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(54) FEED SCREW ASSEMBLY FOR A PLASTICIZING MACHINE FOR PLASTICIZABLE MASSES, PARTICULARLY PLASTICS OR RUBBER

(71) We, NETSTAL-MASCHINEN AG, a Swiss Body Corporate, of CH-8752 Nafels, Switzerland, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates in general to the construction of plasticizing devices and, in particular, to a new and useful feed screw assembly of a molding machine for plasticizable masses, particularly for plastics or rubber, which includes a passage portion of the screw which has a bore therethrough defining a mixing passage with mixing elements therein for effecting the intermixing of the material as it passes therethrough, and which is included as a portion of the assembly in such a manner that a communicating passage from the periphery of the upstream screw portion feeds the material into the mixing passages, and a downstream outflow permits the discharge of the material from the mixing passage after it is mixed.

Frequently, the masses treated in plasticizing machines are only plasticized during their advance through the screw, or they are provided with coloring matter or other additives just prior to being supplied to the screw. In most cases, the feeding action of the screw is insufficient to effect a satisfactory mixing or homogenization of the mass, for example, as to the temperature distribution, degree of melting, and substance dispersion. It is known, for example, in injection machines for plastics, to effect the melting of the plastic to be molded in a plasticating unit which substantially comprises a cylinder and a screw received therein. During the so-called metering phase, the screw feeds the mass by rotation into the cylinder volume located in front thereof, namely, the so-called anteroom, of the screw. Simultaneously, the screw is displaced to the rear by the material fed so that the anteroom continuously increases in volume in accordance with the volume of the material fed therein. The heat necessary for melting the mass is produced by heating the cylinder and also by the friction in the mass itself. As soon as the volume of the mass, necessary for the molded part, is plasticized, the so-termed injection phase is started. In this phase, the screw moves axially forwardly and pushes the plastic mass from the anteroom or front portion into the cavity of the mold. A return flow of the mass is usually prevented by a so-called non-return lock. It is also possible, however, to effect the injection without a non-return lock. As is well known, while using a conventional plasticating unit of the above described type, a satisfactory mixing cannot be obtained. The result is a non-homogeneous distribution of the temperature and of the colorant and additives. Thus, with a conventional plasticizing unit, for example, it is not possible to produce high quality molded parts with a perfect color distribution by supplying a liquid coloring matter to a granulated plastic of natural color. Even with a dry or master-batch coloring, defects in the coloring quality are obtained which, with thin-walled molded parts, make the addition of coloring matter in plasticating unit impossible.

To improve the mixing effect, shearing and mixing devices have been provided which are mounted on the periphery of the screw. Such devices have a particular disadvantage in the occurrence of frictional heat which may result in a damaging of the thermally sensitive masses. A further disadvantage is the complicated shape and increased overall length of the screw. Experience has also shown that the cleaning of such mixing devices, for color

change, leaves large amounts of waste plastic and even requires dismounting of the screw. In addition, applications have been found requiring an even better homogenization of the plastic mass than can be obtained with shearing elements mounted on the outside. This applies particularly to the coloring of thin-walled molded parts and the coloring with liquid coloring matters.

A further attempt to obtain a better mixing is a mixer head, such as described, for example, in U.S. Patent No. 3,785,620. The mixer head comprises so-called "static mixing elements", which expression, when used herein and in the claims, means mixing elements which remain stationary relative to one another and to the wall of the passage through which the mass to be mixed flows, the elements dividing the mass flowing therethrough into layers which become displaced relative to one another by the shape of the mixing elements in a manner such that a mixing effect is obtained. The known mixer heads are secured to the injection end of the heating cylinder so that, during the injection operation, the plasticized mass flows first through the static mixing elements and then into the mold cavity. In such arrangements, the mixed head must mix a large volume in a short time. As a result, such mixing devices require large cross-sections in order to minimize the additional pressure drop in the mixing elements which unfavourably affect the injection performance of the machine. The disadvantage thereof is that the overall length is also increased because the ratio of length to diameter is determining for the mixing effect of the static mixing elements. The large mixing volume extends the period of dwell of the plastic in the zone of high temperature which leads to damage of the thermally sensitive masses.

Another disadvantage of the known mixer heads is that they must be equipped with a heating and a corresponding control device. Hitherto also, it has not been possible to use controlled closing nozzles in connection with the known mixing devices, which closing nozzles have to prevent the escape of mass from the plasticating unit during the metering phase.

