Oct. 25, 1966 E. BECK ET AL 3,280,425

APPARATUS FOR PLASTIFYING AND EXTRUDING THERMOPLASTIC MATERIAL

Filed April 15, 1964

Fig. 1

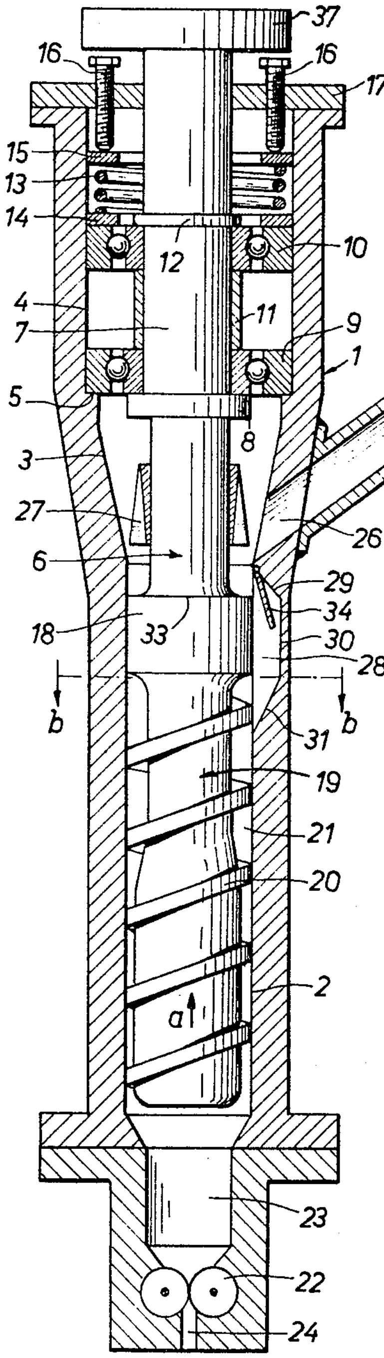


Fig. 3

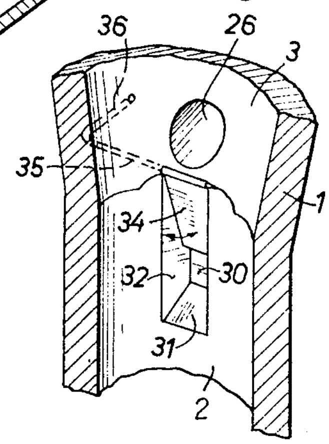
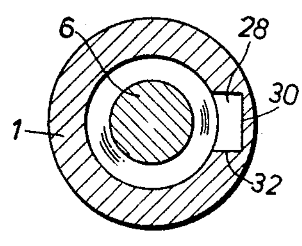


Fig. 2



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APPARATUS FOR PLASTIFYING AND EXTRUDING THERMOPLASTIC MATERIAL

Erich Beck, 20 Hochfeldstrasse, Goggingen, near Augsburg, Germany, and Walter Bösch, 49 Lavaterstrasse, Zurich, Switzerland

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This invention relates to an apparatus for plastifying and extruding thermoplastic material such as a synthetic resin, and more particularly to apparatus of this kind comprising a spinning pump or metering pump for the plastified material which is to be extruded, e.g. through a spinning nozzle, and a worm-type press for plastifying the thermoplastic material, which has been supplied in comminuted form, e.g. as a powder or as a granulate, and feeding it to the said spinning pump. The latter preferably is a volumetric displacement pump, e.g. a gearwheel pump. Still more particularly, the invention relates to means for regulating the supply of thermoplastic material into the said worm-type press, in order to adapt the output thereof to the output of the spinning pump.

Worm-type presses are known in which the worm spindle is conical and is adapted to be forced back against the pressure exerted on it by a spring, in order to regulate the output of the press. With such an arrangement, the worm spindle will be forced back axially in the bore of the housing of the press whenever the spinning pump is overfed, and due to the increased difference between its own diameter and the diameter of the housing bore, it will feed less material to the spinning pump. On the other hand, if this pump is underfed, the worm press will deliver more material to it.

Another mode of regulating the supply of the plastified material to the spinning pump consists in providing a slipping clutch in the drive of the worm press, the slip of which clutch will be greater or smaller depending on the quantity of plastified material absorbed by the spinning pump.

With either of the aforesaid devices, the pressure of the plastified material between the worm press and the spinning pump is to be maintained substantially constant and the plastified material required by the spinning pump at its actual running speed is to be supplied in controlled quantity by the worm press.

