United States Patent

Lynch et al.

[15] **3,687,288**

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[54] **SEPARATOR AND METHOD**

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[52] **U.S. Cl.** **210/84,** 210/112, 210/137, 210/179, 210/512, 259/8

[51] **Int. Cl.** **B01d 21/26**

[58] **Field of Search**.....210/83, 84, 101, 103, 109, 210/112, 137, 179, 183, 252, 262, 259, 261, 294, 322, 413, 512; 259/7–10

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[57] **ABSTRACT**

A separator screw and housing with conical intermediate portion and with inlet intermediate its two outlets, has a much greater screw pitch on its forward cylindrical end than in the adjacent end of the conical portion. Beyond the forward outlet is a single cylindrical feed-out screw and housing, with the feed-out screw run at a much slower speed than the separator screw. Pressure sensors in the conical portion of the separator screw give a differential pressure on the basis of which the speed of the feed-out screw is controlled by a proportioning controller. Between the separator screw proper and the rear outlet may be a chamber with longitudinal vanes.

20 Claims, 7 Drawing Figures

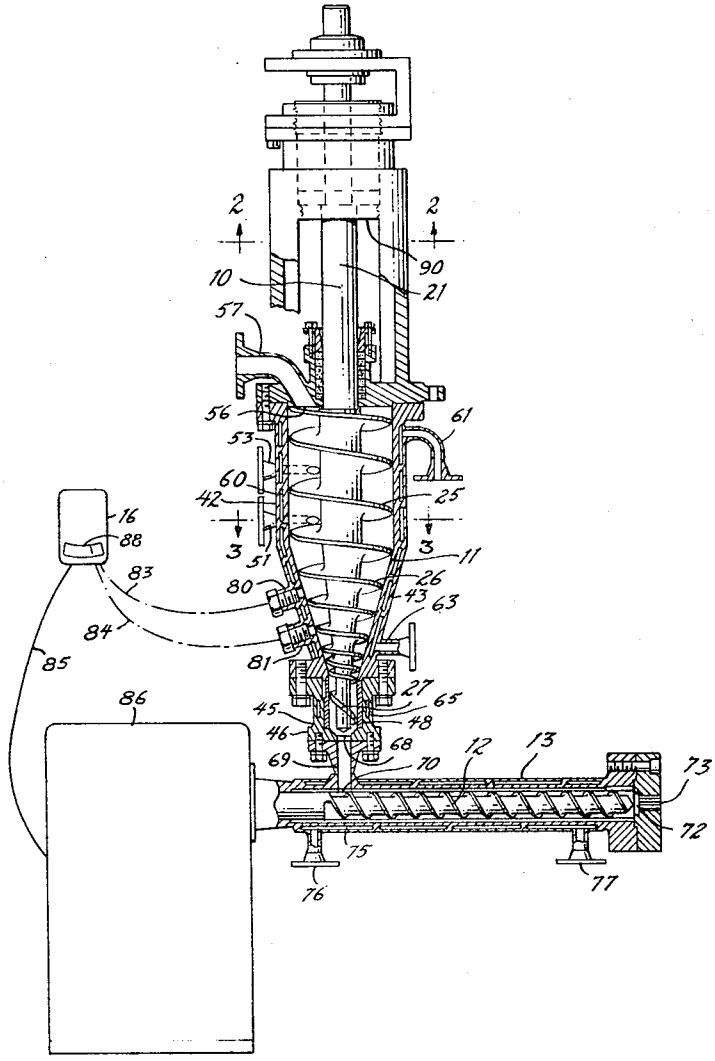


Fig. 1

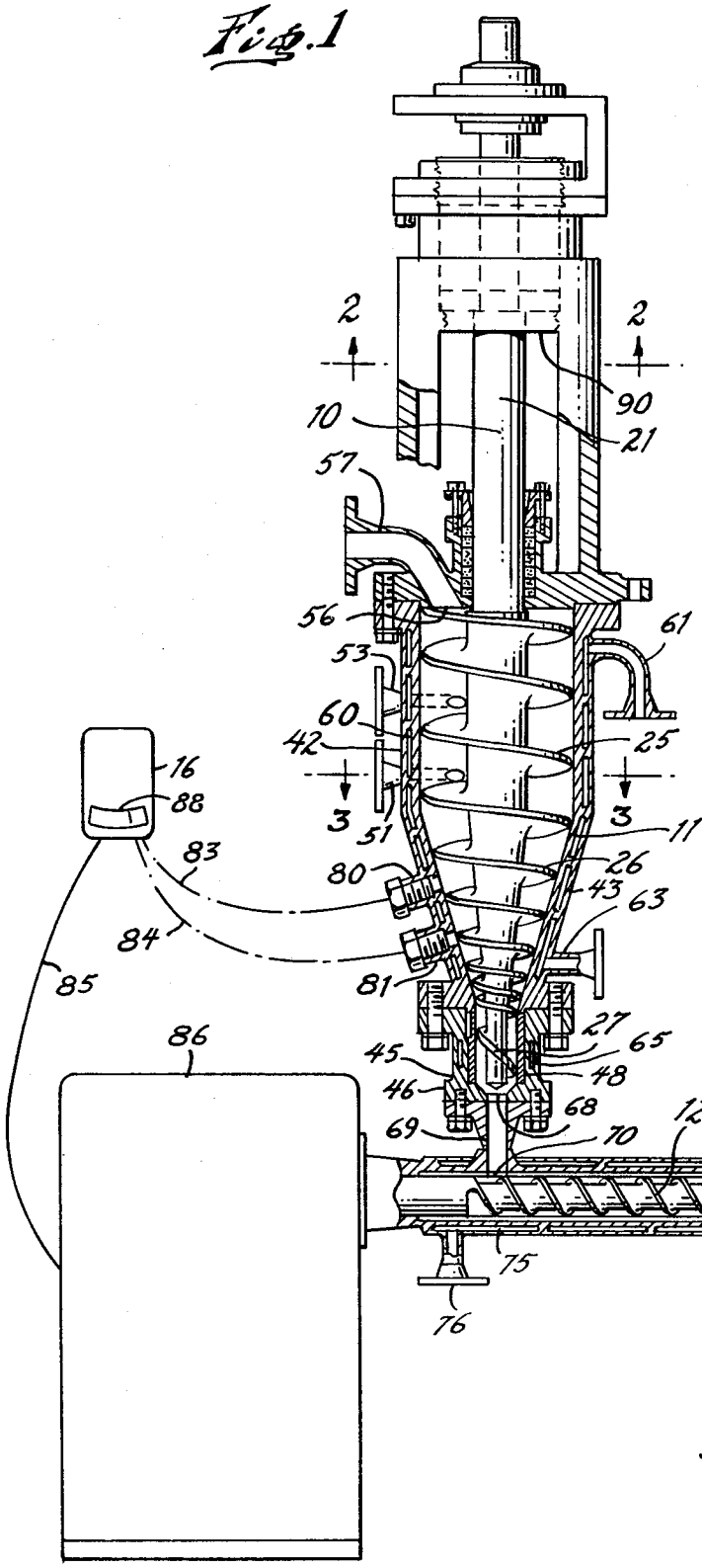
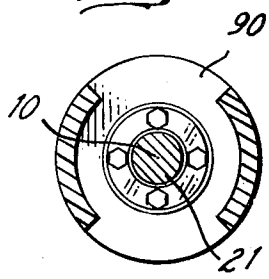


Fig. 2.



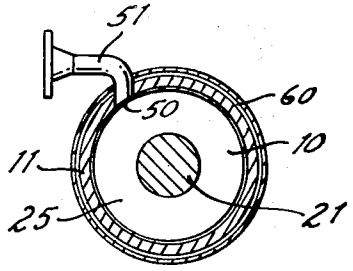


Fig. 3.

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Fig. 4.

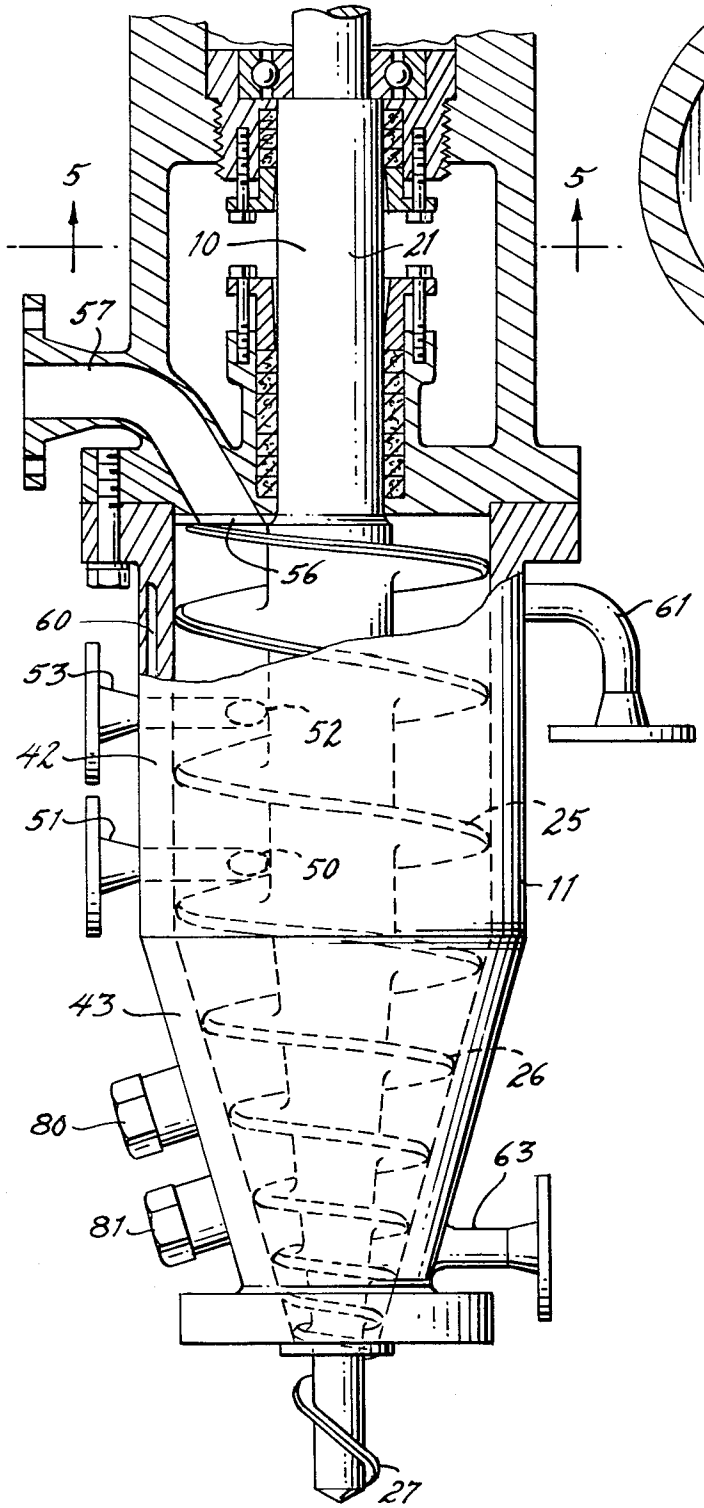
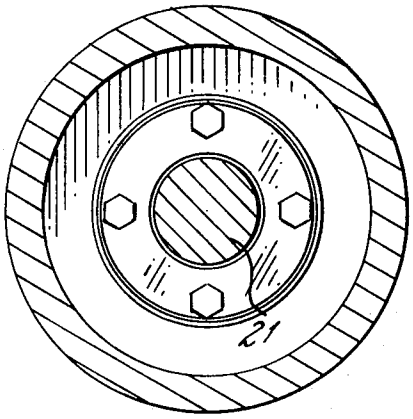


