

July 21, 1936.

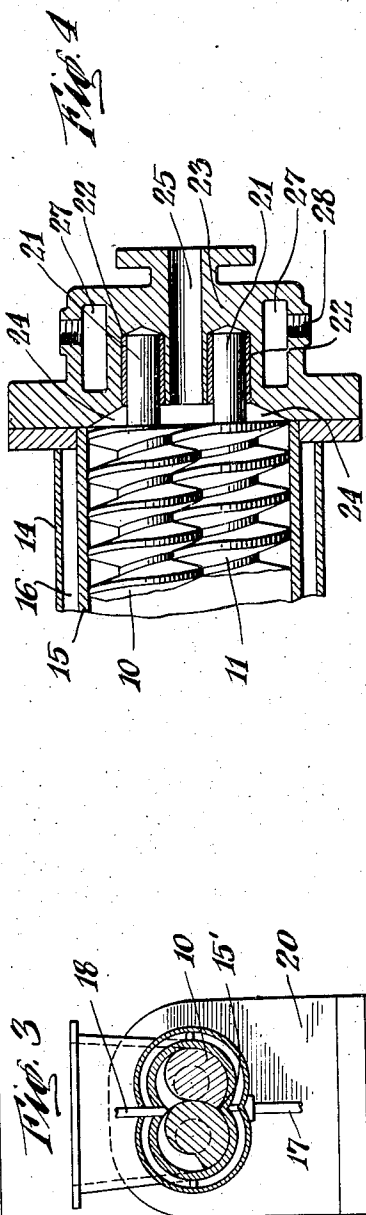
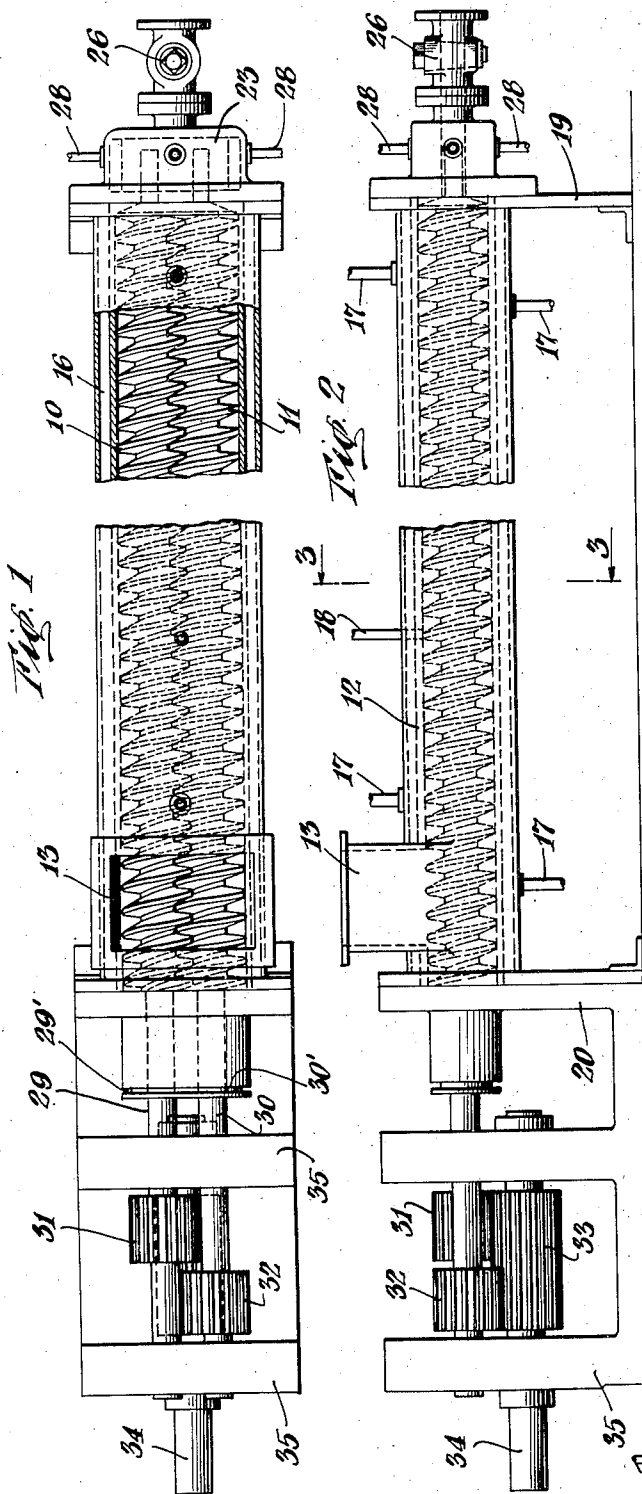
F. F. PEASE

2,048,286

APPARATUS FOR TREATING PLASTIC MATERIALS

Filed Aug. 17, 1933

4 Sheets-Sheet 1



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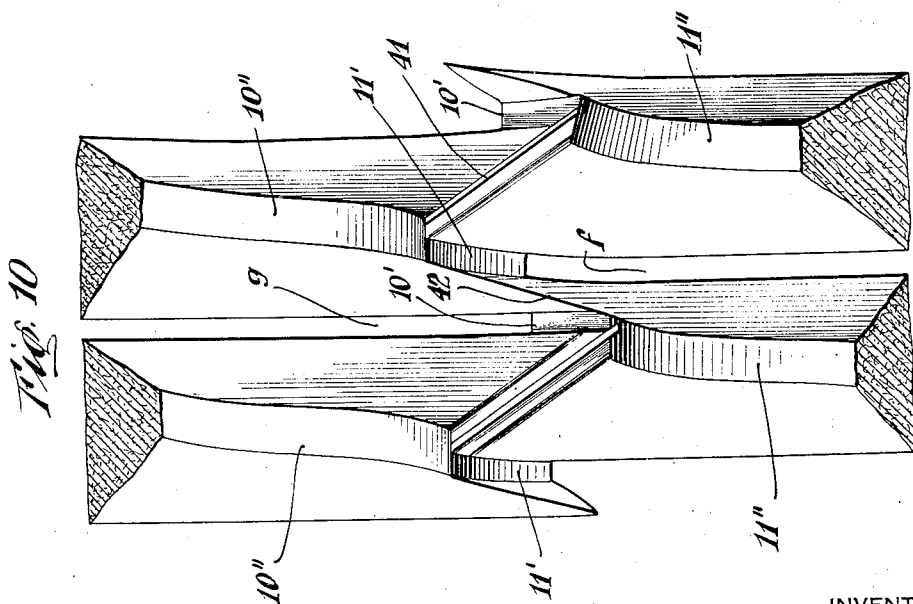
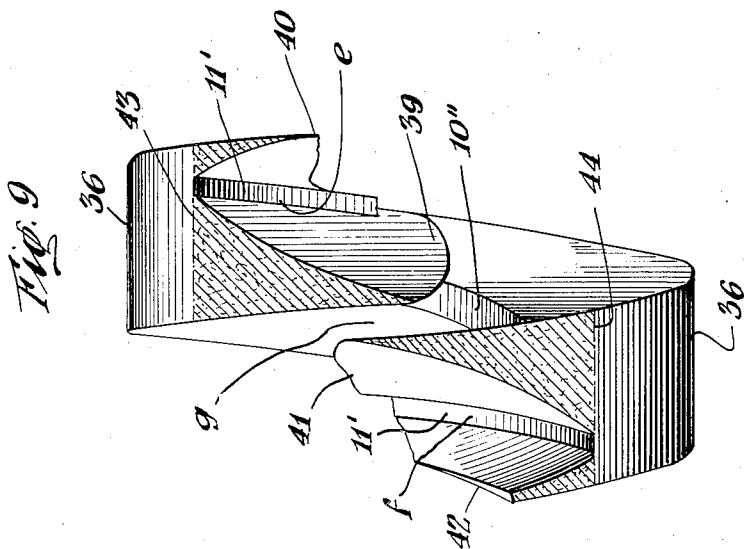
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4 Sheets-Sheet 3