It is well-known that in worm presses, a substantial part of the energy required for plastifying the thermoplastic material can be supplied through the worm spindle drive shaft in the form of mechanical energy. With regulating devices of the above kind, the regulation of the quantity of plastified material therefore results in variations of its viscosity, which variations make it impossible to maintain a constant pressure in the material ahead of the spinning pump.

It is an object of the present invention to provide regulating means by which the supply of plastified material and the adjustment of the pressure intermediate the worm press and the spinning pump may be regulated independently of the viscosity of the plastified mass.

Another object of the invention is to permit the use of a high-speed worm press with substantially adiabatic operation, in which the whole of the plastifying energy required is supplied in mechanical form through the driving shaft of the worm spindle.

These and other objects are achieved according to the present invention by providing at the entrance of the worm press a piston-like diametral enlargement of the worm spindle, and by further providing in the wall of the housing of the worm pump a recess having inclined bottom portions at its entrance and at its issue, which latter are more or less obturated by the said piston-like enlargement of the worm spindle depending on the axial position thereof.

By such an arrangement, it is possible to obtain a volumertic regulation of the supply of the plastified material in which the pressure thereof intermediate the worm press and the spinning pump can be adjusted substantially independent of the volume of material advanced along the worm spindle.

Adjustment of the pressure can be effected in well-known manner by modifying the pressure of a spring by which the worm spindle is biased towards its delivery end and which may be mounted between a shoulder on the worm spindle and the end wall of its housing, or by pneumatic or hydraulic devices.

Since tests have revealed that the quantity of material passing through the said recess depends on the size and distribution of the granules of which it consists on entering the worm press, it is desirable to make the available cross-sectional area of this recess variable in such manner that the relation between any given axial displacement of the spindle and the corresponding change in the said available cross-section of the recess can be modified as desired. This may be achieved by providing in the recess a flap which constitutes a portion of the bottom of the recess and permits the inclination of said bottom portion to be varied.

It has further been observed that various materials contain a proportion of granules of excessive size which by and by become accumulated ahead of the said recess. To prevent this, in a preferred embodiment of the invention stirring means are provided on the worm spindle at the rear of its piston-like enlargement. These stirring means may be arranged in such position with respect to the port through which the material is supplied, that whenever the worm spindle is displaced to the rear and its piston-like enlargement at least partly obturates the entrance to the said recess, the stirring means become displaced out of the path of the material flowing from the said port to the said recess, so that their effect on that material is reduced or ceases altogether, while as the pressure in front of the worm spindle decreases and the latter moves forward again, thereby increasing the open cross-section of the said recess entrance, the stirring means become displaced into the said path of the material and aid the passage also of the larger granules in the latter into said recess.

According to still another improvement provided by the present invention, the apparatus may comprise damping means responsive to the axial displacement of the worm spindle. According to one embodiment, such damping means may act on the supply of the material, or according to another such embodiment, they may serve for damping the axial movement of the worm spindle itself. This spindle may have, for example, an annular groove controlling a hydraulic damping device.

In the accompanying drawing, a preferred embodiment of the invention is depicted by way of example.

In this drawing:

FIG. 1 is a longitudinal section through an apparatus according to the invention.

FIG. 2 is a cross-section according to line *b*—*b* of FIG. 1, and

FIG. 3 is a perspective view of a portion of the housing wall in the apparatus according to FIG. 1.

The apparatus represented in FIGS. 1 to 3 comprises a housing **1** which has a longitudinal bore composed of various sections, namely, a substantially cylindrical forward section **2**, a conical section **3** the diameter of which increases towards the rear, and a further cylindrical rear section 4 which is bounded at its forward end by an annular abutment shoulder **5**.

A worm spindle **6** which also comprises a number of integral sections is mounted in the housing **1** so as to be both rotatable and axially slidable. At its rear, the spindle **6** has a driving flange **37** and a cylindric stem **7** terminated at its front end by a collar **8** against which the inner race of a ball bearing **9** centered on the stem **7** is maintained. Another ball bearing **10** is also mounted on the stem **7**, the inner races of the two ball bearings being axially spaced by a sleeve **11** and retained by a circlip **12** engaging an axially coextensive circumferential groove in the surface of the stem **7**. The outer races of both ball bearings **9** and **10** make a sliding fit in the cylindrical rear section **4** of the housing bore, thus permitting the worm spindle **6** to slide axially in the housing **1**. Preferably, each of the outer races of the ball bearings **9** and **10** carries a radial pin (not shown) engaging a longitudinal groove in the housing wall to prevent rotation of these outer races. The assembly comprising the worm spindle **6** and the two ball bearings is acted upon by a coaxial compression spring **13** interposed between a washer ring **14** resting on the outer race of the ball bearing **10** and another similar washer ring **15** which is adjustably positioned in the housing **1** by means of screws **16** (preferably three, placed at 120° from each other about the axis of housing **1**, although only two of them are shown in the same diametral plane) screwed into a cover **17** secured to the housing **1** by means not shown.