Fig. 5.



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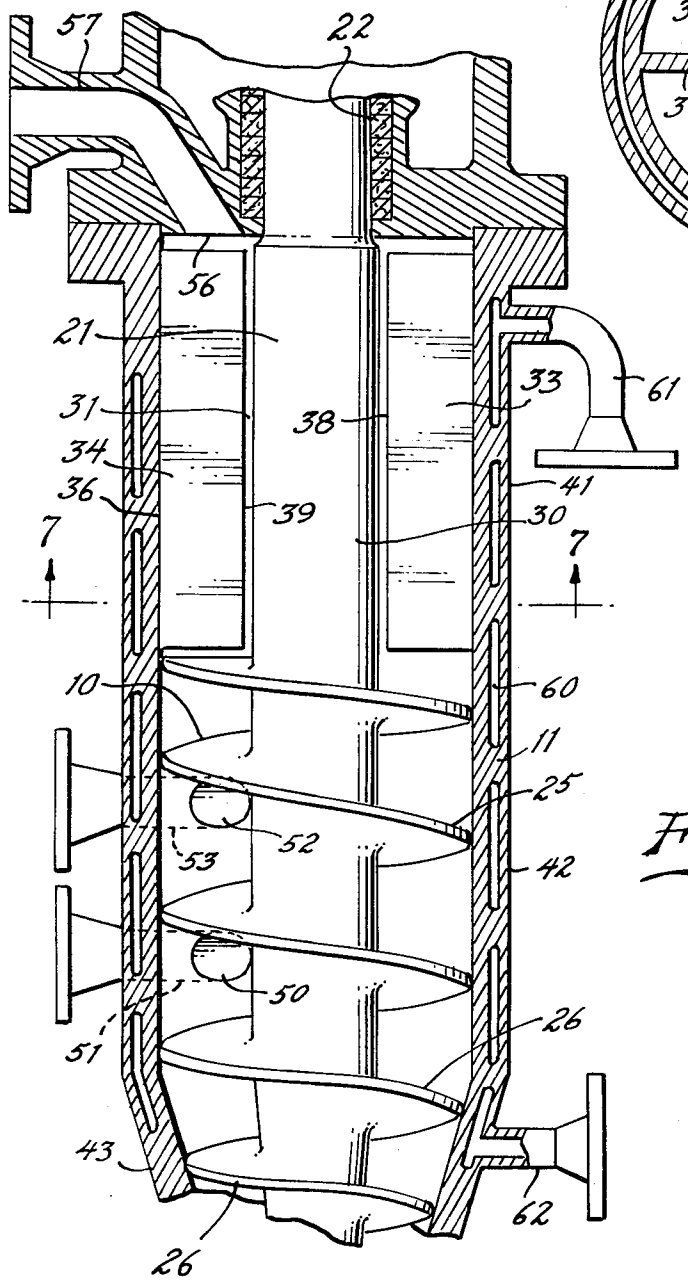


Fig. 6.

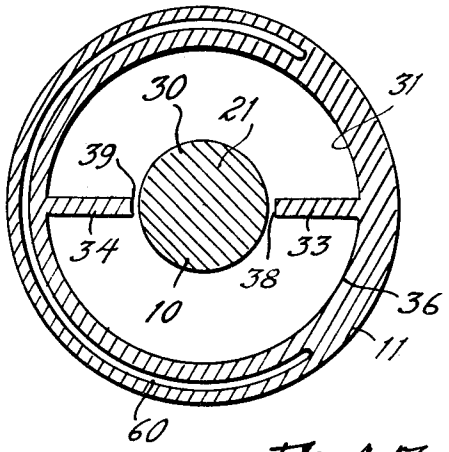


Fig. 7.

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SEPARATOR AND METHOD

SUMMARY OF THE INVENTION

This invention relates to a separator screw setup and method involved therein.

A purpose of the invention is to provide such a setup and furnish such a method in which surging or irregularities of throughput coming out of the setup, not based on change of input, are minimized.

A further purpose of the invention is to provide such a setup and method which can respond and adjust well to variations in the input into the setup, and vary the output in good correlation with such variation in input.

A further purpose of the invention is to provide such a setup which tends to maximize separation of the respective components and to prevent as far as possible any material which actually by rights should form part of one component from remaining mixed in with the other component, and does so in a very economical, practical way.