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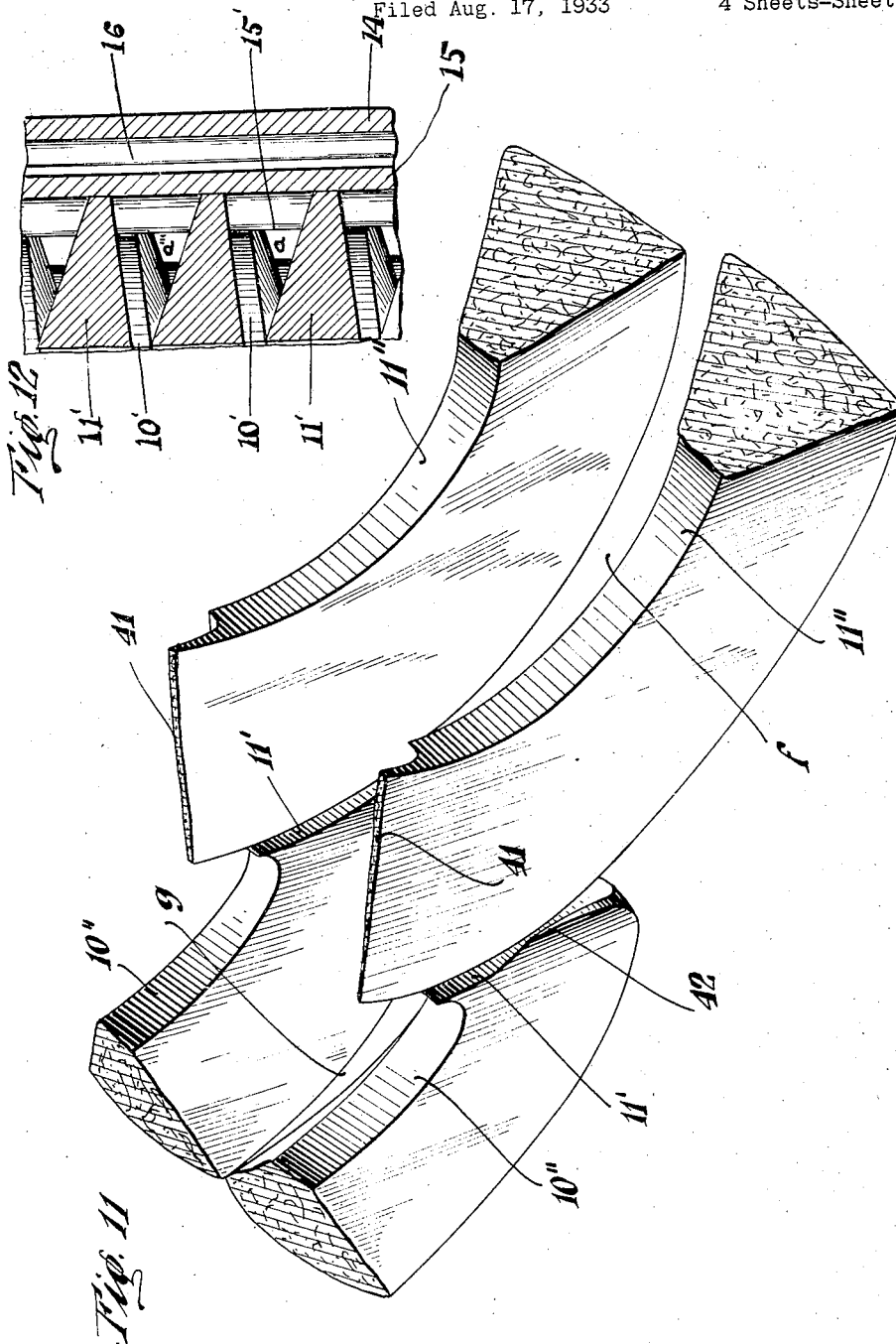
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APPARATUS FOR TREATING PLASTIC MATERIALS

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,048,286

APPARATUS FOR TREATING PLASTIC MATERIALS

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Application August 17, 1933, Serial No. 635,528

16 Claims. (Cl. 18—12)

The invention relates to an improvement in apparatus for treating plastic materials to modify or change certain of their physical characteristics, and more particularly to improved means for mixing, working, homogenizing and otherwise mechanically treating plastic materials while simultaneously subjecting them to temperature and pressure control to produce the desired changes and modifications therein.

Previously, there have been difficulties experienced in working with relatively viscous masses, such as soap, for example, to obtain a completely uniform and homogeneous mass having desired modified characteristics. These difficulties apparently have been due to the fact that proper physical conditions have not been maintained through the entire mass, sufficient to bring about a desired modification. They have also been due to the lack of a suitable apparatus for carrying out a treating process.

In the copending application of John W. Bodman, for soap and process of producing same, Serial No. 665,063, filed April 8, 1933, there is disclosed a process of treating soap in plastic condition to produce a finished product having certain improved physical and structural characteristics, such as, a reduction in the size of the soap crystals by recrystallization under heat, pressure and agitation, and their redistribution or rearrangement in the soap mass whereby the soap is given improved wearing qualities, has a finer "feel" or texture, does not swell and crack when left in water and possesses other improved qualities. The invention disclosed in the present application comprises an improved apparatus for carrying out the soap modifying process disclosed in said Bodman application, but it will be understood that the present invention is not to be restricted to such soap modifying process, since it is capable of general application in treating plastic materials to change or modify certain of their physical and structural characteristics, or simply to change or modify their physical condition as by converting a plastic substance in a solid or granular condition into a fluent or semi-fluid state.

