April 7, 1964 H. J. RENAUD 3,128,053

EQUIPMENT FOR COMPOUNDING MATERIALS

Filed May 8, 1961 4 Sheets-Sheet 1

Fig. 1

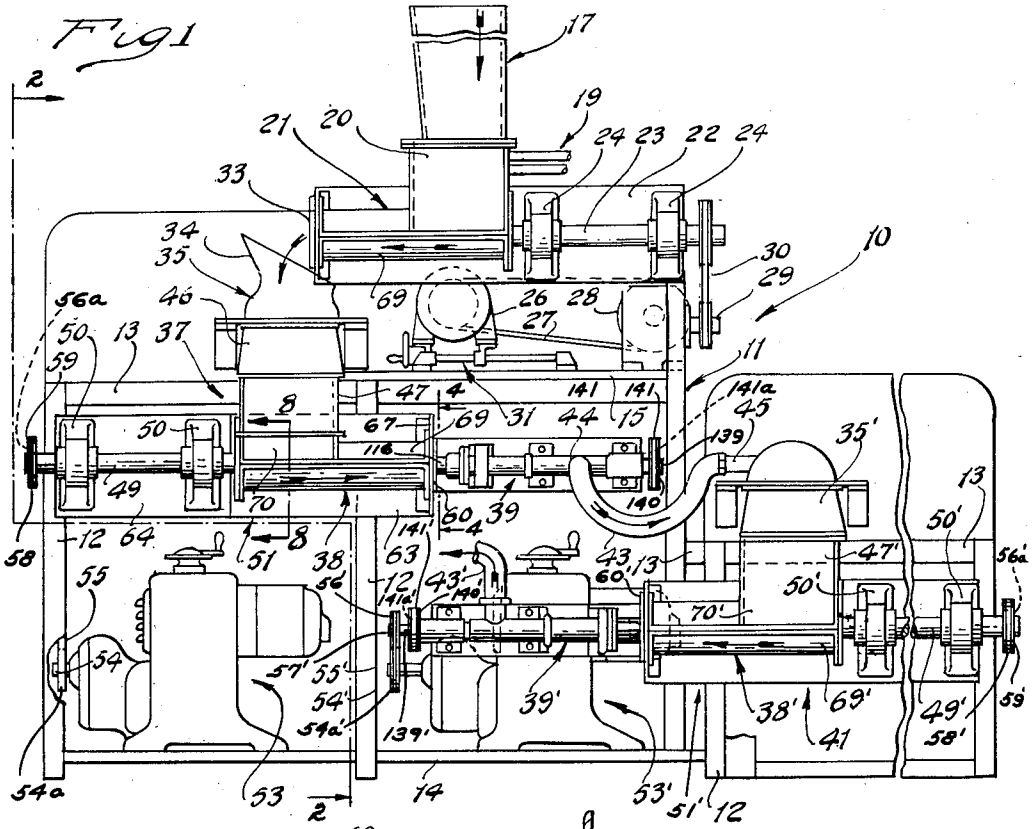
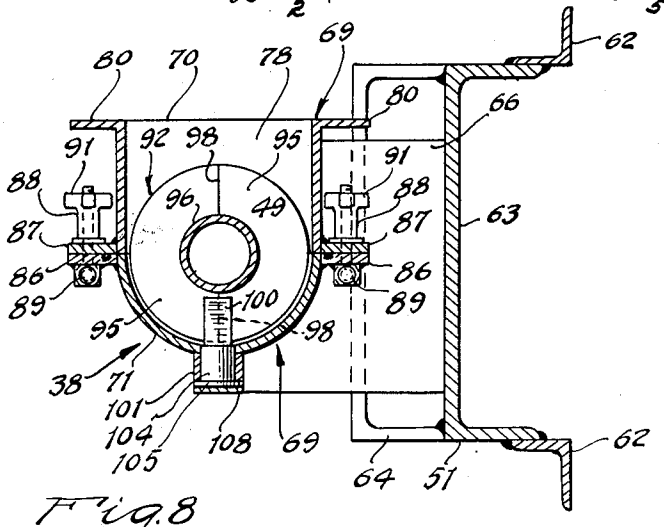