A further purpose of the invention is to provide such a setup in a form which is extremely practical from an overall standpoint.

Further purposes will appear in the specification and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, we have chosen to illustrate certain only of the particular embodiments in which our invention may appear, the forms shown being chosen from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

FIG. 1 is an elevational, partly diagrammatic view of an embodiment of the screw setup of my invention, broken away especially to show interior.

FIG. 2 is a cross-sectional view along the line 2—2 on FIG. 1.

FIG. 3 is a cross-sectional view along the line 3—3 on FIG. 1.

FIG. 4 is a fragmentary enlarged elevational view, partly broken away, of the separator housing and screw of a somewhat variant, less preferred embodiment, as compared to that of FIG. 1.

FIG. 5 is a cross-sectional view along the line 5—5 on FIG. 4.

FIG. 6 is a fragmentary vertical section of the separator screw of still another embodiment of my invention, this last being the preferred embodiment, especially for certain purposes.

FIG. 7 is a cross-sectional view along the lines 7—7 on FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Our invention is a particular improvement over that described in Lynch and Nichols, U. S. Pat. No. 3,288,443 which is incorporated by reference herein for additional disclosure as to features which remain substantially the same.

The setup involved in that earlier patent has gone into extended service, where it meets many needs.

However, we have observed its operation carefully, and our observation has shown that in certain situations various difficulties appear.

For one thing, when it is used to remove solvent from thermoplastic or thermosetting polymers, very viscous materials, dewatering polymer in crumb form or performing some other operation where the material leaving the product outlet of the machine is in the form of a polymer melt or highly viscous mass, there may be difficulty with erratic discharge rate from the machine.

Though we are by no means sure what the cause of this is, the most probable cause of this seems to us to be that when the machine is started up, the die at the outlet end is filled slowly and then because the materials in question are mostly pseudoplastic or thixotropic, the viscosity of the material increases in the die due to the lack of shearing and of motion. The screw gradually fills up with material of lower viscosity under shear until sufficient pressure is developed to force the viscous material through the die. After the viscous material is pushed from the die, it is followed by the less viscous material which flows at a much greater rate, requiring less pressure to push it through the die. The level of the material in the machine decreases to the point where the flow of low viscosity material through the die slows down due to inadequate pressure. As the material slows down in flow through the die, the viscosity increases and the cycle is repeated.

We have also determined that greater efficiency would be secured from our devolatilizer when there are used speeds which are higher than would originally have been thought of, for example when there are used peripheral speeds in the range from 500 to 1,200 feet per minute. This is especially the case in the removal of solvent from polymeric material. In normal operation we would put a heated solution consisting of polymer and solvent into the devolatilizer and this, of course, would foam on entrance into the vacuum area of the devolatilizer due to the solvent changing into a gas. With such a higher speed, the additional centrifugal force developed by the higher speed forces the material more strongly against the inside shell wall and rapidly breaks the foam down by exposing new surfaces to the vacuum. As the material moves forward along the shell surface, propelled by the screw, the volume of the foam decreases until viscous non-foam is obtained. The volume of the gas escaping along the root of the screw also decreases as the material moves forward. The heat transfer rate through the shell wall into the material is increased. With such higher speeds the horsepower requirement is increased, and this is for the most part directly converted into heat in the product. Such methods of heat addition are helpful to devolatilization, in that large amounts of heat are lost from the polymer due to solvent vaporization and must be replaced if devolatilization is to continue, and plasticity, particularly with thermoplastic materials, is to be maintained. Such higher speeds also generate heat in the pumping screw section of such a devolatilizer, this pumping screw section being a place where close clearance prevails. That also causes the pumping screw to have a displacement far greater than the capacity of the machine to devolatilize. If it should be attempted to simply change the dimensions of the pumping screw section in the device of the patent, to give dimensions more suitable for use at high speed, this would make the short end thus changed pressure sensitive and would give an impractical result.

There are certain processes where high screw speeds would be undesirable due to the generation of excessive heats which would cause heat sensitive polymers to degrade and thermosetting polymers to set up solid.

Slower screw speeds are also desirable in the removal of liquid from crumb or gel rubber or polymer. In this instance the rubber or polymer and water-like liquor are in slurry form and the slurry is fed into the normal inlet port. The polymer crumb is fed forward and the liquor leaves by way of the port at the rear of the machine where in the case of devolatilization, the solvent is normally removed under vacuum. It appears the crumb is squeezed tighter and tighter as it progresses forward causing the liquor to move through the crumb under various stages of compression and out of the rear ports. The flow from the outlet of the machine during this type of operation is also erratic. In addition to erratic flow, excessive heat can lead to cavitation full of steam in the pumping screw portion, causing flow to stop completely.

Another problem is that as a practical matter such a devolatilizer is very likely to be installed in a pre-existing system. Thus it normally has a feed rate which is a predetermined thing established by a previously installed and operating polymerization process. Thus the machine, to achieve optimal results, should operate at a rate which is governed by the operation of a process feeding material to it, which process it in no way itself controls or influences.

Another difficulty is sometimes encountered when slurries of rubber or polymer crumb or gel in water-like liquors are being separated, particularly where the specific gravities of the solids and liquors are close to each other and the solids do not readily precipitate. When the screw is rotating there will be turbulence in the screw flights, and it may be difficult to prevent solids in undue quantities from leaving the machine through the rear ports along with the liquid.

