularly suitable for the manufacture of lower density aerated detergent laundry bars, the last pairs of paddles (adjacent the discharge end) are not offset 45° in the manner just described but are, instead, offset 90° from each other (e.g. in the last five pairs of paddles, each pair may be offset 90° from its preceding and succeeding pair); this arrangement has been found to give a highly aerated low density product, the air being injected under pressure into the device upstream of the discharge end and through the lower half of the housing (e.g. at inlet **33**, FIG. 2).

In another discharge arrangement, illustrated in FIGS. 12 and 13, there is no side discharge tube. Instead, the processed detergent mixture is discharged from the end of the device, e.g. through a discharge passageway **38** in a plate **39** having circular holes **41** for receiving the parallel shafts **12**. In one form which has been used with the paddle arrangement described in the preceding paragraph, the plate **39** is about one inch thick and the discharge passageway is horizontal and rectangular, being about 2 inches wide and about 1 inch high, the plate being spaced, for example, about 1 to 6 inches from the ends **42, 43** of the upper and lower ridges **22, 23**, the shape of the cavity in the housing adjacent the plate **39** being a symmetrical oval formed by two spaced opposed vertical semicircles (of the same diameter and aligned with the corresponding inner walls of the main cavity in the housing) joined by tangent horizontal lines. In the illustrated embodiment, the upper part of the discharge passageway **38** is about at the same level as the top of the lower ridge **33** and the center of the discharge passageway is offset about 10–15° from the center of the cavity in the housing. It will be noted that the discharge opening is at the right side of the apparatus, which (in contrast to the left side) is the side where the motion of the tips of the paddles has a generally upward component when the paddles are rotated on the direction shown by the arrows in FIG. 12.

In another discharge arrangement illustrated in FIG. 14, there are a series of screw elements **46**, identical with feed screw elements **13** at the inlet end of the machine, mounted on the shafts **12**. Discharge may take place from a side discharge tube **47** shown in broken lines, but more preferably from a discharge passageway **48** like that shown in FIG. 13 (or both). The provision of the feed screw elements at the discharge end makes it possible to obtain a much higher discharge pressure (e.g. on the order of 125 p.s.i.g.) which is particularly advantageous when the machine is used for making high-density detergent laundry bars at high rates of production.

In the overall arrangement shown schematically in FIG.

15, the extruded bar **51** continuously leaving the discharge tube **36** is taken up on moving endless belt **52**, cooled and aged to harden it, passed through a conventional cutting device **53** and then pressed in a conventional soap bar press **54**.

Typically, the extrusion opening may have an area of at least about two square inches and a height (equivalent to the thickness of the individual bars) in the range of about ¾ to 3 inches, and a width of about 2 inches or more. The width of the extrusion opening may be equal to the width of a single bar, or may be a multiple of that width (e.g. two or three times that width), in which case the extrudate may be cut lengthwise before or after it is fully cooled and hardened (e.g. by pulling or pushing it past one or more cutting elements, such as thin verticle wires, which may be heated to facilitate the cutting).

In the manufacture of the detergent laundry bar, there are employed a synthetic anionic detergent and a substantial proportion of a water-soluble solid builder salt, generally in excess of the amount of said detergent.

The water-soluble anionic organic synthetic detergents which may be present in the compositions contain a sulfo acid solubilizing group joined (directly or indirectly through an intermediate linkage) to a hydrophobic organic group. Thus, such detergents include both organic sulfonates, e.g. $R—SO_3^-$ compounds and organic sulfates, e.g. $R—O—SO_3^-$ compounds, having sufficient water solubility to form detersive aqueous solutions with foaming properties in concentrations which are suitable for use in laundering operations. In the formula, R is a radical having an aliphatic chain of at least six carbons, the radical preferably having about 8–30 carbons. The detergents may be used in individually or in any desired combination.