Fig. 8



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Fig. 2

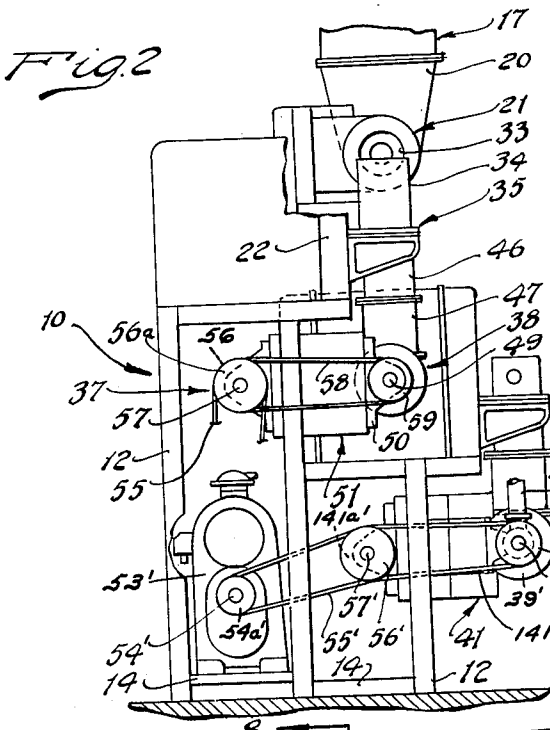
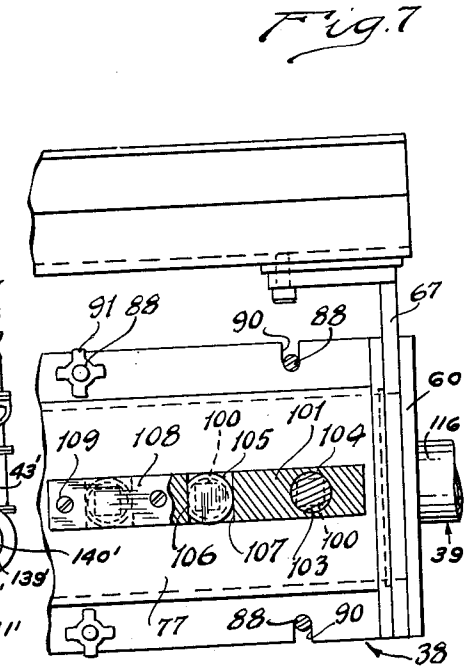