Our improved separator setup of the present invention is well suited to eliminate or minimize all these difficulties. It takes a separator screw with a conical mid-portion, a large-diametered cylindrical portion toward the rear, and a small-diametered cylindrical portion at the front end, as in the Lynch and Nichols patent already mentioned. It deepens the fights, and increases the pitch, of the small-diametered portion at the front end, or in other words, the pumping section of the previous screw, and adds a separate pumping screw forward of that front end, which pumping screw rotates at its own speed, which is much lower than the speed of the separator screw and which separate pumping screw is designed to be much less pressure-sensitive than the pumping screw section of the separator screw would be.

For example, in the new design, the small-diametered cylindrical portion of the separator screw will have a pitch which will range from one-tenth of the diameter (0.1 D) to twice the diameter (2 D) of the screw at this point and will have a depth of groove ranging from three-hundredths of the diameter (0.03 D) to three hundred seventy-five thousandths of the diameter (0.375 D) of this part of the screw. The length of this pumping screw section will be comparatively short, especially when considered in terms of the pitch length, and may and often will be only one pitch length which is preferred. The peripheral speed of the pumping screw section of the separator screw will be 150 to 400 feet per minute.

In contrast, the separate pumping screw will be much longer, with a length to diameter ratio ranging from 4 to 1 to 14 to 1. Its pitch may for example be equal to the diameter and its screw depth will be in the range from two-hundredths of the diameter (0.02 D) to three-tenths of the diameter (0.3 D). Its peripheral speed will in contrast be in the range from 15 to 150 feet per minute. This will give comparatively little variation in screw output in the face of variation in pressure and viscosity. For example in one such screw, where viscosity would range from one-tenth to five-tenths (0.1 to 0.5) pound seconds per square inch, and back pressure would range from 750 to 2,500 pounds per square inch gauge pressure, the calculated variation in screw output as between minimum and maximum flow would be only from a minimum output of 0.848 cubic inches per second to a maximum output of 0.888 cubic inches per second.

Our present invention also includes sensing devices in the conical portion of the separator screw on the basis of which a proportional controller will transmit a pneumatic signal to a variable speed drive which operates the pumping screw and thereby the level of the material within the separator will be controlled.

Speed is changed in the feed-out screw over a range of approximately plus or minus 10–15 percent. Thus, if a die and pelletizer were being used, the length of the pellets cut would be changed to such a small degree as to be virtually unnoticeable. For instance, if one-eighth inch long pellets were being made, the change from norm would be within 0.0125 inch. The feed-out screw has the capacity to temporarily serve as a reservoir or accumulator while the separator screw is at its high or low level of process material.

Another feature of our present invention is that behind the large-diametered cylindrical portion of the separator screw there is a portion in which the screw shaft extends back without any screw upon it. Within a circular housing spaced from the shaft to give room for a chamber, preferably extending the entire length of the chamber, there are two oppositely placed longitudinal vanes which extend from the chamber wall inward to a point almost to the shaft. The rear outlet port is at the rear end of this chamber, positioned in a way to draw from both halves of the chamber.

More specific description of these and other special features of the present invention, consisting of improvements over the patented device and method, will be found in the description of specific embodiments which follows. By the various improvements, the difficulties described are eliminated or minimized.

Describing in illustration and not in limitation and referring to the drawings:

As already indicated, the embodiment of FIG. **6** and **7** is our preferred embodiment. This embodiment, as to the parts of the setup not shown in FIGS. **6** and **7**, is like the embodiment of FIGS. **1**, **2** and **3**, and in describing the embodiment of FIGS. **6** and **7**, FIGS. **1**, **2**, and **3** will be referred to for the rest of the embodiment.

The device of FIGS. **6** and **7** includes separator screw **10**, separator housing **11**, feed-out screw **12** and feed-out housing **13**, together with control system **16**.

Separator screw **10** is mounted on shaft **21** to run in bearings positioned above the screw proper, which in this particular embodiment is vertical in position. (The bearings are not specifically shown in this particular embodiment of FIGS. **6** and **7**; they may be ball bearings as in FIG. **4**, but will be preferably positioned at a relatively higher point as in the embodiment of FIG. **1**). As will be seen, the bottom part of the screw and housing also serve a bearing function.

The topmost part of the screw proper is cylindrical portion **25** of comparatively greater diameter. Below it is conical portion **26** tapering in a downward direction from that diameter to a much smaller diameter, and below that, cylindrical portion **27** with the smaller diameter.

As will be noted, the screw has a pitch, that is, a distance between successive threads, which is preferably greater in an intermediate area in the upper cylindrical portion **25** than it is at the very top or the very bottom of the upper cylindrical portion. Furthermore, from the very bottom of the upper cylindrical portion on down through the conical portion **26**, the pitch decreases until at the bottom of the conical portion it reaches its smallest point. Then the pitch in the lower cylindrical portion **27** is much greater than it was in the bottom of the conical portion, and preferably consists of a single turn of relatively large pitch.

Above upper cylindrical screw portion **25** of relatively great diameter, and below the bearings, is simple shaft portion **30** running in a chamber **31** between oppositely positioned stationary vanes **33** and **34** each extending from chamber wall **36** radially toward the shaft, and terminating a little short of the shaft at **38** and **39** respectively. These vanes are preferably removable.