In front of, i.e. below, the collar **8**, the worm spindle **6** extends forwardly through the conical section 3 of the housing bore and in front thereof it has a piston-like cylindrical enlargement or collar **18** which makes a sliding fit in the forward cylindrical section **2** of the housing bore both in the lowermost position of the worm spindle **6**, with the outer race of ball bearing **9** abutting the annular shoulder **5** in the housing, and in the uppermost position of the spindle **6**, when the spring **13** is fully compressed.

The foremost section **19** of the worm spindle **6** is formed by the worm proper and has a helical rib **20** which makes a substantially sealing but movable fit in the cylindrical section **2** of the housing bore, and with the wall of the latter defines a helical duct **21** which is open at the front end of the spindle but closed at the rear by the piston-like enlargement.

At the front end of the housing **1** is mounted a spinning pump of a conventional positive-displacement type, here schematically shown as a gearwheel pump **22**, the inlet chamber **23** of which is in open communication with the lower end of the housing bore section **2** and which is adapted to deliver the displaced material through an outlet port **24** to which an extruding nozzle (not shown) may be fitted.

The material which is to pass the described apparatus is supplied thereto from a hopper **25** through a supply port **26** in the wall of the housing, which port issues into the lower part of the conical section **3** of the housing bore. Within this conical section **3** and at a level which in the represented foremost position of the worm spindle **6** corresponds to the issue of the supply port **26**, a set of stirring vanes **27** is mounted on the worm spindle **6** and it will be seen that when the latter is in its uppermost position, the stirring vanes **27** will be substantially out of the way of the material entering the housing bore through the supply port **26**.

In the rearmost portion of the cylindrical forward section **2** of the housing bore is provided a recess **28** bounded by a sloping entrance wall **29**, an axially extending bottom wall **30** and a sloping outlet wall **31** as well as parallel side walls **32**. This recess is at such a level in the said portion of the housing bore that its entrance cross-section defined by the rear or upper edge **33** of the enlargement **18**, the entrance wall **29** and the side walls **32** varies substantially between a maximum when the worm spindle **6** is in its foremost position as shown in the drawing, and an amount approaching zero when the worm spindle is in its rearmost position, the said upper edge **33** then nearly coinciding with the upper edge of the entrance wall **29**.

However, in the preferred embodiment described here, it is not the entrance wall **29** itself which in effect cooperates with the edge **33** to define the said entrance cross-section of the recess **28** but an adjustable flap **34** mounted on a thin shaft **35** which is swingably supported in the housing at the very upper edge of the recess **28**. As shown in dotted lines in FIG. 3, this shaft **35** extends to the outside of the housing and is bent to provide an arm **36** for adjusting the position of flap **34** as required. At its forward or lower end, the recess **28** issues into the helical duct **21** along the worm spindle **6** regardless of the axial position thereof within its above-defined range of displacement.

In operation, the worm spindle is rotated from an appropriate source of mechanical power (not shown) by means of its coupling flange **37** at a speed adapted and proportional to that of the spinning pump **22**, which preferably is driven from the same source of power. The material to be extruded such as a synthetic resin in granulated form, is supplied through the hopper **25** and the supply port **26** into the conical section **3** of the housing bore, above the piston-like enlargement **18** of the worm spindle **6**. There, it being assumed that this spindle is in its lowermost position as shown in the drawing, the granulated material is stirred by the vanes **27** on the rotating spindle. It then flows downwards through the recess **28** in a continuous stream, in a quantity depending on the cross-section available between the upper edge **33** of the enlargement **18** and the flap **34**, and reaches the beginning of the helical duct **21** along the worm section **19** of spindle **6**. Due to the rotation of the latter, it is propelled forwardly through the said duct, which becomes gradually narrower towards its forward end. At the same time, the material is subjected to friction due to the relative movement of the spindle and the stationary housing, whereby energy supplied in mechanical form for rotation of the spindle is converted into heat and the material becomes heated and plastified. It leaves the helical duct **21** and enters the inlet **23** of the spinning pump **22** in plastic condition, whereupon it is metered out by this pump **22** through the delivery duct **24** and the extruding nozzle (not shown).