Fig. 7



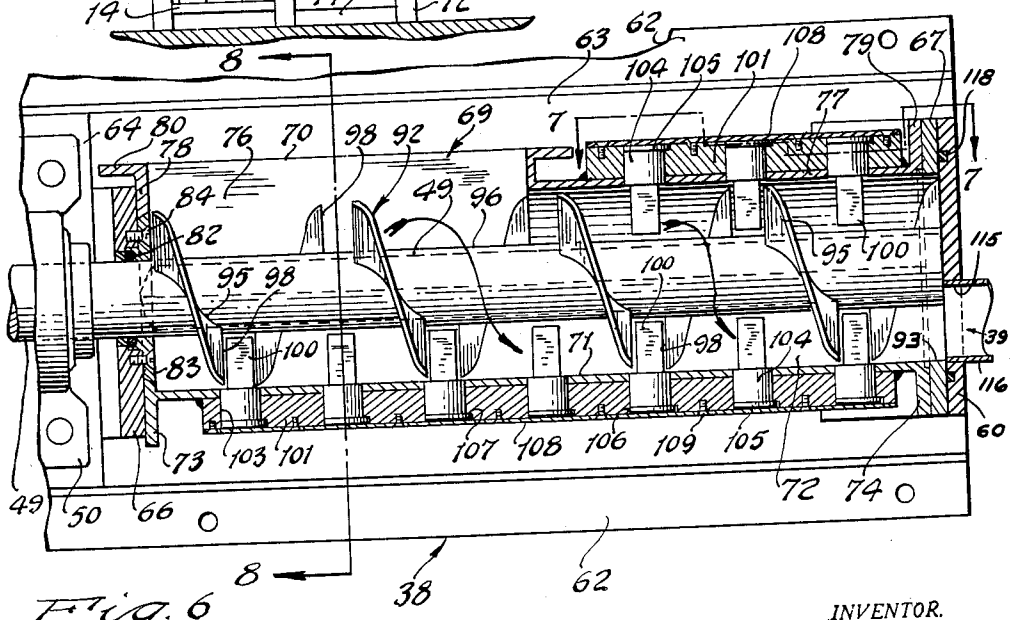


Fig. 6

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FIG. 2A

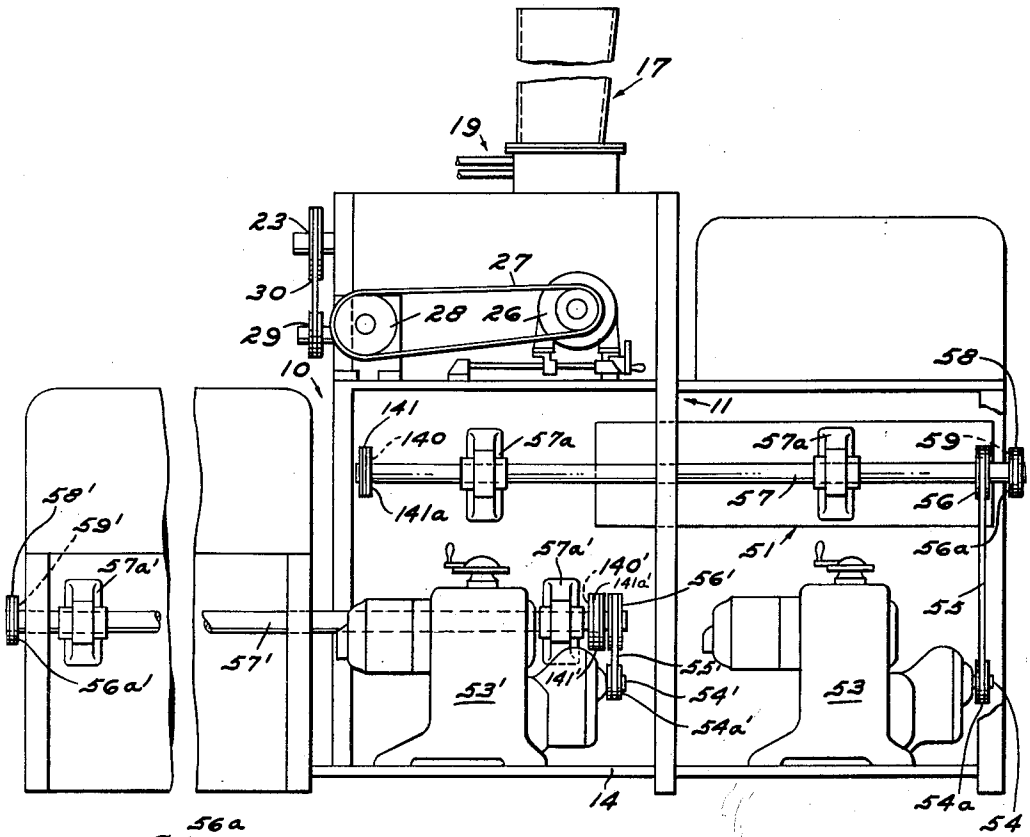
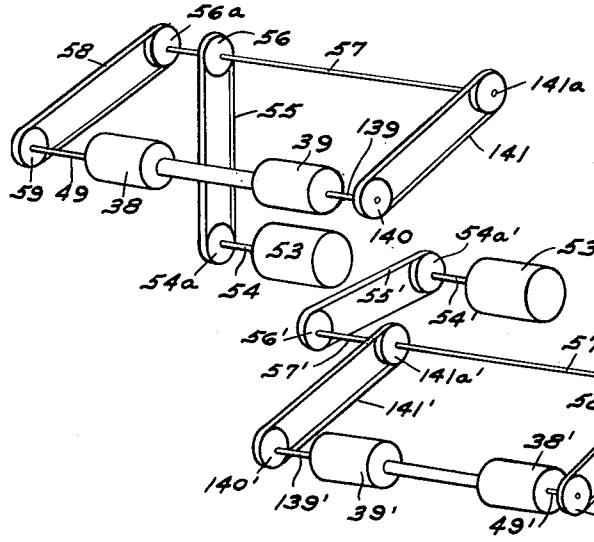


FIG. 3



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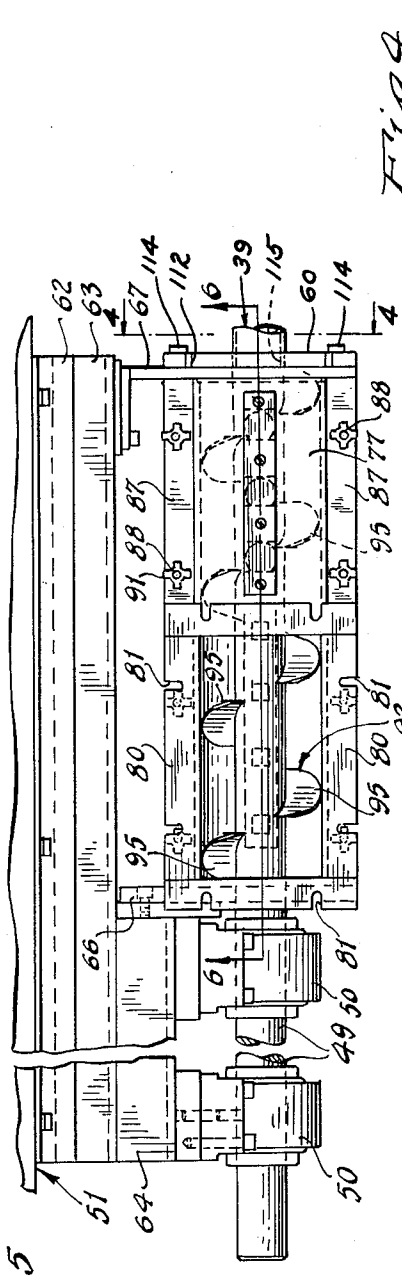