Separator housing **11** is cylindrical in wall **41** of chamber **31** and also portion **42** in which it surrounds the relatively large diameter screw portion, these two cylindrical portions being preferably of the same diameter constituting a continuous cylindrical shell, and being preferably of equal length, one to the other. However, other relative lengths may be employed as for example, having chamber **31** shorter than cylindrical screw portion **25**, for example one-half the length of that cylindrical screw portion. Below cylindrical portion **25**, separator housing **11** tapers down in conical portion **43** along with the taper of the screw. Below this conical portion it has cylindrical portion **45** made up of outside wall **46** and cylindrical lining **48**.

The cylindrical lining **48** is preferably of some suitable bearing material such as a nickel base hard face alloy consisting of the following:

carbon	.75%
chromium	13.5%
boron	3%
silicon	4.25%
iron	4.75%
nickel	balance

and in such case serves as bearing for the relatively small diametered cylindrical portion **27** of the screw, which is preferably of some material that engages and cooperates with the bearing material for bearing purposes such as a hard surfacing on the surface such as the following:

C	0.7 to 1.14%
Mn	2% max.
Cr	26 to 32%
W	3 to 6%
Ni	3% max.
Si	2% max.
Other	4.5% max.
Co	remainder

In the wall of cylindrical housing portion **42** opposite the cylindrical screw portion of relatively large dimension is inlet opening **50** fed by passage **51** and also inlet opening **52** fed by passage **53**, this giving optional positions of the inlet opening depending upon which happens to suit best for the particular circumstances.

In the top of chamber **31** is outlet opening **56** from which proceeds outlet passage **57**, this being the outlet for the component which is separated which is least influenced by the tendency of the separator screw to cause material to progress in the downward direction. The screw is rotated by means not shown, such as a motor, in a direction to produce that downward tendency of progression, which may at times be called the direction of screw impulsion, or more simply the forward direction, the upward direction being thus the rearward direction, and the lower end of the separator screw being its forward end and its upper end its rearward end.

In the walls of housing **11** are suitable passages **60** through which suitable fluids may be passed to make these walls of the housing serve as a jacket for heating or cooling purposes as far as the material inside the cylinder is concerned. In FIG. **6** this jacket is shown as a spiral set of passages having one end at the top of the housing side walls, with communication with the outside for admission or discharge of heating or cooling fluid by passage **61** and another end of the passages in the upper part of the conical section, having communication with the outside at the other end of the heating or cooling system at **62**, but preferably the jacket with its passages may extend nearly to the bottom of the conical portion as in FIGS. **1** and **4**, with their communication with the outside at **63**.

In any event there will preferably be similar jacketing in the bottom cylindrical section wall at **65**, having openings to the outside not shown.

At the lower end of the separator housing is outlet **68** for that component of the separated material which is the more subject to the impelling effect of the separator screw.

Beyond this, passage **69** communicates with feed-out housing **13** near one end, and more specifically near the end away from which the feed-out screw **12** tends to impel the material, which can be called the rear end of the feed-out housing.

From inlet **70** at the end of passage **69**, this particular component is fed by feed-out screw **12** to outlet opening **72** at the opposite end of the screw, beyond which it may suitably pass through die **73**, for example, which may be provided for such purposes as extrusion. Feed-out screw **12** is preferably a cylindrical type of screw with housing **13** which surrounds it being likewise cylindrical. Housing **13** likewise has within it passages **75**, which may as shown be in spiral form running almost the entire length of the jacket between passages **76** and **77** communicating with the outside, thus likewise permitting heating or cooling fluid, by means of attachments (not shown) to passages **76** and **77**, to pass through the housing and heat or cool the material inside.

Pressure sensors **80** and **81** at different points along the length of the conical portion of the separator screw housing **11**, which sense pressure in the interior of that housing at those respective points, communicate their respective pressures to control **16**, as diagrammatically shown by lines **83** and **84**. Control **16** in turn, on the basis of the relation of that differential pressure to a preset differential pressure, communicates signals, as shown by line **85**, to a variable speed drive **86** which drives feed-out screw **12**. This will preferably be a proportioning type of control, with controller **16** providing greater correction in case of greater deviation from the desired preset figure. In the form shown, controller **16**, the proportioning control, also has indicator **88** on its face.

As shown in FIGS. **1** and **2**, in the upper part of the shaft, beyond the end of the housing, there is preferably an open area **90** to facilitate work on the device when needed, although the somewhat different construction in the top found in FIG. **4** is also possible. This open area **90** involves a breaking away of the supporting structure in such a way that instead of cylindrical surrounding support structure, about one-half of this cylindrical structure is open.

The forms of FIGS. **1** to **3** and the form of FIGS. **4** and **5**, though as already indicated in many respects similar to that of FIG. **6**, are essentially somewhat variant forms which lack chamber portion **41** of the housing, and also do not have chamber **31** itself, vanes **33** and **34** and shaft portion **30** without screw, and in which individual component outlet **56**, for the component which is less urged along the screw, the passage **57** leading from that outlet, are located right beyond the top of the separator screw proper.

In operation, a suitable mixture, for example to be devolatilized, is inserted into the inlet, and passes through the separator screw, the component fed backwards in relation to the direction of the screw motion going out the outlet of the rear of the screw and the component fed forward in the direction of screw motion going out the outlet at the forward end of the separator screw. If a device having a settling chamber is used, the component flowing out the rear end is more thoroughly separated.