Among the suitable water soluble anionic sulfonated detergents, the higher alkyl aryl sulfonate detergents having about 8 to 15 carbon atoms in the alkyl group are particularly effective. It is preferred to use the higher alkyl benzene sulfonate detergents for optimum effects, though other detergents containing a mononuclear aryl group, such as xylene, toluene, or phenol, may be used also. The higher alkyl substituent on the aromatic nucleus may be branched or straight-chained in structure. Examples of straight chain alkyl groups are n-decyl, n-dodecyl and n-tetradecyl groups derived from natural fatty acids and petroleum.

Examples of branched chain alkyl derivatives are propylene and butylene polymers such as propylene trimer, tetramer and pentamer. Examples of other suitable water soluble anionic sulfonated detergents which may be satisfactorily used in the compositions of this invention are the alkane sulfonates containing about 8 to 20 carbon atoms in the alkyl group and the alkyl sulfonates wherein the alkyl group of about 8 to 20 carbon atoms is linked to the sulfonic acid group through a $—COOR_1—$ group, e.g. oleic acid isothionate, $—CONHR_1$ group, e.g. lauric acid taurate, or a $—OR_1$ group, e.g. dodecyl glyceryl ether sulfonate, wherein the R_1 is a lower alkyl or a substituted lower alkyl group containing 2–3 carbon atoms.

Among the suitable water soluble organic sulfated detergents which it is preferred to use in compositions of the invention are alkyl sulfates, e.g. sodium lauryl or coconut fatty alcohol sulfate, and the alkyl ethyleneoxy ether sulfates, e.g. sodium lauryl tri-ethyleneoxy sulfate, said alkyl groups having about 8 to 20 carbon atoms and the ethyleneoxy sulfates containing about 1 to 15, preferably 2 to 10 moles of ethylene oxide. The alkyl groups may be derived from naturally occurring glycerides or synthetically from petroleum, e.g. cracked waxes or ethylene polymerization.

Other suitable organic sulfate detergents include sulfuric acid esters of polyhydric alcohols, incompletely esterified with higher fatty acids, e.g. coconut oil monoglyceride monosulfate, and sulfated higher alkyl phenol-ethylene oxide condensates having an average of about 2 to 18 moles of ethylene oxide per phenol group and about 6 to 18 carbons in the alkyl group. The sulfated higher alkyl phenol-ethylene oxide condensates which it is preferred to employ have about 4 to 6 moles of ethylene oxide per phenol group and about 8 to 12 carbon atoms in the alkyl group.

As previously indicated, these sulfate and sulfonate detergents advantageously are supplied to the shearing zone in acid liquid state and are present in the final product in the form of their alkali metal and alkaline earth metal salts. The preferred alkali metals are sodium and potassium and the preferred alkaline earth metals are calcium and magnesium. Optimum effects are obtained with the sodium salts in general.

The proportion of anionic organic detergent should be suitably selected so as to yield a product having the desired performance and physical characteristics. The detergent active functions as a foaming and cleansing agent as well as a plasticizer in the compositions of the invention. The proportion of said detergent will be minor compared to the inorganic salts, usually in the range of about 10 to 40% by weight, and preferably about 15 to 30% by weight, of the finished bar.

The water soluble inorganic builder salts are known in the art generally and may be any suitable alkali metal, alkaline earth metal, or heavy metal salt or combinations thereof. Ammonium or an ethanolammonium salt in a suitable amount may be added also, but generally, the sodium and potassium salts or similar salts effective to add hardness or strength to the bar are preferred. Examples are the water soluble sodium and potassium phosphates, silicates, carbonates, bicarbonates, borates, sulfates and chlorides. The builder salts contribute detersive efficiency when used in combination with sulfonic acid and/or sulfuric ester organic synthetic detergents. Particularly preferred builder salts are the alkaline builder salts such as polyphosphates, silicates, borates, etc. Inasmuch as the builder effects and processing characteristics of the individual salts vary to some extent, generally mixtures of inorganic builder salts are used in variable, predominating proportions, e.g. about 45–85% by weight of the finished bar, preferably in proportion of about 50–65% by weight.