Fig. 5

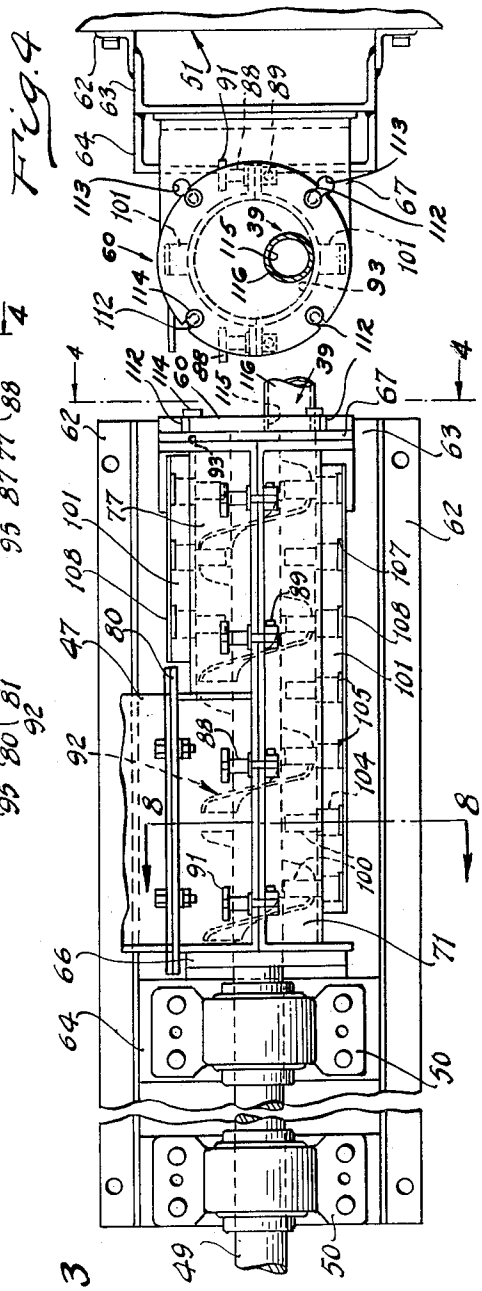


Fig. 3

Fig. 4

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3,128,053

EQUIPMENT FOR COMPOUNDING MATERIALS

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Filed May 8, 1961, Ser. No. 108,383
12 Claims. (Cl. 241—101)

The present invention relates to an improved apparatus for the continuous formulating and compounding of dry and wet materials, in the production of various industrial compounds such as plastic resin compositions presently in wide industrial use. However, it is to be understood that the principles of the invention are also applicable in the accurate proportionate formulation, blending and compounding of various other types of materials, in which a close control of the proportioning and an intimate, incremental mixing and blending of the ingredients are desired.

This application is a continuation-in-part of my copending application, Serial No. 778,950, filed December 8, 1958, and now abandoned; the present method and equipment also represent improvements over the procedure and apparatus illustrated and described in the patent to Harold J. Renaud and George M. Kovac, No. 2,874,907 of February 24, 1959.

It is an object of the invention to provide apparatus of great versatility and reliability as to control, as well as operating at a high productive rate in the blending of relatively dry and wet materials. The nature of the improvements are such that the equipment is well suited for the preparation of compounds which are either thixotropic or dilatant under the agitation involved in blending.

Another object is to provide improved mixing and blending apparatus which is entirely continuous in its operation, from the initial reception of accurately weighed out or measured dry and wet ingredients to the delivery of the mixed fluid product, in widely varying degrees of viscosity; which apparatus or equipment occupies a minimum of productive floor space.

Another object is to provide apparatus, by which dry and wet materials are continuously and progressively advanced, in the practically uninterrupted agitation thereof, through an entirely closed path and under substantial pressure. During the continuous flow between material intake and discharge points it is repeatedly worked over, agitated and incrementally blended by units of both the hammer mill type and the rotary screw type and by pumping units of the helical rotor and stator type to effect the transfer from one unit to the other and to deliver the blended product.

While the equipment in question incorporates certain material handling and treating units of well known commercial and industrial types, it is a further object of the invention to provide improvements, particularly in a combination of screw mixing, blending and pump forwarding components, whereby a very thorough and intimate admixture of the ingredients, accompanied by reduction of particle size, is effected, the final discharged material being of entirely homogeneous texture and ready for immediate packaging.

With the above in mind, it is a further and more specific object to provide, in a novel association with a helical stator and rotor type of pump, an improved rotary screw type material mixing and blending unit. This unit features a screw conveyor mechanism, including a single shaft driving a plurality of axially separated helical screw formations in a longitudinally enclosed zone, including a material-receiving hopper portion and a cylindrical mixing and forwarding portion which discharges to the intake of the pump, the latter being reversed in regard to its usual

intake and discharge provisions. In accordance with the invention, the axial spaces between the separated screw elements of the blender are occupied by radially projecting fixed anvil members, against which the screw-advanced material is driven in its advance, thus insuring a breaking up of any relatively large sized aggregate formations or agglomerations, and the final output of a mixture of 100% homogeneous texture, as mentioned above.

Yet another object is to provide blending apparatus of the character described, featuring a screw type blender and conveyor mechanism characterized by axially and circumferentially discontinuous, partially helical screw elements of the sort referred to, in combination with a rotary pump of the helical rotor and helical stator type, with an intake portion of the pump stator opening axially at one end of the rotor axis and applied directly to a discharge opening of the screw blending unit.

A still further object is to provide apparatus according to the preceding paragraph, in which each screw blender and pump unit has a common variable speed drive source for the screw and pump rotors thereof, enabling the same to be driven at different relative speeds, as called for by the characteristic consistency of the mixture being blended.

The foregoing as well as other objects will become more apparent as this description proceeds, especially when considered in connection with the accompanying drawings illustrating the invention, wherein:

FIG. 1 is an elevational view, somewhat schematic in nature, of the improved equipment for performing the method, this equipment involving the use of plural subassemblies, each constituted similarly, however;

FIG. 2 is a vertical sectional view of the equipment of FIG. 1, as from line 2—2 of that figure;

FIG. 2A is a schematic rear elevational view of the equipment;

FIG. 3 is a fragmentary side elevational view in enlarged scale, illustrating one of the improved screw conveyor and mixing units of the equipment;

FIG. 4 is a fragmentary view in vertical section along line 4—4 of FIGS. 1, 3 and 5;

FIG. 5 is a fragmentary top plan view of the unit in question, with its material-receiving hopper removed;

FIG. 6 is a fragmentary view in enlarged scale and in vertical section along line 6—6 of FIG. 5;

FIG. 7 is a view in horizontal section along a line corresponding to broken line 7—7 of FIG. 6;

FIG. 8 is a view in transverse vertical section along line 8—8 of FIGS. 1, 3 and 6; and

FIG. 9 is a schematic view in perspective showing the arrangement of shafting, pulleys and belts employed in the drive of various components of the equipment.