The component flowing out the forward outlet then is picked up by a feed-out screw, desirably running slower than the separator screw. Pressure in the taper housing portion of the separator screw or pressure differential in the taper portion of the separator screw is sensed and the speed of the feed-out screw is regulated. In this regulation of the speed of the feed-out screw, normally as the pressure goes up beyond a predetermined norm or as the pressure differential increases beyond a predetermined norm, the feed-out screw is caused to increase its speed.

When the language "interrelating controller" or "interrelating controller means" is used in the claims, this means a controller or controller means which operates automatically to interrelate the thing which it controls with the thing according to which it is controlled.

In view of our invention and disclosure, variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of our invention without copying the apparatus and method shown, and we therefore claim all such insofar as they fall within the reasonable spirit and scope of our claims.

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

1. A device for separating material into a plurality of portions differently responsive to the drive of a screw, comprising a separator screw at least part of which is tapered in shape, which separator screw is rotated in a direction to drive the portion that is more responsive to the drive of a screw in the direction along the screw in which the taper narrows, which will be called the forward direction, a separator housing surrounding the separator screw and having an inlet for material to be separated, which inlet is at an intermediate point along the separator screw, the separator also having outlets for separated materials, one of which is in the forward direction along the screw from the inlet and one of which is in the rearward direction from the inlet, a feed-out screw and a feed-out housing surrounding the feed-out screw and connected to receive the separated portion from the above mentioned forward outlet, at least one pressure sensor which senses pressure in the interior of the separator housing, and a control controlling the operation of the feed-out screw on a basis involving at least partly the pressure thus sensed.

2. A device of claim **1**, in which there is a second pressure sensor which senses pressure in the interior of the separator housing, but at a different point along the separator screw from the first pressure sensor, and the control is based on the difference in pressure between the two pressure sensors.

3. A device of claim **2**, in which the control is a proportioning control which changes the operation of the feed-out screw to a greater degree when there is a greater deviation from what is desired than when there is a lesser deviation.

4. A device of claim **1**, in which the control controlling the operation of the feed-out screw on a basis involving at least partly the pressure thus sensed controls the speed of revolution of the feed-out screw.

5. A device of claim **1**, in which the control controlling the operation of the feed-out screw on a basis involving at least partly the pressure thus sensed controls the speed of revolution of the feed-out screw to run at a slower rate in revolutions per minute than the separator screw.

6. A device of claim **1**, in which the separator screw includes a cylindrical non-tapering further portion forward of the narrower end of the tapered portion and this further portion at least includes a length of screw having a pitch greater than that of the tapered portion near the said opening, and in which the separator housing includes a non-tapering portion surrounding this further portion of the screw and forming at least a part of the path for separated material between the tapered portion of the separator housing and the feed-out screw housing.

7. A device of claim **6**, in which the said further portion includes at least one complete turn of screw, which turn and its corresponding surrounding housing portion function as a bearing.

8. A device of claim **1**, in which the separator screw includes a settling portion located at a place rearward of the larger end of the tapered portion, which settling portion has a shaft without any screw, and which device

includes a settling housing surrounding the settling portion of the separator screw which settling housing is spaced from the outside diameter of that shaft to form a settling space and has at least one stationary longitudinal vane within that settling space.

9. A separator for material capable of being separated into a plurality of parts having at least somewhat different characteristics as far as tendency to respond to the urging of a screw is concerned comprising a separator screw having a tapered portion which tapers down in the forward direction and a cylindrical portion forward of the tapering portion and having a diameter substantially the same as that of the small end of the tapering portion, the cylindrical portion having a pitch which is at all places greater than the smallest pitch found in the tapering portion, a separator housing surrounding the separator screw and having an inlet at a point farther back from the forward end of the tapering portion of the screw, a rear outlet further back than the inlet, and a forward outlet further forward than the rear end of the cylindrical portion, feed-out screw means which rotate separately from the separator screw, a feed-out housing surrounding the feed-out screw means and connected to receive from the forward outlet of the separator housing and interrelating controller means for turning the feed-out screw means at a speed which will withdraw the material more slowly than the separator screw tends to urge the material forward.

10. A separator screw according to claim 9, in which the means for turning the feed-out screw means turns it at a lower rotational speed than the separator screw.

11. A separator according to claim 9, in which the feed-out screw means is a single feed-out screw.

12. Apparatus for separating material comprising a separator screw and housing having an inlet and outlets for effluents that have been separated from each other, one of which outlets is toward the front end of the screw as compared to the other outlet, a feed-out screw connected to the outlet nearest the front end of the separator screw which feed-out screw rotates separately from the separator screw and has characteristics enabling it to hold back on material coming from the outlet, if run slow enough, and means to automatically and continuously regulate the speed of the feed-out screw in accordance with the amount of buildup of material in the separator screw to maintain a predetermined holdback pressure around the separator screw.

13. A device for separating materials comprising a separator screw, a housing surrounding that screw, an inlet in the housing at an intermediate point therein, a first outlet from the housing for some of what has been admitted, which first outlet is at a point in the direction of separator screw impulsion from the inlet, the interior of the housing including a chamber beyond the end of the separator screw in the direction opposite to that of separator screw impulsion, a second outlet from the housing, which second outlet is from this chamber, for some of the material which has been admitted to the housing, which second outlet is at least substantially beyond the end of the separator screw nearest to the chamber and in a direction from the inlet which is counter to the direction of screw impulsion, at least one stationary vane located in the chamber and extending substantially longitudinally relative to a direct line from the said nearest end of the separator screw to the second outlet from the housing, a feed-out screw housing receiving the material flowing from the first outlet, a feed-out screw in the feed-out screw housing and means for automatically and continuously turning the feed-out screw at a speed which will maintain a hold back pressure between the separator screw housing and the separator screw.