In the water soluble inorganic builder salt mixtures used in the detergent laundry bar compositions, it is preferred to have present a mixture of sodium tripolyphosphate and sodium or potassium bicarbonate. The combination or mixture of salts wherein the bicarbonate to tripolyphosphate ratio is selected from the range of about 1:1 to about 3:1, and which when admixed with the particular organic detergent and water in proportions such that this mixture of inorganic salts is at least about 40% of the total weight of the manufactured bar, results in desired processing effects and produce bars having superior physical characteristics. Preferably, the proportions of this particular inorganic salt mixture is within the range of about 45 to about 65% by weight of the manufactured bar.

Both Phase I and Phase II sodium tripolyphosphate and mixtures thereof may be successfully used in the compositions. The usual commercial tripolyphosphate consists mainly of the Phase II material. The commercial tripolyphosphate material is usually essentially tripolyphosphate, e.g. 87–95%, with small amounts, e.g. 4–13% of other phosphates, e.g. pyrophosphate and orthophosphate. Sodium tripolyphosphate in its hydrated form may be used also. While trisodium orthophosphate may be used in the amounts indicated, its presence often results in a bar which tends to "sweat" in hot, humid climates and whose surface tends to slough off more readily in such climates.

The sodium or potassium bicarbonate is an effective pH buffer and is preferred because the particular tripolyphosphate bicarbonate mixture results in plastic detergent compositions which yield superior extruded bars. This material is also desirable in that it is relatively inexpensive, has suitable solubility and does not cause "frosting" on the surface of the bar. The sodium bicarbonate may be incorporated directly as anhydrous bicarbonate or in the form of sesquicarbonate, a hydrate containing both bicarbonate and carbonate.

Other suitable builder salts which may be incorporated in the built synthetic detergent bar compositions include the water soluble sodium and potassium silicates, carbonates, borates, e.g. sodium tetraborate, chlorides and sulfates, e.g. magnesium sulfate. Generally, the total proportion of these additional builder salts will be within the range of from 0.5 to 24% by weight of the manufactured bar. The sodium and potassium silicates having a $Na_2O:SiO_2$ ratio within the range of 1:1 to about 3.5:1 are particularly effective as corrosion inhibitors in proportions of about 1 to 8% by weight of the finished bar. The sodium sulfate content is advantageously kept low, e.g. below ⅓ the weight of the phosphate (on an anhydrous basis); preferably, to avoid frosting, the sodium sulfate content is below about 5% of the weight of the bar.

The final essential ingredient in the built synthetic detergent bar composition is water or similar material. This component is generally present in a proportion within the range of about 2 to 30% by weight of the bar. This material serves as a plasticizer; also, when the anionic detergent is formed in situ in the intensive shearing zone by reaction of injected liquid detergent acid (e.g. alkyl benzene sulfonic acid), the water helps promote the neutralization reaction. It will be appreciated that the total amount of water is the sum of the amount added with the other ingredients in the feed (e.g. in the sulfonic acid, or with the salts, or separately) and the amount formed during the neutralization reaction. It is preferred that the water is from about 4% to 25% by weight.

Optionally, a fatty acid alkylolamide may be included in the composition. Such materials are generally condensation products of higher fatty acids having about 10 to 14 carbon atoms in the acyl group with alkylolamides selected from the group consisting of mono-ethanolamine, diethanolamine and isopropanolamine. Examples are lauric, capric, myristic and coconut monoethanolamide, diethanolamide and isopropanolamide. The alkylolamide suds builders may be present in proportions within the range of about 0 to 5%, preferably about 2%.

Various other ingredients may be included if desired. The compositions may beneficially include specific chelating agents capable of complexing iron such as the water soluble salts of ethylene diamine tetraacetic acid and the like. Other conventional auxiliary material which may be incorporated in the compositions are soil-suspending agents such as sodium carboxymethylcellulose, tarnish inhibitors such as melamine, fluorescent brightening agents, perfumes, coloring agents, germicides or bacteriostats, skin-conditioning agents such as glycerine or lanolin, and the like. These materials may be admixed with the compositions in any suitable manner which does not substantially adversely affect the plasticity of the compositions.