As shown as a whole in FIGS. 1, 2 and 2A, the improved apparatus of the invention is generally designated by the reference numeral 10. It is supported in a relatively small floor area by means of a rugged skeleton framework 11 constituted by upright and horizontal beams 12, 13, respectively, provided with lower level and upper level decking or flooring 14, 15, respectively, upon which the various operating components of the equipment are stably supported. Suitable stairways and grillwork flooring enabling operators to have access to any and all components of the equipment are likewise provided, of an obvious type not requiring illustration or description.

The reference numeral 17 designates the transition piece of suitable blending equipment disposed at still a higher level, with which the present invention does not concern itself. As illustrated in the Renaud et al. patent, identified above, this equipment is for the purpose of measuring and initially blending all dry components of the mixture to be handled. It may therefore involve appropriate

gravimetric material measuring apparatus, a suitable dry blender, preferably of the twin shell type to which reference is made in the Renaud et al. patent, and other associated apparatus including a conveyor or the like to discharge the blended dry materials to the hopper transition piece 17.

The reference numeral 19 generally designates the piping of a liquid material supply system which, like the transition piece 17, discharges (under appropriate control by liquid proportioning means, not shown) to the intake hopper 20 of a first screw type conveying, mixing and blending unit 21 according to the invention. For convenience, this unit, as well as other similar and similarly functioning, will be referred to by the term "screw blender." Details of a unit of this type are shown in FIGS. 3 through 8 and will be hereinafter described.

The blender unit 21 may be appropriately supported upon a suitable upright superstructure 22 of the main framework constituted by beams 12 and 13, at an elevation above the upper deck 15. Screw blender 21 is provided with a horizontal drive shaft 23 journalled in suitably spaced pillow blocks 24 on superstructure 22.

For the purpose of driving the shaft 23, a suitable electrical drive motor 26 is supported on the deck 15, and is drivingly connected, as by a chain belt 27, with a worm and worm gear type speed reducer 28. The 90° output shaft 29 of this reducer is in turn connected by a chain belt and pulley arrangement 30 with the shaft 23. Appropriate adjusting provisions may be made at 31 to variably position the drive motor 26 and maintain tension in chain belt 27.

An initial, relatively rough admixture, agitation and blending of the dry and wet ingredients, accompanied by initial impact breaking of large size particles, aggregates (if any) or agglomerates, takes place in the screw blender 21 as the materials are forwarded in the direction of the arrow applied to that unit. They are discharged laterally through the discharge throat 33 of the unit 21 to the intake hopper 34 of a hammer type mill unit 35. This unit is also duplicated in the equipment, hence, in order to distinguish from the screw blenders, it and its counterpart will be designated by the term "mill blender."

The mill blender 35 may be Model No. 116–71–5 produced by The Cog Corporation Division of Motiograph Inc., of Chicago, Illinois, or it may be the so-called Fitz Mill, manufactured by W. J. Fitzpatrick Co. of Chicago, Illinois, i.e., the Model D-Series (1606) of that producer. It, per se, constitutes no part of the invention and any equivalent type of hammer mill unit may be substituted. It functions to effect a further mechanical mixing and blending of the dry and wet ingredients discharged from the screw blender 21; and both of these units have the effect of producing an intimate and incremental blended mixture. That is, each relatively minute increment of a mass of material treated in the procedure tends to reflect accurately, even at the start of the mixing procedure, the ultimate incremental and homogeneous proportioning of the ingredients which is desired as the ultimate output of the equipment, in so far as amount and weight are concerned. At that ultimate output point, any incremental portion of the wet mass selected at random is exactly the same as any other portion at the same point as to composition, texture, viscosity, etc.

The mill blender 35 is part of a secondary blending sub-assembly 37, generally comprising the blender 35 itself, a secondary screw blender 38 similar to the unit 21 and a pump 39 of the helical rotor-helical stator type. It is the function of the pump 39 to transfer the product, as further and secondarily blended by and from the sub-assembly 37, to a tertiary blending sub-assembly, generally designated 41, which is constituted by units similar to those composing the sub-assembly 37. The units making up the respective secondary and tertiary sub-assemblies being the same, those of the latter will be designated by the same reference numerals, primed, as are employed to

designate parts and relationships of units of the former, and further description will be dispensed with.

Referring to FIG. 1 of the drawings, a discharge line or conduit 43 extends from the radial discharge fitting 44 of the pump 39 of sub-assembly 37 to intake fitting 45 of the mill blender 35' of the sub-assembly 41.

The secondary mill blender 35 discharges through a throat or transition piece 46 to an intake throat or hopper 47 of the secondary screw blender 38, details of which are illustrated in FIGS. 3 through 8 and will be described. The driving shaft 49 of the screw blender 38 is journalled horizontally in pillow blocks 50 sustained by an appropriate vertical mount or supporting means, generally designated 51, constructed of channels, angle irons and bracket, in a manner to be described, and carried on framework upright beams 12.