Of course, similar problems also arise with injection-molding machines designed with a screw plastification and ram injection, where the screw plasticizes the mass and feeds it into an injection cylinder. At the end of the metering phase, an injecting ram pushes the mass from the injection cylinder into the mold cavity.

Analogous considerations apply to screw extruders, to so-called melt extruders in which the mass is fed to the screw in an already molten state, and to plasticating extruders in which, as in the injection-molding machines, the mass is not plasticized sooner than in the screw cylinder.

The present invention has for its object to improve the homogenisation of a plasticized mass by incorporating static mixing elements in a feed screw assembly.

From one aspect the invention consists in a feed screw assembly of a molding machine for plasticizable masses, particularly, for plastics and rubber, said assembly comprising a screw portion and a passage portion having a mixing passage therethrough with static mixing elements fixed within said mixing passage for intermixing a plasticizable material passing through said passage.

From another aspect the invention consists in a plasticating machine comprising a cylinder, a feed screw assembly rotatably supported with said cylinder, a passage portion of said feed screw assembly located adjacent the forward end thereof having an outer periphery spaced from the interior wall of said cylinder and having a bore extending therethrough defining a mixing passage for the material being fed, static mixing elements in said mixing passage for causing the diversion and intermixing of the material passing therethrough, said feed screw assembly being constructed with a screw portion having a continuous screw thread to advance material in said cylinder through the space between said screw thread and the interior wall of said cylinder towards the outer periphery of the passage portion during rotation of said feed screw assembly and to move the material through said mixing passage, a communicating passage or passages located upstream of the outer periphery of the passage portion and connecting the periphery of the screw portion to said mixing passage for the inflow thereinto, and upstream of the mixing elements therein, of the material advanced by the screw thread, the space between the outer periphery of the passage portion and the interior wall of the cylinder being such that material advanced by the screw thread upstream thereof will be diverted into said communicating passage or passages to flow through said mixing passage while permitting some of the material to flow through said space, and an outflow passage or passages from said mixing passage, downstream of the mixing elements therein, for the outflow of material from the mixing passage to the interior of the cylinder downstream of the feed screw assembly.

The passage portion may form a part of the screw itself, or it may be a part inserted into the screw or attached to the front end thereof.

With the contruction according to the invention, the passage in which the mixing elements are disposed is not limited by the cylinder wall and the material flowing

through the mixing passage is mixed only by splitting it up into partial streams and reuniting the streams into a single stream, and not by a stirring or shearing effect between the cylinder wall and the mixing elements. The rotary motion of the passage portion with the screw portion facilitates the splitting of the material into partial streams insofar as, for example, laminar non-hemogeneities becomes subdivided at the entrance of the passage portion. A heat transfer from the material to non-heated cylinder portions is impossible so that an additional heating provided, for example, in the known, firmly mounted, mixer heads and having to compensate such heat transfer, are also unnecessary. On the other hand, a local overheating of the material through friction on fixed parts is also made impossible. Since, in an injection-molding machine, during the metering phase, the material flows through the mixing elements, always relatively low throughout rates are obtained, as compared to the known firmly mounted mixer heads and, consequently, relative long periods of dwell of the material in the mxing elements are available for the mixing and homogenzing process. This makes large mixing cross-sections and overall lengths of the mixing device unnecessary.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings in which there are illustrated preferred embodiments of the invention and in which:—

Fig. 1 is a partial axial sectional view of a feed screw assembly having an intermediate passage portion constructed in accordance with the invention; and

Figs. 2, 3 and 4 are views, similar to Fig. 1, of other embodiments of the invention.

Referring to the drawings, the embodiment of Fig. 1 comprises a plasticizer, generally designated 50, which includes a cylinder 1, having a bore therethrough 1*a* for the feeding of plasticizable masses, and it may be, for example, an injection-molding machine or an extruder. A feed screw assembly is rotatable in bore 1*a* and has screw portions 2 for feeding the plasticizable mass in the direction of arrow *a*.

In accordance with the invention, feed screw assembly 2 includes screw portions 2 and a passage part of portion 4, which may be made separately from or integrally with the screw portions 2 and which is arranged coaxially of, and firmly connected to the screw portions, if made separately. A plurality of such passage parts or portions may be provided if necessary or desirable. In some instances, it is advantageous to have a plurality of passage parts 4 arranged at spaced axial locations along the screw assembly.