Other ingredients which may be employed are starches (such as tapioca flour, cornstarch, yucca starch or potato starch); the presence of the starch aids in the processing of the mixture, improves its workability and appears to promote its flow over the inner walls of the bar-forming die of the machine. Other agents which have related effects, and which may be added together with or in place of the starch, are clays such as bentonite and kaolin, which like starch tend to absorb moisture and swell to form gels in hot aqueous media, and finely divided cellulose (Solka-Floc). These additives may be included in amounts up to about 20%; their effects are marked above about 5% (e.g. 7%); a preferred proportion is about 10–12% of starch. Starch also helps to give the bar a brighter color.

Another processing aid is a wax such as paraffin, which may be added as fine flakes mixed with the builder salts or dissolved or dispersed in heated detergent sulfonic acid. Related waxy materials such as petrolatum may also be used. The wax also helps to increase the life of the bar in ordinary use and to prevent "sweating" of the bar in certain climates, when used in small amounts (e.g. ¼ to 1½%); smaller and larger amounts may be used as desired.

As previously indicated, the anionic detergent may be produced in situ in the shearing zone. In this case, a stream of the liquid acidic form of the detergent and a stream of neutralizing agent (such as aqueous NaOH) may be injected continuously into the shearing zone; alternatively, the liquid neutralizing agent may be omitted and sufficient solid neutralizing agent (e.g. finely divided alkali metal carbonate and/or bicarbonate) may be included with the other solid ingredients.

Further details relating to the composition and process for making detergent bars are found in the application of Austin and Lee, Ser. No. 469,144, filed July 2, 1965, whose disclosure is incorporated herein by reference. The apparatus of this invention may also be used for making other types of detergent products.

The following example is given to illustrate the invention further.

EXAMPLE

In this example, the apparatus used was that of FIG. 14 having an internal cavity about 3 feet long, the internal diameter of each of the intersecting circles being about 5 inches, the feed screw flights (two turns) extending about 4 inches in each shaft, the discharge screw flights (two turns) also extending about 4 inches on each shaft, the long axes of the paddle faces being almost 5 inches long, and the short axes being 2 inches long, the paddles being about one inch thick, the offset between long axes of successive paddles being 45°, the pattern of paddles being: eight pairs of advancing paddles at the feed end, followed by two pairs of non-advancing paddles, two pairs of advancing paddles, this and two-and-two arrangement being repeated three times more, then one pair of non-advancing paddles and the 4 inches of discharge screw flights.

The discharge was effected through the off-center rectangular discharge passageway previously described, spaced about 5 inches from the nearest pair of paddles. The speed of rotation of the co-rotating shafts was about 150 r.p.m. The rates of feed were 605 pounds per hour of the dry mixture and 75 pounds per hour of water, which was injected continuously in the lower portion of the cavity at about 9 inches downstream of the feed screw section. After a normalization period of about 15 minutes, a smooth bar was extruded continuously. The extruded material which, as extruded, had a temperature of about 130° F., was permitted to cool, in a quiescent state, to room temperature and was then cut into individual bars and pressed at a pressure of about 200 p.s.i. The specific gravity of the bars was 1.5–1.6. The dry mixture used in this example was a finely divided blend of 41% sodium tridecyl benzenesulfonate (branched chain type, from sulfonation of a mixture of reaction products of benzene); 12% of tapioca flour, 24% sodium bicarbonate, 22% pentasodium tripolyphosphate (commercial grade anhydrous) plus perfume and minor impurities, which had been screened through a standard 40 mesh screen to remove lumps.

Numerous modifications and variations of the embodiments of this invention can be made without departing from the spirit and scope thereof. Accordingly, it is to be understood that this invention is not to be limited except as defined in the appended claims.