The reference numeral 53 generally designates a variable speed motor drive unit for the secondary blending sub-assembly 37, the unit 53 being on the lower deck or floor 14. This unit is a conventional "Vari-Drive" type, as produced by U.S. Electrical Motors, Inc., of Milford, Connecticut and Los Angeles, California, and it is capable of supplying a relatively heavy driving torque under widely varying speeds. To this end, and as shown in FIGS. 1, 2 and 2A, an output shaft 54 of drive unit 53 is drivingly connected by a belt and pulley connection including pulley 54*a* on shaft 54, an upwardly trained belt 55 and a pulley 56 fixed on a longitudinal countershaft 57 which is mounted on the framework 11 at the approximate level of the secondary screw blender 38 by journal members 57*a* at the rear of the framework (FIG. 2A). As thus driven from unit 53, shaft 57 is provided with a further outboard pulley 56*a*, which is connected by a horizontally trained chain belt 58 with another pulley 59 fixed on shaft 49 of the screw blender unit 38, thus to drive the latter. Countershaft 57 extends from one end of the combined assembly of blender and pump units 38, 39 to the opposite end.

The drive for the mill blender 35 may be taken from this line of power in a manner which will suggest itself to those skilled in the art.

It is seen by reference to FIG. 1, that the variable speed driving unit 53' for the components of the tertiary blending sub-assembly are substantially the same as described above, although, since this sub-assembly is at a lower level, its driving chain belt 55' (corresponding to the belt 55) is disposed almost horizontally. In both instances the variable speed drive devices 53, 53', in addition to driving the belts 55, 58 and 55', 58' of the drives for the secondary screw blender sub-assembly 37 and the tertiary sub-assembly 41, also act to drive the pumps 39 and 39' associated respectively therewith, in a manner to be described.

The pump 39, referred to as a helical rotor, helical stator one, is a positive displacement pump of the progressive cavity screw type, as marketed by Robbins & Meyers Corp., Moyno Pump Division, of Springfield, Ohio, with its intake and discharge ends reversed in reference to their normal disposition. This pump is illustrated and described in a publication of said company entitled "The Astonishing R and M Moyno Pump," book No. 22, pages 4, 5, 8 and 14 being referred to. Pump 39 has its intake end, as hooked up in the present equipment in a manner hereinafter described, in axial communication at a special slip plate or adapter connector 60 with the discharge end of the screw blender 38, and the rotor element and stator element (not shown) of the pump 39 receive material to be further advanced and blended from the screw (to be described) of the unit 38, as the screw is driven by the drive shaft 49. Pump 39 discharges radially between its axial ends. It has a shaft 139, on which its rotor (not shown) is mounted, in general axial or linear alignment with the screw drive shaft 49, and is equipped at its external axial end opposite its intake end with a pulley 140 which is driven

through a belt 141 from a pulley 141*a* secured on the longitudinal shaft 57 operated by the variable speed drive unit 53 independently of the drive of screw shaft 49. The composition of the belting and pulley provisions on the countershaft 57 is similar to that for the drive of screw shaft 49; and this is true also of shaft 49' and countershaft 57' of unit 41 although relative positions may vary, as appears in FIGS. 1 and 2A.

Thus both the screw of unit 38 and the rotor of pump 39 are positively driven at variable speed by the variable speed power device 53, and may be driven in variable speed relation to one another by an appropriate selection of take-off pulleys and belting associated with their respective shafts 49, 139 and the countershaft 57. As indicated above, the same general driving relationship, but in a reverse sense positionwise on the equipment, exists for the tertiary blender sub-assembly 41, which is supported by a mount 51' similar to the mount 51.

Referring now to FIGS. 3 through 8 of the drawings, structural details of the screw blender 38 are shown, and it is to be understood that details of the corresponding screw unit 38' driven by power device 53' are similar.

For the purpose of constructing the supporting means 51 mounting this unit, a pair of the framework uprights 12 may have vertically spaced horizontal angle irons 62 suitably secured thereto, as by welding, and an elongated, horizontally extending channel section 63 has its flanges disposed between and welded to the horizontal flanges of the angle irons 62. The upright web portion of the channel 63 in turn serves as a support for an upright mounting base 64 of channel section, upon which the respective pillow blocks 50 are suitably bolted or otherwise secured, as illustrated in FIGS. 3 and 5.

Directly to one side of the mounting base 64, i.e., to the right, as illustrated in FIGS. 3, 5 and 6, the vertical web portion of the channel 63 has fixedly secured thereto and rigidly sustains an inboard supporting bracket 66 for the screw blender 38, and a further outboard supporting bracket 67 for the unit 38 is similarly secured to the member 63 in a zone spaced substantially to the right, and adjacent the right hand end of the latter, as viewed in FIGS. 3, 5 and 6. Between them, the inboard and outboard supporting brackets 66, 67 mount the housing 69 of the screw blender 38.