The passage part 4 has an outer periphery which is spaced inwardly from the interior wall of cylinder 1 with only a small clearance 6 therebetween. In the embodiment shown, the passage part includes an annular helical groove 7. The small learance 6 is dimensioned for seaing the passage part 4 against the cylinder wall to an extent such that only an amount of mass can pass through this clearance as is necessary for a continuous cleaning or scavenging of the clearance 6 in order to permit free rotation of passage part 4 and screw portions 2. Groove 7 facilitates this cleaning process but, in some cases, is omitted.

Passage part 4 has a bore 40 which defines a mixing passage and which extends completely through the part and has fixed therein a plurality of static mixing elements 4*a*, which are not shown in detail, but which provide means for deflecting and diverting the material into a plurality of streams which are intermixed during their movement through the bore 40.

A communicating upstream passage or passes 3, extend(s) from the periphery of the upstream screw portion 2 inwardly to the bore 40 for the inflow of the material and a downstream discharge passage or passages 5 permit(s) the outflow of the material from the bore 40 to the space around screw portion 2 at the forward end.

When the screw assembly rotates, the mass, which is plasticized and which is provided with colouring matter or other additives, is advanced by the upstream screw portion 2 and diverted through passage 3 into the bore 40 where the mass stream is split by the static mixing elements 4*a* into a plurality of layers which become mutually displaced due to the shape of the mixing elements and are reunited again. This results in a very satisfactory mixing and homogenization of the mass. The mass flows out through passage 5 and is further advanced by the front screw portion 2, either into a metering space for subsequent injection into a mold, or into a space for the direct shaping by an extrusion die.

In the embodiment shown in Fig. 2, a plasticizing device, generally designated 50′, includes a cylinder 1′ having a screw 2′ rotatably positioned therein. In this construction, a passage part 4′ is located at the front end of screw 2′ and has a small clearance 6′ (dimensioned as explained above) with the interior of the cylinder 1′. A bore 40′ is provided with a plurality of static mixing elements 4*a*′ which provide an intermixing of the material which is passed through an upstream communicating passage or passages 3′ into bore 40′ and exits through an open outlet portion 52, at the front end of the screw. The material flows directly through the flared outlet portion 52 into the inner space of cylinder 1′ downstream of the screw

2′.

In the embodiment of Fig. 3, a plasticizer, generally designated 50″, includes a cylinder 1″ having a screw 2″ rotatable and axially displaceably movable therein. Plasticize 50″ is an injection molding machine and, in this embodiment, a mixing part 4″ is made up of a plurality of elements, including an inner cylindrical part 8*a* of a supporting member 8 which is screwed into a threaded receiving socket 20 at the front end of the screw 2″. Part 8*a* has an interior bore 80 having static mixing elements 4*a*″ therein similar to the other embodiments. In addition, a cap 9 is threaded on to the end of the cylindrical part 8*a*, and a nonreturn lock member 10 comprising an axially slidable annular part or sleeve 10 is supported with a clearance 11 around the cylindrical part 8*a*. The cap 9 is provided with an outflow passage or passages 5″ for the material which has been mixed, and an inflow passage or passages 3″ formed both in the cylindrical part 8*a* and also by the space between supporting member 8 and the non-return lock member or sleeve 10. The mass is directed by the mixing elements 4*a*″ so as to avoid dead spaces and thereby prevent deterioration of the mass through thermal influence.

The non-return lock member has a clearance 6″ with the interior wall of the cylinder 1″. A seal is obtained at surfaces 12 and 13 which abut against each other during the initial feeding operation. Fig. 3 shows the non-return lock 10 in an open position in which it bears against cap 9. During the injection, the non-return lock is displaced rearwardly so that sealing is effected between the surfaces 14 and 15 which abut against each other to prevent a reverse flow of the mass.