What is claimed is:

1. Apparatus for the continuous mixing of solid and liquid material to form a pasty mass and for the continuous extrusion of said mass in the form of a bar of

predetermined cross section, said apparatus comprising a generally horizontal elongated housing, a pair of parallel substantially horizontal shafts symmetrically positioned with respect to an imaginary central plane, means for driving said shafts to rotate both shafts in the same direction, said shafts having thereon a series of paired mixing and shearing projections arranged lengthwise of said shafts and within said housing, said paired projections being constructed and arranged so that, during the rotation of said shafts, said projections wipe each other's surfaces and the inside of said housing, said housing having adjacent one of its ends a feed opening for the introduction of material to be mixed therein and having adjacent its opposite end a discharge passageway for the extrusion of the mixed mass in the form of a bar of predetermined cross section, said discharge passageway being offset with respect to said central plane, said projections including pairs of paddles, each pair comprising a paddle mounted on one of said shafts and a cooperating and aligned paddle mounted on the other of said shafts, each paddle being elongated and having an arcuate edge profile and tips at opposite ends, the inner walls of said housing conforming to the shape of concentric intersecting circular cylinders centered on the axes of said shafts and of slightly greater radius than the radial distance between the axis of the corresponding shaft and the tip of the paddie thereon, said paddles being constructed and arranged so that, during rotation of said shafts and of the paddles carried thereby, the tip of each paired paddle wipes successively against the arcuate edge of the other paired paddle and the inner wall of the housing, said plane being vertical, said housing having an end wall, said discharge passageway being a generally rectangular opening in said end wall and being principally situated within the imaginary circle constituting a horizontal projection of that one of said cylinders which houses those paddles whose tips move upward along the inner wall of the housing.
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2. Apparatus for the continuous mixing of solid and liquid material to form a pasty mass and for the continuous extrusion of said mass in the form of a bar of predetermined cross section, said apparatus comprising a generally horizontal elongated housing, a pair of parallel substantially horizontal shafts symmetrically positioned with respect to an imaginary central plane, means for driving said shafts to rotate both shafts in the same direction, said shafts having thereon a series of paired mixing and shearing projections arranged lengthwise of said shafts and within said housing, said paired projections being constructed and arranged so that, during the rotation of said shafts, said projections wipe each other's surfaces and the inside of said housing, said housing having adjacent one of its ends a feed opening for the introduction of material to be mixed therein and having adjacent its opposite end a discharge passageway for the extrusion of the mixed mass in the form of a bar of predetermined cross section, said discharge passageway being offset with respect to said central plane, said projections including pairs of paddles, each pair comprising a paddle mounted on one of said shafts and a cooperating and aligned paddle mounted on the other of said shafts, each paddle being elongated and having an arcuate edge profile and tips at opposite ends, the inner walls of said housing conforming to the shape of concentric intersecting circular cylinders centered on the axes of said shafts and of slightly greater radius than the radial distance between the axis of the corresponding shaft and the tip of the paddle thereon, said paddles being constructed and arranged so that, during the rotation of said shafts and of the paddles carried thereby, the tip of each paired paddle wipes successively against the arcuate edge of the other paired paddle and the inner wall of the housing, said discharge passageway being a tube leading from an inner wall of said housing along a path transverse to said plane.

3. Apparatus as set forth in claim **2**, said discharge passageway leading from an inner wall of that one of said cylinders which houses those paddles whose tips move upward along the inner wall of the housing.

4. Apparatus for the continuous mixing of solid and liquid material to form a pasty mass and for the continuous extrusion of said mass in the form of a bar of predetermined cross section, said apparatus comprising a generally horizontal elongated housing, a pair of parallel substantially horizontal shafts symmetrically positioned with respect to an imaginary central plane, means for driving said shafts to rotate both shafts in the same direction, said shafts having thereon a series of paired mixing and shearing paddles arranged lengthwise of said shafts and within said housing, each pair comprising a paddle mounted on one of said shafts and a cooperating and aligned paddle mounted on the other of said shafts, each paddle being elongated and having an arcuate edge profile and tips at opposite ends, the inner walls of said housing conforming to the shape of concentric intersecting circular cylinders centered on the axes of said shafts and of slightly greater radius than the radial distance between the axis of the corresponding shaft and the tip of the paddle thereon, said paddles being constructed and arranged so that, during the rotation of said shafts and of the paddles carried thereby, the tip of each paired paddle wipes successively against the arcuate edge of the other paired paddle and the inner wall of the housing, said housing having adjacent one of its ends a feed opening for the introduction of material to be mixed therein and having adjacent its opposite end a discharge passageway for the extrusion of the mixed mass in the form of a bar of predetermined cross section, said shafts having mounted thereon pairs of intermeshed helical screws mounted adjacent said opposite end to force the mixed mass through said discharge passageway.