The housing 69 comprising a first, open-topped and trough-like material receiving portion 70 of the cross sectional contour best shown in FIG. 8. It is generally semi-cylindrical and axially elongated at its bottom wall or floor 71. The semi-cylindrical bottom contour of the housing hopper portion 70 is carried out throughout the length of the housing, including a fully cylindrical mixing chamber 72, and end wall flanges 73, 74 at the opposite ends of this semi-cylindrical section are appropriately secured by bolting, welding or otherwise, to the respective inboard and outboard mounting brackets 66, 67 adjacent the lower portions of the latter.

The housing 69 is completed by an upper half, including a vertical walled hopper portion 76 and a semi-cylindrical cover portion 77, mating with the lower chamber portion 72. The portions 76, 77 may be produced as an integral casting, including an upright transverse end wall portion at 78 in the plane of the attaching flange 73, and an end cylinder flange 79 in the vertical plane of the attaching flange 74. In the zone surrounding the open-topped, vertical-walled portion 76, the housing is provided with a horizontal flange 80 to which a corresponding attaching flange of the transition member 47 of mill blender 35 may be bolted. To this end, the flange 80 is shown (FIG. 5) as provided with notches or recesses 81 to receive such bolt means.

As illustrated in FIG. 6, the shaft 49 for the screw blender 38 extends through the mounting bracket 66, where it is sealed by an O-ring seal unit 82, and through an appropriate inboard locating plug 83, which is secured

by screws 84 to the adjacent surface of inboard mounting bracket 66.

As illustrated in FIGS. 3, 5 and 8, the upper portion of the screw housing 69, including the left hand hopper portion 70 and the right hand cylinder portion 77, is attached to the top of the lower uniformly semi-cylindrical half of the housing. To this end, the respective lower and upper portions are provided with horizontally extending flanges 86, 87 along their front and rear sides, the latter resting upon the former, and individual clamps 88, pivoted at 89 at spaced points beneth the flanges 86, are receivable in the slots 90 in the respective flanges to clamp the housing parts together, these clamps being operated in a conventional manner by hand knobs 91.

A special type of material conveying, mixing and blending screw 92 is secured on shaft 49 and extends the length of the housing 69, being appropriately piloted in the inboard and outboard mounting brackets 66, 67, and discharging through the latter at a throat 93, as illustrated in FIG. 6. It is at this point that the pump 39 is connected in sealed relation to receive the discharge from housing 69, as by the special adapter plate 60 to be described.

Referring now to FIGS. 6 and 8, the screw 92 is axially discontinuous, as to its helical screw formation. It comprises a series of individual, partially helical wing formations 95 surrounding and welded to an elongated sleeve 96 which is drivingly connected to the shaft 49, each formation 95 extending approximately 180° about the sleeve 96. The successive helical wing members 95 are separated axially from one another at axial spaces 98, but with the helix substantially uninterrupted in the circumferential sense at the zone of these spaces 98. Thus, as a viscous fluid mix is subjected to the action of the screw structure 92, its forwarding is substantially continuous and uninterrupted in this direction, notwithstanding the spaces 98.

A series of radial anvils 100 are arranged along the bottom center line of the housing 69, the semi-cylindrically sectioned floor member 71 of the housing being equipped for this purpose with an axially elongated mounting block 101 of substantial thickness. The anvils 100 are located in the axially spaced zones of the clearance spaces 98 between successive helical formations, being received with close clearance on either side relative to the formations at either side of the space. The anvils are of rectangular cross section, as illustrated best in FIG. 7.

For the purpose of receiving the anvils 100 and mounting the same against rotation about their individual radial axes, the block 101 and housing floor 71 are formed to provide individual cylindrical radial bores 103 which receive anchored cylindrical portions 104 of the respective anvils 100, radially outwardly of their rectangular ends. Outwardly of their cylindrical portions 104, the anvils 100 have flanged shoulders or heads 105 extending only partially about their respective peripheries, as shown in FIG. 7, there being chord-like flats 106 on each of the heads or shoulders 105. In order to receive these heads or shoulders, the outer or lower surface of the block 101 is milled to provide rectangular recesses 107, and the flat 106 of the head or shoulder engages against a flat wall of the recess 107, as shown in FIG. 7 to prevent rotation of the respective anvils 101.

A retainer plate 108 is applied across the lower surface of the block 101, being secured thereto by screws 109, to hold the anvils in place in the bores 103.

As illustrated in FIG. 6, the arrangement of anvils 100 extends along the entire length of the housing 69. A similar arrangement is made along the upper center line of the cylindrical cover member 77, corresponding parts and relationships being indicated by corresponding reference numerals, so that further description may be dispensed with.

It is seen that the anvils 100 effectively break up any

agglomerations or masses of undue or non-uniform size forwarded by the non-continuous helix formations of the screw 92, without materially interrupting a smooth flow of the mixture through the housing 69, from its intake throat portion 70 to its discharge at the axial end throat 93.

As illustrated in FIGS. 3, 4 and 6, the special slip or adapter plate 60, by which screw blender 38 is connected at its discharge end to the intake end of pump 39, is of circular outline, being provided with a plurality of equally spaced, radially outwardly extending notches or recesses 112. The bracket 67 is provided with similarly spaced bayonet type openings 113, adapted to receive bolts or studs 114 extending through the adapter plate notches 112 to secure the plate over the discharge end of the screw blender housing 69. Plate 60 is provided with a discharge opening 115 arranged eccentrically adjacent the bottom thereof, for communication with the housing 69, with the intake end throat 116 of pump 39 fitted to the opening 115 in sealed relation to the latter. Plate 60 is provided on its inner face with an annular groove 118 for the reception of sealing ring means (FIG. 6).