An object of the present invention is to provide an improved apparatus for treating a plastic mass, and uniformly imparting to it desirable physical characteristics.

Another object of my invention is to provide an apparatus for treating a plastic mass under closely controlled conditions to improve or modify the physical characteristics of the mass under treatment.

My invention is based upon the discovery that by simultaneously working, squeezing, intensely agitating and so breaking the cleavage planes throughout all parts of a plastic mass under treatment, and while under closely controlled temperature, pressure and blending conditions, a modification of the structural and physical properties of the mass can be obtained.

I have also found that by the use of two intermeshing agitating members, the working surfaces of which have preferably the contour of continuous grooved threads of identical construction, both as to pitch, direction of twist, size and contour, and of such a shape that the threads of each screw completely fill or block off the spaces between the threads of the other screw so as to prevent the passage of material between the screws at the zone of intermesh, and, further, that by enclosing these intermeshing screws with a close fitting heat interchange jacket with a means for maintaining pressure within the converter, my type of processing can be carried out and the desired products obtained.

I have disclosed the preferred form of apparatus in the drawings although, of course, other modifications may become apparent to those skilled in this art which would not depart from the scope of the invention as disclosed. I, therefore, do not wish to be limited to the specific form shown and described.

Figure 1 represents a plan view of my screw converter with a portion of the casing broken away.

Figure 2 represents a side elevational view of my screw converter.

Figure 3 represents a section taken at 3—3 of Figure 2.

Figure 4 is an enlarged sectional detail of the discharge end of my converter.

Figure 5 is an enlarged sectional detail showing the intermeshing threads of the converter screws.

Figure 6 represents a section taken at 6—6 of Figure 5.

Figure 7 represents a cross section taken at 7—7 of Figure 6.

Figure 8 represents a detail section taken at 8—8 of Figure 6.

Figure 9 is a representation of a segment of the mass under treatment which forms in one convolution of the groove between the threads of a screw.

Figure 10 is a representation of a portion of the mass under treatment showing its form at that portion of the converter where the screws intermesh.

Figure 11 is another view of the portion of the treated mass indicated in Figure 10; and

Figure 12 is a detail section taken at 12—12 of Figure 6.

Referring now more particularly to the drawings, in which like reference characters denote like parts, my apparatus comprises two parallel, intermeshing screw agitators 10 and 11, the axes of which preferably lie in the same horizontal plane. These screws are of the same diameter and have as working surfaces continuous threads, of identical construction as to the direction of pitch, size and contour. A detail of the threads is illustrated, for example, in Figure 5, and as can be seen, the threads are of such shape that when the screws are in their working or intermeshed position, the threads of each screw completely fill or block off the spaces between the threads of the cooperating screw at the zone of intermesh and thereby prevent the passage of material between the screws at this point. The axes of the screw converters are parallel and their centers are such a distance apart that the tip of the thread of one clears the root of the threads of the other with only mechanical working clearance. The greater portion of the helical or working surfaces of these screws are of a single curvature and the intersection of these surfaces with a plane passing through the working axis of a screw is preferably substantially rectilinear except near the root and tip of the threads where they may be slightly rounded. In the form I have shown, the threads are flattened at the tip and a corresponding flat section is provided between their bases. This provides a thread of great strength and sufficient bearing area to resist side thrust, although the particular form of individual thread is not essential to my apparatus.

The important feature in connection with the formation of the threads and of the screws is the relationship of the threads of one screw to the respective grooves in the cooperating screw in which such threads lie. At the line of intermesh between the screws and in the plane of the axes of the screws the threads of one screw completely fill the grooves of the cooperating screws except for working clearance. However, above and below this line of complete intermesh there is a passageway for the material under treatment from the grooves of one screw to the grooves of the cooperating screw. This passageway is defined on one side by the threads of one screw forming a groove and on the other side by the inner wall of the conforming container. It should be kept in mind that this container closely surrounds the unintermeshed portions of each of the screws and has a conforming portion which fits snugly up to the actual line of overlapping of the threads on the screws, as can be seen from Figure 6. The passageway from the grooves of one screw to the grooves of another can be seen from Figure 5 as indicated by $a-a$ and $a'''-a'''$ and also from Figure 8 in which the dotted lines 43—44 indicate the innermost extension of the container in between the screws. The threads of one screw, however, as can be noted from the drawings, by lying in the opposite groove block off a portion of this passageway, $a-a$ or $a'''-a'''$ for example. My apparatus has been so designed that in its preferred form the blocking effect of a thread within this passageway from the grooves of one screw to the grooves of the other screw is approximately two-thirds of the cross-sectional area of a groove, as indicated at a'' of Figure 5.

In other words, as will be later described in greater detail in connection with the operation of my structure, and as indicated in Figure 12 for example, the material under treatment in passing along the passageways indicated in Figure 5 by the reference characters $a-a$ for example, will be extruded or forced through a cross-sectional area of only one-third its original cross-section. I have found that these proportions give a preferred relationship between the extruding action to obtain a maximum working on the material and the maximum passage of material under treatment through my device.

The length of the screws is several times that of their outside diameter and for effective operation, it has been found that the pitch of the screws should be sufficient to give a considerable number of turns in the entire length. These screw agitators preferably are arranged to turn in the same direction and the threads of each screw are positioned at the zone of intermesh in such a manner as to wipe any adhering mass under treatment from the threads of the other.

These screw agitators 10 and 11 are within a casing 12 which completely encloses them in their parallel intermeshed arrangement. At one end of the casing I have shown a hopper 13 extending through the casing which permits the charging of material to be treated to the screw agitators or converters although of course other feeding means may be used. The casing 12, in reality, is composed of two shells 14 and 15 forming a jacketed enclosure 16 to which heating or cooling fluid may be supplied through the inlet or outlet pipes 17. The inner portion 15 of the jacket 12 fits closely around the screw agitators with only an allowance for mechanical working clearance, and follows the contour of the intermeshed screws as shown at 15 of Figure 6 to form two substantially cylindrical jackets. It will be apparent, therefore, that there is substantially no movement of the mass under treatment between the jacket and the screw agitators, the primary movement of the mass being within and between the teeth of the screws as will be later described in greater detail.