14. A device of claim 13, in which the separator screw is mounted on a shaft which extends at least somewhat into the chamber, and the stationary vane mentioned extends from the chamber wall to close proximity to the shaft.

15. A device of claim 13, in which there are two such stationary vanes, which are located respectively on opposite sides of the shaft relative to one another.

16. A device of claim 13, in which the separator screw has a conical portion, with the smaller end of that conical portion further away from the vane than the larger end of that conical portion, and between the chamber and the large end of the conical portion is a cylindrical portion of the separator screw having the same diameter as that large end, and the inlet is at some point along the cylindrical portion.

17. A device for separating materials comprising:

a. a separator screw having an intermediate portion shaped as the frustum of a cone, a relatively large-diameter cylindrical portion at the large end of that intermediate portion, a relatively small-diameter cylindrical portion at the small end of that intermediate portion, and a shaft portion without screw beyond the end of the relatively large-diameter cylindrical portion from the intermediate portion, the pitch of the screw being smallest where the intermediate portion is smallest in diameter and being larger in the relatively small-diameter cylindrical portion and also increasingly larger in the other direction from its minimum point up to a point in the relatively large-diameter cylindrical portion;

b. a separator housing surrounding the separator screw and having a relatively small-diameter cylindrical portion around the relatively small-diametered cylindrical screw, an intermediate portion shaped as a frustum of a cone around the intermediate screw portion, and a relatively large-diameter cylindrical portion around both the relatively large-diameter screw portion and the shaft portion beyond, extending to a distance beyond the relatively large-diameter screw portion which is approximately equal in length to that of the relatively large-diameter screw portion, and the housing including in it passages for heat transfer fluid connected to a source for such fluid and having two opposite longitudinal removable vanes extending inward from the portion around the shaft portion to just short of the shaft, so that a chamber is formed around the shaft which chamber is divided into two by these vanes, and there being an inlet for material to be separated which inlet is located at an intermediate point in the relatively large-diameter cylindrical portion, a first outlet for the component of the material which is more subject to screw impulsion which outlet is beyond the end of the screw at the small-diameter cylindrical por-

tion end, and a second outlet for the component of the material which is less subject to screw impulsion which outlet is at the far end of the chamber from the inlet;

c. a cylindrical pump-out screw which is longer and has a smaller helix angle than the small-diameter portion of the separator screw and is run at a slower rotational speed than the separator screw;

d. a cylindrical pump-out housing surrounding the pump-out screw, having passages to receive heat transfer fluid from a source for such fluid, and having an inlet at its rear end connected to receive material from the first outlet of the separator screw and having an outlet at its forward end; and,

e. a control system including pressure sensors at two different points, longitudinally speaking, in the interior surface of the intermediate portion of the separator housing, and a proportional controller actuated by the pressures thus secured controlling the particular speed of the pump-out screw.

18. A method of separating materials, comprising introducing the material to be separated into a housing surrounding a partly tapering separator screw at an intermediate point relative to the separator screw, operating the separator screw to tend to drive one of the materials in the direction of the small end of the taper and through an outlet from the housing beyond that small end to make the other of the materials proceed in the opposite direction and through an outlet toward that opposite end, pumping the material from the outlet beyond the small end by means of a pumping screw located beyond the outlet, advancing the pumping screw so slowly as to maintain hold-back pressure around the separator screw, sensing the hold-back pressure in the partly tapering screw and controlling the speed of operation of the pumping screw on the basis of the pressure sensed.

19. Apparatus for separating material into parts, comprising an upright separator screw whose direction of impulsion is in the downward direction, a housing surrounding that screw, the interior of the housing including a chamber beyond the end of the separator screw in the direction opposite to that of separator screw impulsion, an inlet in the housing at an intermediate point therein, a first outlet from the housing for a separated portion of the material which has been admitted, which first outlet is at a point in the direction of separator screw impulsion from the inlet, a second outlet from the housing for a separated portion of the material which has been admitted to the housing, the second outlet being from the chamber and located at a point in the chamber which is at least substantially beyond the end of the separator screw nearest to the chamber, and at least one stationary planar vane located in the chamber and extending substantially straight back in the longitudinal direction relative to the axis of the separator screw.

20. Apparatus of claim **19**, in which the separator screw is mounted on a shaft extending into and through the chamber and the previously mentioned second outlet from the housing is at the end of the chamber away from the screw, and the previously mentioned stationary planar vane extends in continuous, unbroken and impervious fashion both all the way from the chamber wall to close proximity to the shaft in a direction radially to the longitudinal axis of the shaft and likewise all the way from near the end of the screw to near that second outlet in the longitudinal direction relative to that axis, and there is an opposite counterpart stationary planar vane located at the directly opposite side of the shaft from the first mentioned stationary planar vane and having the same characteristics as already given for the first mentioned stationary planar vane, the two planar vanes together with the shaft having the substantial effect of dividing the chamber into two compartments in which intermediate flow of material toward the end of the chamber away from the screw becomes substantially straight longitudinally back toward that end of the chamber.

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