Normally, the quantity of material delivered to the worm press through the recess **28** while the worm spindle is in its lowermost position as shown in the drawing, with the flap **34** in a position corresponding to the respective quality of material, is larger than that which will be absorbed by the spinning pump **22**. Accordingly, the pressure at the inlet **23** increases and the worm spindle **6** is pushed back in the direction indicated by arrow *a* against the pressure of the spring **13** until the increased pressure exerted by this spring balances the increased pressure below the worm spindle **6**. Thereby, the edge **33** bounding the enlargement **18** of the spindle restricts the flow of material through the recess **28** and the helical worm duct **21** and thereby stops the increase of the pressure below the worm spindle and at the inlet **23** of the spinning pump **22**. Accordingly, this pressure is maintained substantially constant and the flow of material past the worm spindle is adapted to the demand of the spinning pump **22**.

While the worm spindle **6** is forced back by the pressure prevailing in front of it the stirring vanes **27** move away from the entrance of the recess **28** and out of the main flow of material from the supply port **26** to that recess. Accordingly, they will no longer urge larger granules of material into the recess **28** and to the worm press, since these larger granules may be unable to pass the restricted entrance to the recess **28** and the flow of material towards the spinning pump required in these conditions can be maintained without using such larger granules. Should the entrance to the recess become obstructed, then the pressure in front of the worm spindle **6** will readily drop and the latter be moved forward again, so that stirring vanes **27** will approach the said entrance and disperse the obstructing particles.

It may be desirable in certain cases to provide means for damping the axial movements of the worm spindle or the variations in the flow of the material, resulting from these movements of the spindle. The damping means can comprise, for example, the compression spring **13** and screws **16**, for adjusting the tension of the spring. Alternatively, there can be provided an operative connection associated with, or including, a damping device between the driving flange **37** and the flap **34**, whereby such flap would be adjusted under the influence of both the axial position of the worm spindle **6** and the said damping device. Alternatively, a hydraulic or other damping device could be associated directly with the spindle **6**, e.g. by means of a pin engaging an annular groove of the spindle, for damping the axial movement thereof.

We claim:

1. In an apparatus for plastifying and extruding thermoplastic material, the combination: a housing having a longitudinal bore comprising a cylindric portion, a positive displacement pump connected to said housing and having an inlet communicating with one end of said housing bore, a kneading spindle mounted for rotation in said housing bore and axially displaceable therein between a foremost and a rearmost position, said spindle having a forward portion fitting said cylindric portion of said housing bore and having at least one helical rib formed in its surface, defining in said cylindric portion of the housing bore at least one helical duct communicating at its forward end with said inlet of the positive displacement pump, said kneading spindle further having a piston-like enlargement in advance of said helical rib and in sliding fit with said housing bore, a supply port formed in said housing issuing into its said bore at least

partly to the rear of the zone occupied by said piston-like enlargement of the spindle in the said rearmost position thereof, throttle means located between said helical rib of the spindle and said supply port responsive to the action of the pressure of the thermoplastic material below the worm spindle and at the inlet of the positive displacement pump, said throttle means including a groove-shaped recess in said bore extending in the longitudinal direction of the bore and only part ways around the circumference thereof, said groove having a length in the longitudinal direction of the bore greater than that of said piston-like enlargement and covering a zone occupied by said enlargement in at least part of the range of positions thereof comprised between the said foremost and rearmost positions thereof.

2. The combination as claimed in claim **1**, comprising adjustable flow restricting means mounted in said recess.

3. The combination as claimed in claim **1**, comprising stirring means for mixing and forcing the plastic material into said recess, said stirring means mounted on said spindle for rotation therewith and being located in advance of said recess and at least in part in a zone coextensive with at least part of said supply port whenever the spindle occupies its said foremost position.

4. The combination as claimed in claim **1**, including resilient means biasing said spindle towards its foremost position.

5. The combination as claimed in claim **4**, wherein said resilient means dampens the axial movement of said spindle.

6. The combination of claim **4**, including means for adjusting the biasing force of said resilient means.

7. The combination of claim **6**, wherein said resilient means dampens the axial movement of said spindle.

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WILLIAM J. STEPHENSON, *Primary Examiner.*