The feed hopper at the inlet end of the casing should preferably give access to a sufficient length of the two screw agitators to enable them to take in a full and, if desired, a continuously fed load of material to be processed. It has been found that from four to six threads of the screws is sufficient for this purpose. If a liquid charging stock is to be treated, the feeding conduit can be connected directly to my converter by a flanged connection so that there will be no exposure to the air or loss of any components therefrom.

I have also shown connected to the jacket a conduit 18 which communicates directly with the interior of the screw chamber. This conduit may be used for admitting air, steam or other fluids to the mass within the converter or, if desired, such conduit may also be used for withdrawing, as well as adding, material along the length of the converter.

The converter may be supported by any suitable form of base such as that indicated by reference characters 19 and 20. The shafts 21 at the discharge end of the screw agitators turn in the bearings 22 placed in the discharge head 23. This discharge head is provided with annular conical-shaped recesses 24 positioned between the ends of the screws and the casing discharge head. They communicate with the discharge outlet 25. The discharge outlet 25 may be of any desired

cross-section dependent upon the through-put of the converter and the amount of discharge may be controlled either by interchangeable discharge plates having orifices of various sizes or by a valve 26 as shown. The discharge head is preferably a jacket provided with openings 27 through which a cooling or heating fluid may be passed dependent upon the conditions desired to be maintained, such a fluid being permitted to enter or discharge through the conduits 28.

Each of the screws has extending from the inlet end of the casing a shaft, such as the shafts indicated by the reference characters 29 and 30. These shafts pass through the stuffing boxes 29' and 30' and each is also fitted with a thrust bearing not shown. The shaft 29 is fitted with gear 31 and the shaft 30 with gear 32, both of which are driven by the gear 33 which, in turn, may be driven from any outside source through the shaft 34. It will be noted that this arrangement of the gears in the present illustrative example permits the driving of both of the intermeshing screw agitators in the same direction. These gears and shafts may be journaled on the supports 35.

I have described an apparatus particularly adapted for modifying and working a plastic mass such as soap to produce a resulting substance having novel and desirable characteristics. Also, I have described below the operation of my apparatus in connection with soap. However, I do not wish to be limited to such a specific disclosure as indicated by these examples, for it will be readily apparent to those skilled in the art that my process of homogenizing and texturizing and my apparatus are applicable to other arts, for example, in the processing of hydrogenated materials, or in the modifying of other plasticizable masses.

The material to be charged to my converter may be prepared in any suitable manner and may be in either liquid or a solid form. If desired, ordinary kettle soap having a moisture content of approximately 30% may be charged to the converter, or, if preferred, a liquid mass of soap having a relatively low moisture content may be used. On the other hand, dried or partially dried chips prepared from kettle soap of the type used in the conventional milled soap process may be used. Also my process may be carried out using soap material which has been separated out as an unsuitable or waste material from a soap spray drying operation or other waste material formed in any soap-making process.

Generally, if a relatively dry material is used as charging stock, I have found it desirable to operate my device as a heating means and thus convert the dry substances into a plastic or somewhat fluid form. On the other hand if a hot liquid soap material is charged, it may be advisable to use my device as a cooling means in addition to its other operations and this can be done by charging a cooling solution to the enclosing jackets. In any event the apparatus may be operated as a heat interchange device.

The raw material or charging stock may be fed to the converter with controlled quantities of air, perfume, moisture, filler or other blending ingredients to give the properties desired in the final product. In the converter the charging stock is subjected simultaneously under heat and pressure to agitation of such a nature as to produce a high degree of mixing, kneading and internal shear throughout the entire mass. It is to be noted that the action takes place within a closed container. If a liquid charging stock is

being charged a closed flanged connection may be made with the feed line. The stock at the feed end may be in a relatively solid condition and fed into the feed hopper 13. In such case the feed end of the container is also closed or sealed off due to the complete filling of the spaces between and around the threads of the agitators by the charging stock. There is thus no loss of any of the ingredients of a charging stock. This is particularly important in connection with the blending of volatile ingredients such as perfumes which previously in the usual process have been subjected to considerable losses.

In the operation of my improved apparatus the combined effect of heat, pressure and intense agitation tends to reconstitute the soap, air and other ingredients into a homogeneous mass. By varying the temperature and pressure, as by regulating the opening of the valve 26, for example, within the apparatus, as well as the amount of the agitation, both the distribution of air throughout the mass, as well as the crystalline structure can be controlled over a wide range. While the invention may be practiced as a batch operation in a closed type of mixer, it is preferable for reasons of operating economy that it be carried out as a continuous process.

In the case of soap under certain preferred treating conditions, this material as it is discharged from the apparatus and while it is hot may be most readily described by likening its physical structure to that of fresh marshmallow candy. The character of the material so produced from a given raw material can be modified over a wide range of physical characteristics by varying the pressure and temperature conditions, the air content admitted with the charge, for example, and by the speed of operation and other related conditions.

When the converter is first started up, time may be required to obtain the desired operating conditions and during such initial starting period it may be necessary to discharge the material processed to waste or retreatment. This may be accomplished by installing a three-way cock or valve at the discharge end of the converter so that in starting up, the flow from the converter can be by-passed out of the main system and later by turning the valve the flow can be changed back to the normal discharge piping system when desired operating conditions have been established. It is desirable that the material entering the converter should be fed in at a uniform rate and that it should contain relatively uniform amounts of the ingredients making up its mixture. For example, by feeding the charging stock at a uniform rate, and it should contain relatively uniform amounts of the ingredients making up its mixture, a reasonably constant amount of entrained air is carried into the converter, and under such conditions the soap material is found to be most evenly heated or cooled by the heat interchange jacket and most completely masticated by the screws.

The mass of material within the apparatus, if under unrestricted discharge conditions, would tend to move generally from the inlet to the outlet without change in the state or condition of the material. It is therefore essential that a back flow of material through the thread grooves of the screws be obtained, as by restricting the rate of flow of the material through the apparatus. This operation promotes the mixing and heating of the material being treated and increases

the uniformity and homogeneousness of the product produced.

I may operate my process under pressures as high as 1500 lbs. per square inch or higher and temperatures as high as 1500° F. or higher. When operating my process with substances of the nature of soap temperatures as high or higher than 500° F. may be used if desired, and on soap as high as 300° F. My preferred operating pressures on soap are from 20 to 40 pounds per square inch although higher pressures as indicated may be used.