5. Apparatus as set forth in claim **4**, said plane being vertical, said housing having an end wall, said discharge passageway being a generally rectangular opening in said end wall and being principally situated within the imaginary circle constituting a horizontal projection of that one of said cylinders which houses those paddles whose tips move upward along the inner wall of the housing, said apparatus including conveyor means for supporting the extruded bar as it leaves said opening and cutter means for subdividing said bar into individual laundry bars.

6. Apparatus for the continuous mixing of solid and liquid material to form a pasty mass and for the continuous extrusion of said mass in the form of a bar of predetermined cross section, said apparatus comprising a generally horizontal elongated housing, a pair of parallel substantially horizontal shafts symmetrically positioned with respect to an imaginary central plane, means for driving said shafts to rotate both shafts in the same direction, said shafts having thereon a series of paired mixing and shearing projections arranged lengthwise of said shafts and within said housing, said paired projections being constructed and arranged so that, during the rotation of said shafts, said projections wipe each other's surfaces and the inside of said housing, said housing having adjacent one of its ends a feed opening for the introduction of material to be mixed therein and having adjacent its opposite end a discharge passageway for the extrusion of the mixed mass in the form of a bar of predetermined cross section, said discharge passageway being offset with respect to said central plane, said projections including pairs of paddles, each pair comprising a paddle mounted on one of said shafts and a cooperating and aligned paddle mounted on the other of said shafts, each paddle being elongted and having an arcuate edge profile and tips at opposite ends, the inner walls of said housing conforming to the shape of concentric intersecting circular cylinders centered on the axes of said shafts and of slightly greater radius than the radial distance between the axis of the corresponding shaft and the tip of the paddle thereon, said paddles being constructed and arranged so that, during the rotation of said shafts and of the paddles carried thereby, the tip of each paired paddle wipes successively against the arcuate edge of the other paired paddle and the inner wall of the housing, the two paddles of each pair being of substantially the same size and shape, each paddle having two diametrically opposed tips joined by two convex arcs intersecting equiradial circles, the long axis joining the tips of each paired paddle being at right angles to the corresponding long axis of the other paddle of each pair, each paddle having a front face and a rear face, both said faces being in planes transverse to said central plane, the front face and rear face of some of said paddles being aligned in a direction parallel to the shafts and the front face and rear face of others of said paddles being offset by an acute angle about the respective shafts on which the paddles are mounted, the construction and arrangement of said offset-faced paddles being such as to advance the material being processed in said housing in a direction toward the discharge end of said housing.

7. Apparatus for the continuous mixing of solid and liquid material to form a pasty mass and for the continous extrusion of said mass in the form of a bar of predetermined cross section, said apparatus comprising a generally horizontal elongated housing, a pair of parallel substantially horizontal shafts, means for driving said shafts to rotate both shafts in the same direction, said shafts having thereon a series of paired mixing and shearing projections arranged lengthwise of said shafts and within said housing, said projections including pairs of paddles, each pair comprising a paddle mounted on one of said shafts and a cooperating and aligned paddle mounted on the other of said shafts, each paddle being

elongated and having an arcuate edge profile and tips at opposite ends, the inner walls of said housing conforming to the shape of concentric intersecting circular cylinders centered on the axes of said shafts and of slightly greater radius than the radial distance between the axis of the corresponding shaft and the tip of the paddle thereon, said paddles being constructed and arranged so that, during the rotation of said shafts and of the paddles carried thereby, the tip of each paired paddle wipes successively against the arcuate edge of the other paired paddle and the inner wall of the housing, said housing having adjacent one of its ends a feed opening for the introduction of material to be mixed therein and having adjacent its opposite end a discharge passageway for the extrusion of the mixed mass in the form of a bar of predetermined cross section, said discharge passageway leading from an inner wall of the housing along a path transverse to said shafts.

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