Upon issue through the discharge line 43 to the tertiary blending sub-assembly, the processing is continued and completed in a similar manner by the mill blender 35', screw blender 38' and pump 39' of that sub-assembly. It issues through the discharge line or conduit 43' of the pump 39' to any appropriate packaging apparatus or like point of disposal.

The apparatus is compact as to space requirements. It features individual drives for the primary screw blender 21, the secondary blender sub-assembly 37 and the tertiary blender sub-assembly 41, in the form of the motor 26 and reducer 28 for the first, the variable speed drive unit 53 for the second, and the corresponding drive unit 53' for the third unit. This enables all units and sub-assemblies to be individually driven at desired speeds, in the light of desired characteristics to be produced in the finished product, or of its characteristics as received by the respective units and/or sub-assemblies.

What I claim as my invention is:

1. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having a discharge opening at one axial end thereof, and a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means driving the same at the axial end thereof opposite its axial intake end to forward material received at said intake end thereof through a closed path and under pressure, the pump discharging radially between said axial ends.

2. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said screw being axially and circumferentially discontinuous, being characterized by axially spaced, partially helical screw elements, and said blending chamber being provided with fixed radial anvil elements projecting between successive screw elements, said chamber having a discharge opening at one axial end thereof, and a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means driving the same at the axial end thereof opposite its axial intake end to forward material received at said intake end thereof through a closed path and under pressure, the pump discharging radially between said axial ends.

3. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having a discharge opening at one axial end thereof, a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means forwarding material received at said intake thereof through a closed path and under pressure, and means for simultaneously driving said blending screw and said pump rotor at speeds variable relative to one another, including means driving the pump at the axial end thereof opposite its axial intake end, the pump discharging radially between said axial ends.

4. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said screw being axially and circumferentially discontinuous, being characterized by axially spaced, partially helical screw elements, and said blending chamber being provided with fixed radial anvil elements projecting between successive screw elements, said chamber having a discharge opening at one axial end thereof, a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means forwarding material received at said intake thereof through a closed path and under pressure, and means for simultaneously driving said blending screw and said pump rotor at speeds variable relative to one another, including means driving the pump at the axial end thereof opposite its axial intake end, the pump discharging radially between said axial ends.

5. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having a discharge opening at one axial end thereof, a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means forwarding material received at said intake thereof through a closed path and under pressure, and means common to said blending unit and pump for simultaneously driving said blending screw and said pump rotor at speeds variable relative to one another, including means driving the pump at the axial end thereof opposite its axial intake end, the pump discharging radially between said axial ends.

6. In apparatus for mixing and blending materials, the combination of a mill-type mixing unit, a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having an intake throat opening radially thereto and in receiving relation to said first named unit, and a discharge opening at one axial end thereof, and a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means forwarding material received at said intake thereof through a closed path and under pressure.

7. In apparatus for mixing and blending materials, the combination of a mill-type mixing unit, a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having an intake throat opening radially thereto and in receiving relation to said first named unit, and a discharge opening at one axial end thereof, and a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving re-

lation to said discharge opening of said blending chamber, said pump having means driving the same at the axial end thereof opposite its axial intake end to forward material received at said intake end thereof through a closed path and under pressure, the pump discharging radially between said axial ends.

8. Apparatus in accordance with claim 6, in which said screw of said blending unit is axially and circumferentially discontinuous, being characterized by axially spaced, partially helical screw elements, said blending chamber being provided with fixed radial anvil elements projecting between successive screw elements.

9. Apparatus in accordance with claim 7, in which said screw of said blending unit is axially and circumferentially discontinuous, being characterized by axially spaced, partially helical screw elements, said blending chamber being provided with fixed radial anvil elements projecting between successive screw elements.

10. Apparatus in accordance with claim 7, and further comprising means for simultaneously driving the blending screw and pump rotor at speeds variable relative to one another, including means drivingly engaging said pump driving means at said axial end opposite the axial intake end.

11. In apparatus for mixing and blending materials, the combination of a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having a discharge opening at one axial end thereof, and a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said

pump having means driving the same at the axial end thereof opposite its axial intake end to forward material received at said intake end thereof through a closed path and under pressure, the pump discharging radially between said axial ends through a discharge fitting, and a further blending unit having its intake in communication with said pump through said discharge fitting.

12. In apparatus for mixing and blending materials, the combination of a mill-type mixing unit, a blending unit of the rotating screw type having a cylindrical blending chamber in which a driven conveying and blending screw rotates, said chamber having an intake throat opening radially thereto and in receiving relation to said first named unit, and a discharge opening at one axial end thereof, a pump of the helical rotor-helical stator type having an intake at one end of the rotary axis of its rotor which is in direct and substantially coaxial receiving relation to said discharge opening of said blending chamber, said pump having means driving the same at the axial end thereof opposite its axial intake end to forward material received at said intake end thereof through a closed path and under pressure the pump discharging radially between said axial ends through a discharge fitting, and a further blending unit having its intake in communication with said pump through said discharge fitting.

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