I have noted in connection with soap, when operating at a low temperature, say at 170° F., for example, if the discharge valve is so regulated that a high pressure is built up, that without additional externally applied heat the marshmallow-like material discharged will begin to rise in temperature and the discharge pressure to fall correspondingly until a pressure of 25 to 30 lbs. per square inch is reached. This result is evidently caused by the fact that in increasing the resistance to the discharge of the converted material, the action of the converter is intensified; that is, a more vigorous backflow through the passageways and kneading is induced, and thus, as the material is more thoroughly heated its fluidity is greatly increased so that it is discharged through the discharge valve more easily and with less back pressure.

I have found that the quantity of marshmallow-like products discharged from the apparatus depends for one thing upon the speed at which the screws are driven, and that it remains substantially constant for a given speed under given conditions, for the amount discharged is dependent then upon the rate of rotation of the screws. The action of the converter can be controlled by varying the heat interchange conditions between the enclosing jacket and the material within the converter. The action can also be controlled by varying the setting of the discharge valve. I have found it preferable to control the conditions so that the converter will deliver the maximum quantity of material which it will handle at a given speed. I have found, for example, that in operating with a feed having approximately 20% moisture content, the most satisfactory "marshmallow" produced was discharged at a temperature of from 195° F. to 205° F. and at a discharge pressure of from 25 to 40 lbs. per square inch.

As an example of the type of product which can be produced when operating with soap I have found that the so-called marshmallow discharged from my apparatus consists of a mass which is plastic while hot and which is aerated with minute bubbles of air or air mixed with water vapor. These bubbles may vary in size and are usually from 20 to 60 thousandths of a millimeter (.0008 inch to .0024 inch) in diameter. The aeration may vary from 1% to 35% or more of the volume of the marshmallow. This marshmallow had a specific gravity when hot of less than .65 and a specific gravity when cold of less than .70. This material has besides other valuable properties a facility to be granulated and also a tendency when granulated to form irregularly shaped granules. The aeration tends to produce light granules of comparatively uniformly multi-cellular structure which can be controlled in averaged specific gravity or density.

As already pointed out, the threads of the screw agitators mesh closely except for working clearance and thus the threads of one block off at the

zone of intermesh the space between the threads of the cooperating screw. The movement of the screws tends always, of course, to force the mass towards the discharge end. However, the discharge is limited to less than that which normally would be extruded and a considerable pressure is built up within the container. Therefore, besides the squeezing and flowing along the zone of intermesh and along the threads, and the continual scraping or wiping of the container walls 15, there is also a backward flow of material along the screws to compensate for the amount being pushed forward which cannot be discharged. There is a path of appreciable area across the intersection of the screws from one to another as indicated on Figure 5 of the drawings by the letter *a*. This path forms a normal leakage area and permits a certain amount of backflow along the threads in the direction indicated by the arrows *a*—*a* depending upon the pressure built up upon the soap at the discharge end. This leakage area may also be considered as extending around the threads through the open portions indicated at *a'*, Figure 5, along a leakage area of the opposite side of the screws corresponding to *a*—*a*, and appearing at the open portion *a''* and continuing across the screws in the direction as indicated by the arrows *a''*—*a''*.

A reference to Figure 12 of the drawings which is a sectional detail of my converter taken at 12—12 of Figure 6 indicates these passages *a* and *a''* and also shows the blocking effect obtained by means of the threads 10' in the grooves between the threads 11'. This figure also shows the inner edge 15' of the jacket 15 extending into the intermeshing region between the screws 10 and 11. Within this intermeshing zone the mass under treatment is preferably extruded through a passageway approximately one-third of the cross-sectional area of a groove between the threads. This restricted passageway through which the material is extruded or forced can also be seen clearly from Figure 12, which is a cross section of the space between the screw threads and the wall 15. If such a soap mass could be taken from one of the screws without distortion, one complete convolution of such mass would appear substantially as shown in Figure 9. The cylindrical portion 10'' of this mass corresponds to the cylindrical portion 10'' between the threads 10' of the screw agitator as indicated in Figure 5. The cylindrical side 36 corresponds to the cylindrical inner wall portions 36 of the jacket 15 between the outer edges of the threads 10'. The recesses *e* and *f* are formed by the threads of the intermeshing screw 11, and their narrow cylindrical portions 11' indicate the edges of the threads 11' of Figure 5. The space indicated by *g* of the mass of Figure 9 is formed and filled by the outer edge 10' of the thread 10 of Figure 5. The knife edges formed at the zone of intersection of the screws as indicated by the reference characters 39, 40, 41 and 42, should be particularly noted for these help to indicate the intensive kneading, and working to which the mass under treatment is subjected in passing from the grooves between the threads of one screw to those of the opposed screw.

The dotted lines 43 and 44 of Figure 9 indicate the plane of intersection of the agitating screws. This plane of intersection has also been indicated along the line 8—8 of Figure 6. Figure 8 shows a detail of the screw agitators with a section cut through along this plane of intersection, 75

the lines 43—43 and 44—44 of Figure 8 corresponding to the lines 43 and 44 of Figure 9.

It can be seen from Figure 8 that the knife edge 39 of Figure 9 is formed by the intersection at 39 of the intermeshing threads, and that the knife edge 40 of Figure 9 is formed by the intermeshing of a thread 11' with a thread 10' as at 40 of Figure 8. The knife edge 41 on the opposite end of the toroid, that is one convolution around the screw 10, is formed by the intersection of the threads 10' and 11' at 41 of Figure 8. The knife edge 42 of Figure 9 will also be found in Figure 8 at 42 and is also formed by the intersection of a thread 11' and another thread 10'.

In Figures 10 and 11 a portion of the masses at the zone of intersection of the agitating screws has been indicated. The view shown in Figure 10 is of these masses looking from the position indicated by 7—7 of Figure 6. Figure 11 is a perspective view of the same masses as shown in Figure 10. Both Figures 10 and 11 clearly show the intersection of the toroid masses formed between the threads 10' as illustrated by the mass of Figure 9, with a corresponding toroid formed between the threads 11' of the cooperating screw. It should be appreciated that the mass illustrated in Figure 9 in reality does not have the completed curvature as shown, but that rather the portion between the lines 43 and 44 shown as crosshatched is within the zone of intermesh and actually joins on within this zone to a similar mass as can be seen from Figures 10 and 11. The cylindrical portions between the threads 10' and 11' have been indicated in Figures 10 and 11 by the reference characters 10'' and 11''. The impressions made by the flat portions at the edges 10' of the threads 10 in the opposing mass have been indicated by the reference characters 10' and the corresponding impressions made by the threads 11 indicated by the reference characters 11'. It will be noted that the recesses *f* and *g* of Figure 9 are also found in Figures 10 and 11 and that the knife edges 41 and 42 are also identified in both figures.

Plastic masses of the nature of soap, that is, those having a relatively high viscosity, exhibit simultaneously the properties of both liquids and solids. Even a slight plasticity in the mass permits to a marked extent that property of fluids transmitting pressure equally in all directions. In this connection it will be noted that the mass is shaped by restraining walls and completely fills the space so formed. Also, the high viscosity of the plastic material causes it to resist internal motion and thus it exhibits the property of a solid in moving as a mass without change of shape when acted upon by forces exerted upon the surface. It will be apparent from the drawings and it can be readily shown that the total surface area of the mass in contact with a screw is greater than the surface area in contact with the casing, and I have found that a preferable ratio of such areas is approximately 2 to 1. The frictional grip, therefore, on the soap mass, due to the surfaces with which it is in contact, is greater with the agitating screw than with the stationary casing, and thus there is a tendency for the soap mass to be moved by the screw agitators. This tendency is aided to a certain extent by the wedge-shaped cross section formed by the threads. When the casing is used as a heating medium, there is a tendency to soften the plastic mass in contact with it thus forming a lubricant and decreasing its adherence to this surface. The effect of compacting the soap mass

under pressure in these helical spaces between the threads of the agitators tends to increase the tendency of the agitators to carry the soap around with it. This tendency of the soap toroid to behave as a solid and turn with a screw without change, is, of course, prevented by the blocking of the intermeshed threads of the opposite screw at the zone of intermesh. This blocking increases the pressure on the soap mass particularly at this zone and the pressure is transmitted as hydraulic pressure throughout a part at least of the entire mass and thus increases the grip of the screw surfaces on the mass tending to carry the mass along. In this way considerable pressure is built up over a relatively small cross-sectional area at the point of blocking off or intermeshing. The result is that internal shear is set up within the mass and it becomes deformed and is forced through the restricted area of communication from the grooves of one screw to the grooves of the other.

If the soap in the space between the threads of the screw immediately adjacent to the triangular portions formed below and above the lines of intermesh 43 and 44 is under less pressure than that existing in the nose of the oncoming toroid of soap, the latter, of course, can be deformed and so flow over into this space of lower pressure. Such a space of reduced pressure does, in fact, exist between the threads of the opposite screw in this zone of intermesh as the action of the intermeshing screw is tending to carry its own toroid of a rather plastic mass away from the zone of intermesh. The communicating space between the convolution of the threads of one screw and those of the opposite adjacent screw in this zone of intermesh can be seen from Figures 5 to 8.

As is already noted from the illustrative mass of Figures 9, 10 and 11, the soap mass moving in the zone of intermesh is continuously terminating in a series of thin knife edge sections, such as indicated by reference characters 39, 40, 41 and 42 of Figures 9, 10 and 11. Not only are knife-edged portions 39, 40, 41 and 42 being continuously formed by the flow or movement around the screws but there is also a kneading and extruding operation due to the continuous flow of the mass from one screw to another in the backflow as indicated on Figure 5. This backflow moves in the directions indicated by the lines *a—b* or *a'''—b'''* and thus there is a compression and extrusion action due to the threads 10' partially blocking off the space between the threads 11' of the screw 11. This latter condition can be seen from the mass illustrated at Figure 9.

These sections of the mass which are subjected to intense working are generally situated in the zone of mutual tangency of the working faces of the intermeshing screws, as indicated by Figures 5, 6, 7 and 8, in which the direction of motion of parts is shown. These mutually tangential surfaces are in each instance moving in opposite directions at the zones of contact so that the mass of soap in each toroid as it is forced into the zone of intermesh and becomes blocked off is subjected to an increasing degree of internal shear in the layers which become thinner and thinner and which ultimately are brought down to a thin film in the nip of curved surfaces moving in opposite directions to one another. This action might be compared to the milling action of rolls, but is more drastic as the difference between the relative surface speeds of these

curved surfaces is greater than in the case with milling rolls. This action occurs both above and below the center line of the axis of the two screws. Each of the screws is continuously feeding new stock into this zone.

Another way in which internal shear is brought about with its consequent mechanical working on the mass is by means of the difference between the average velocity of the screw agitator and the mass velocity of the soap toroid in contact with it. The amount of this difference will vary with the operating conditions but it always tends to exist to a considerable degree. This difference in velocity, together with the conditions of back pressure and flow in the zone of intermesh, causes internal shear within the soap mass which may take place either locally at the points of contact between the toroid and its retaining walls or generally across the entire cross section of the toroid depending upon relative values of the coefficient of internal shear of the mass under treatment and the coefficient of friction between the mass and the material of the agitator.

Another important phase of this process for the carrying out of which the apparatus described is especially adapted is the uniform heating of the soap mass under pressure. The source of temperature control is the jacket of the casing through which either hot or cold fluids can circulate to modify the temperature of the mass within the working zone. As the working temperatures at which the desired results are secured must be controlled within close limits and are close to the point at which the soap stock can become damaged by over-heating, it is highly essential that the apparatus operate in such a way as to maintain the entire mass of soap at a uniform temperature without any localized over-heating.

As the jacket can only impart its heat through the soap actually in contact with it, I have provided a means by which an unusually complete agitation can be secured and provision is made for continually exposing a fresh portion of soap to the jacket wall in order to avoid localized over-heating. Effective agitation is secured by the way in which the intermeshing screw threads of each agitator smear through the oncoming toroids being carried into the zone of intermesh by the threads of the opposite screw and drag material from the inner radius of these toroids to the outer radius of the new toroids which are constantly being formed in the threads of the opposite screw as they leave the zone of intermesh, carrying with them the stock which is forced through by the action of the opposing screw.

Thus the material is being constantly transferred from the inner radius of the toroids which have no direct supply of heat to the outer surfaces which are in contact with the jacket. The adherence of soap to the jacket itself is effectively prevented by the action of the screw agitators, the outer surfaces of which scrape the entire surface of the jacket with each revolution. Thus a means is provided for the uniform control of the temperature of the mass of soap within this apparatus which is essential to the control of the characteristics of the resulting product.

On account of the effective sealing of the apparatus through the complete filling of the threads of the screw by the soap as it is fed into the apparatus it is possible to constantly seal off the working zones with the jacket so effec-

tively as to permit heating the soap mass in these working zones well above the temperature at which the water in the soap would be boiled off if the soap were exposed to the atmospheric pressure. For example, temperatures between 160° F. and 230° F. may be used. The attainment of such temperatures is highly essential to the rebonding of discrete particles which may be fed into the receiving hopper and which have been gradually brought into close contact by the pressure built up within the apparatus.

The accurate control of these conditions of pressure and temperature throughout the soap mass can be maintained with sufficient uniformity to permit the selective melting of the various ingredients within a soap stock, for example, which can be selected in such a way as to give different temperatures of fusion. Subjecting the soap stock to heat and pressure only will not reconstitute and rearrange the structure of the soap. It is necessary, while a soap stock is being subjected to both heat and pressure to agitate it thoroughly throughout the mass by mechanical means. This agitation is carried out not only so that all portions of the mass are equally exposed to the source of heat or cooling action but also so that all portions of the mass are moved relative to each other, in order that the various ingredients constituting the mass may have the opportunity to segregate under the influence of heat and pressure. The intense kneading, extruding, working and internal shearing action which I carry out upon the mass in my improved apparatus, as above described, are particularly advantageous in obtaining the desired reconstituting and rearranging of the ingredients of the mass under treatment.

The treated material may be discharged from my screw agitating apparatus by releasing it through the valve 26. If desired, the released material may be treated to obtain a granular form, or it may be discharged into a container and allowed to solidify into suitable form for any further processing. It is necessary, of course, to have a sufficient and proper temperature differential to carry out the cooling, solidifying, and hardening process. Also, of course, a proper time interval must be permitted for such operations, dependent upon the most desirable conditions. If so desired there may be a preliminary cooling within the agitator by passing a cooling solution through the jacketed head 23. The solidified mass may be cut into cakes and bars in the same manner as a framed or milled soap is cut. If the soap produced is of a floating variety, the cutting of the soap into cakes and bars and the pressing of the cakes and bars into ultimate finished products does not substantially affect the specific gravity of the soap.

In floating soaps heretofore produced, the entrapped air bubbles are relatively large and further are irregularly distributed throughout the body of the soap. On the contrary, the soap produced by the process described, making use also of my apparatus as described has entrapped air bubbles uniformly distributed throughout the body of the soap and in a finely divided condition. In fact, the air bubbles may be so small and so evenly distributed throughout the body of the soap when produced as described, that they are not noticeable to the unaided eye when the soap is cut into cakes and bars, and the texture of the soap is superior to that of the finest milled soaps as produced by present commercial practices. The amount of air incorporated into the

soap and hence the specific gravity of the product can be controlled over a wide range by properly adjusting the temperature and pressure conditions within the screw converter apparatus. The degree of aeration may be such that the volume of air cells will equal more than 35% of the volume of the soap product obtained. On the other hand, by carrying out the operation at a relatively high temperature or other suitable modifying conditions so that the viscosity of the soap for example, is lowered, a product can be produced which has a minimum amount of air incorporated in it. Such an operation could result in the production of a non-floating soap.

By means of my process and apparatus I am able to obtain a soap product, for example, having the desirable properties of the soap produced by the process disclosed in the copending application, Serial No. 665,063, filed April 8, 1933, of John W. Bodman, and processing with my apparatus in connection with soap is to be regarded as an improvement thereon. The soap produced is free from laminations of the type which are commonly present in soap due to the segmentation of the pellets making up the soap bar. Further, soap produced by my process is of a fine, compact homogeneous structure throughout and is entirely free from small hard "specks" which are commonly found embedded in soap and which are thought to be due to particles of excessively dehydrated portions of a soap mass. This soap has a different "feel", or texture from ordinary soaps and has unusual smoothness. It will also be noticed that the break of a bar of such soap is different from that of soaps previously produced. This difference is due to the homogeneous structure and unusual crystalline formations resulting from the operations carried out in the treating chamber.

I have already pointed out that my apparatus is not limited to the use with a soap stock but may be used on other materials to modify or otherwise treat to produce desired characteristics. By operating my process in a closed system I am further able to process materials normally volatile without loss from the system. It will be noted that I am able to obtain a close and positive control of the treating conditions and further that I am able to maintain such positive control of conditions even though there are variations in the external conditions under which the operation is carried out. If desired I may use one or more converters connected in series. This arrangement is particularly advantageous when operating on a dried or partially dried soap material for example, the dried material can be fed into a hopper of the first stage converter and modified therein to a semi-plastic form by heating and kneading. It may then be discharged to the second stage converter which completes the working of the soap and discharges it in the form of a converted or reconstituted viscous mass. Various stages of heating and cooling a material under treatment may be carried out by utilizing a series of converters.

Certain changes and modifications perhaps will become apparent to those skilled in the art which may be made without departing from the spirit of my invention. I therefore do not wish to be limited by this specific disclosure but only by the appended claims.

I claim:

1. An apparatus adapted to convert a viscous material, comprising intermeshing screws having parallel axes arranged to rotate in the same direction, means for driving said screws, a con-

tainer confining said screws and fitting the perimeters of the unintermeshing portions, and means for maintaining a pressure within said container.

2. An apparatus adapted to convert a viscous material into a different state or condition, comprising intermeshing parallel screws, said screws having threads fitting between opposed identical threads and filling at the zone of intermesh the grooves between such threads on the opposed screw so as to prevent the passage of material between the screws at the zone of intermesh, means for driving said screws, a container confining said screws and fitting the perimeters of the unintermeshing portions, and a means for maintaining a pressure within said container.

3. An apparatus adapted to convert a viscous material into a different state or condition comprising intermeshing parallel screws, threads on said screws lying between opposed identical threads and filling the grooves between such threads on the opposed screw within the zone of intermesh, said threads being further constructed and arranged upon the rotation of said screw to lie in contacting relationship at all points along the sides of the threads of said opposed screw so as to prevent the passage of material between the screws at the point of contact, means for driving said screws, means confining said screws having an inlet and an outlet and fitting the perimeters of the unintermeshing portions, and a pressure regulating means at the outlet of said confining means.

4. An apparatus for subjecting viscous material to intensive working while under controlled conditions comprising the combination of intermeshing parallel screws, said screws having threads which fill the grooves between correspondingly shaped threads on the opposed screw at the zone of intermeshing so as to prevent the passage of material between the screws at the zone of intermeshing, means for driving said screws, a shell fitting the perimeters of the unintermeshing portions and confining said screws and means for restricting the discharge of treated material from said shell whereby a pressure is maintained within said shell.

5. An apparatus for subjecting viscous material to intensive working while under controlled conditions comprising the combination of intermeshing parallel screws, said screws having threads blocking the grooves between the correspondingly shaped threads on the opposed screw at the zone of intermeshing, means for driving said screws in the same direction, a container fitting the perimeters of the unintermeshing portions and confining said screws, inlet and outlet means on said container, and means on said outlet for maintaining a pressure within said container.

6. An apparatus for subjecting a plasticizable material to mechanical working while under closely controlled conditions of temperature and pressure whereby a conversion in the state or condition of the material is obtained comprising the combination of intermeshing parallel screws, said screws having threads filling the grooves between correspondingly shaped threads on the opposed screw at the zone of intermeshing so as to prevent the passage of material between the screws at the zone of intermeshing, said threads having further the same direction of twist, means for driving said screws, a container fitting the perimeters of the unintermeshed portions and confining said screws, means for heating said container, 75

and means for maintaining a pressure within said container.

7. An apparatus for subjecting a plasticizable material to mechanical working while under controlled conditions of temperature and pressure, comprising the combination of intermeshing parallel screws, said screws having threads filling the grooves between correspondingly shaped threads on the opposed screw so as to prevent the passage of material between the screw at the point of intermesh, said threads upon rotation of said screws closely contacting against the sides of correspondingly shaped threads on the opposed screw at the zone of intermesh, means for driving said screws, a jacketed heat exchange container fitting the perimeters of the unintermeshing portions and confining said screws, means for admitting substances adapted for heat transfer to the jacket of said container and means for maintaining a pressure within said container.

8. An apparatus for subjecting a plasticizable material to mechanical working while under controlled conditions of temperature and pressure, comprising the combination of intermeshing parallel screws, said screws having threads blocking the grooves between correspondingly shaped threads on the opposed screw, said threads being wider at the base than at their outer periphery and lying in close contact at all times with the sides of said threads on the opposed screw at the zone of intermesh, whereby each of the threads is substantially wiped clean of material under treatment upon rotation of said screws, means for driving said screws, a heat exchange means fitting the perimeters of the unintermeshing portions confining said screws and means for maintaining a pressure upon the confined material under treatment within said heat exchange means.

9. An apparatus for subjecting a plasticizable material to intensive mechanical working while under controlled conditions of temperature and pressure, comprising the combination of intermeshing parallel screws, said screws having threads filling the grooves between correspondingly shaped threads on the opposed screw at the zone of intermesh so as to prevent the passage of material between the screws at the zone of intermesh, means for driving said screws, a jacketed heat exchange container fitting the perimeters of the unintermeshing portions of said screws, a head connected to said jacketed container enclosing the discharge end of said screws, journals within said head carrying the shafts of said screws, said head having an outlet for the material discharged by said screws and a means at the outlet of said head for controlling the pressure on the confined material under treatment within said heat exchange container.

10. An apparatus for subjecting a plasticizable material to intensive mechanical working while under controlled conditions of heating and pressure, comprising the combination of intermeshing parallel screws, said screws having threads filling the grooves between correspondingly shaped threads on the opposed screw so as to prevent the passage of material between the screws at the zone of intermesh, said threads upon rotation of said screws closely contacting against the sides of correspondingly shaped threads on the opposed screw at the zone of intermesh, means for driving said screws, a jacketed heat exchange container fitting the perimeters of the unintermeshing portions of said screws, means for admitting a heat exchange medium to said

jacketed container, a head connected to said jacketed container enclosing the discharge end of said screws, journals within said head carrying the shafts of said screws, said head having an outlet for the material discharged by said screws, and means at the outlet of said head for controlling the pressure on the confined material under treatment within said heat exchange container.

11. An apparatus for subjecting a viscous material to intensive mechanical working while under controlled conditions of heat and pressure, comprising the combination of intermeshing parallel screws, said screws having threads filling the grooves between correspondingly shaped threads on the opposed screw at the zone of intermesh so as to prevent the passage of material between the screws at the zone of intermesh, means for driving said screws, a jacketed heat exchange container fitting the perimeters of the intermeshing portions of said screws and confining the same, said jacketed heat exchange container having an inlet for the charging of the material to be treated and an outlet for the discharge of treated material, means at the outlet of said heat exchange container for regulating the discharge therefrom and controlling the pressure therein, and means intermediate said inlet and outlet of said heat exchange container whereby substances may be admitted or withdrawn from said heat exchange container.

12. An apparatus adapted to convert a viscous material into a different state or condition comprising intermeshing parallel screws, said screws having threads of identical pitch, size, contour and direction of twist, said threads being further positioned so that the threads of one of said screws fits into the space between the roots of the threads of the other of said screws filling the same within the zone of intermesh, means for rotating said screws in the same direction, a jacketed heat exchange container enclosing said screws and fitting the perimeters of the unintermeshed portions, inlet and discharge means to said container, and a pressure regulating means at said discharge.

13. An apparatus for subjecting a plasticizable material to mechanical working while under controlled conditions of temperature and pressure, comprising the combination of intermeshing parallel screws, said screws having threads and intermediate grooves whereby the threads of one screw block off the grooves of the other screw within a plane of intermesh, a container closely fitting the perimeters of the unintermeshed portions of said screws, the threads of said screws bearing a relationship to the grooves of said screws such that in cooperation with that portion of the container positioned adjacent the intermeshing portions of the screws a thread blocks off approximately two-thirds of the cross sectional area of the enclosed cooperating groove within which said thread lies.

14. An apparatus adapted to treat a viscous material comprising screws having parallel axes arranged to rotate in the same direction, said screws having intermeshing threads, means for driving said screws, a container confining said screws and closely fitting the perimeters of the unintermeshed portions, means for maintaining a pressure within said container, said threads of one screw being positioned to block off the grooves of the other cooperating screw within a plane of intermesh, the threads of said screws bearing a relationship to the grooves of said screws

such that in cooperation with that portion of the container positioned adjacent the intermeshed portions of the screws a thread blocks off approximately two-thirds of the cross-sectional area of the enclosed cooperating groove within which said thread lies.

15. An apparatus for treating plasticizable materials to change them from one state or condition into a different state or condition comprising a casing, means cooperating with the casing for dividing it into a plurality of series of chambers, the chambers of one series corresponding to the chambers of another series, there being passageways between the corresponding chambers, said chambers being of large volume relatively to the passageways, said means being constructed and arranged to force the material from the chambers of one series into the corresponding chambers of the next series so as to agitate and knead the material passing through the passageways, means for effecting heat exchange in the material in the chambers, and means for putting the material under pressure.

16. An apparatus for treating plasticizable materials to change them from one state or condition into a different state or condition comprising a casing, means cooperating with the casing for dividing it into two series of a plurality of chambers arranged side by side, the chambers of one series corresponding to the chambers of the other series, there being passageways between the corresponding chambers, said chambers being of large volume relatively to the passageways, said means being constructed and arranged to force the material from the chambers of one series into the corresponding chambers of the next series and back again into different chambers of the first series, and so on, whereby the material is carried through the chambers from the first to the last thereof and subjected to agitation and kneading, means for heat exchange in the material in the chambers, and means for putting the material under pressure.

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