In the embodiment shown in Fig. 4, a plasticizing machine 50‴ comprises a cylinder 1‴ having a screw 2‴ therein. Here again, the mixing device is combined with a non-return lock. The mass flows through radial openings 3‴ into the interior of a support member 16. Separate annular sleeve members 17, 18 are arranged so as to define an interior bore 40‴ defining a mixing passage having static mixing elements 4*a*‴ therein retained by an end member 19. During the metering phase, the mass flows through the mixing elements 4*a*‴ and pushes the annular sleeve members 17, 18 and end member 19 against the cap 21. Then the mass is discharged from the mixing device through the openings 22 and 5‴. The mass is directed so as to avoid dead spaces and thermal damaging of the mass in its passage. The sleeve members 17, 18 operate as a non-return lock. They are shown in their open position during the metering phase. During the injection, sleeve members 17, 18, along with the mixing elements 4a‴, become displaced rearwardly (permitted by the clearance 20) so that the sealing surfaces 23 and 24 apply against each other. Thereby, a back flow of the mass is prevented. The non-return lock is opened again by the metering pressure force acting on an annular surface 25.

WHAT WE CLAIM IS:—

1. A feed screw assembly of a molding machine for plasticizable masses, particularly, for plastics and rubber, said assembly comprising a screw portion and a passage portion having a mixing passage therethrough with static mixing elements fixed within said mixing passage for intermixing a plasticizable material passing through said passage.

2. A feed screw assembly according to claim 1, wherein said passage portion has an interior bore which is coaxial with the axis of the screw portion and in which the static mixing elements are fixed, and communication passages establishing communication between said mixing passage and the periphery of said screw portion.

3. A plasticizing machine comprising a cylinder, a feed screw assembly rotatably supported within said cylinder, a passage portion of said feed screw assembly located adjacent the forward end thereof having an outer periphery spaced from the interior wall of said cylinder and having a bore extending therethrough defining a mixing passage for the material being fed, static mixing elements in said mixing passage for causing the diversion and intermixing of the material passing therethrough, said feed screw assembly being constructed with a screw portion having a continuous screw thread to advance material in said cylinder through the space between said screw thread and the interior wall of said cylinder towards the outer periphery of the passage portion during rotation of said feed screw assembly and to move the material through said mixing passage, a communicating passage or passages located upstream of the outer periphery of the passage portion and connecting the periphery of the screw portion to said mixing passage for the inflow thereinto, and upstream of the mixing elements therein, of the material advanced by the screw thread, the space between the outer periphery of the passage portion and the interior wall of the cylinder being such that material advanced by the screw thread upstream thereof will be diverted into said communicating passage or passages to flow through said mixing passage while permitting some of the material to flow through said space, and an outflow passage or passages from said mixing passage, downstream of the mixing elements therein, for the outflow of material from the mixing passage to the interior of the cylinder down-

stream of the feed screw assembly.

4. A plasticizing machine according to claim 3, wherein said passage portion is separate from said screw portion and is non-rotatably connected to said screw portion.

5. A plasticizing machine according to claim 3 or 4, including a helical groove defining a cleaning groove on said outer periphery of said passage portion.

6. A plasticizing machine according to claim 3, 4 or 5, wherein said passage portion includes an axially slidable sleeve member having one end bounding said upstream communicating passage or passages, said sleeve being axially movable to open or close off said communicating passage or passages.

7. A plasticizing machine according to claim 3, 4 or 5, wherein said passage portion comprises a hollow supporting member having a front end with an opening extending inwardly into said hollow supporting member, a cap threaded on said hollow supporting member and closing the opening on the front end of said hollow supporting member, a sleeve member slidable on said hollow member, said upstream communicating passage or passages being bounded by an edge of said sleeve member, the opposite end of said sleeve member being capable of abutting against said cap, and said sleeve member being displaceable to close said upstream communicating passage or passages.

8. A plasticizing machine according to claim 3, 4 or 5, wherein said passage portion comprises a supporting member connected to said screw portion, and a plurality of interfitted sleeve members which are axially slidable and define an interior bore forming said mixing passage having said mixing means therein, having an outflow opening or openings at the front end thereof for the discharge of material from the mixing passage, and having an inflow passage bounded by an edge of at least one of said sleeve members which is displaceable to close said inflow passage.

9. A plasticizing machine according to claim 3, wherein said passage portion comprises a member connected to the front end of said screw portion, the front end of the mixing passage in said member being open to the interior of the cylinder upstream of the feed screw assembly.

10. A feed screw assembly constructed and adapted to operate substantially as hereinbefore described with reference to any one of the Figures of the accompanying drawings.

11. A plasticizing machine constructed and adapted to operate substantially as hereinbefore described with reference to any one of the Figures of the accompanying drawings.

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1564340 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

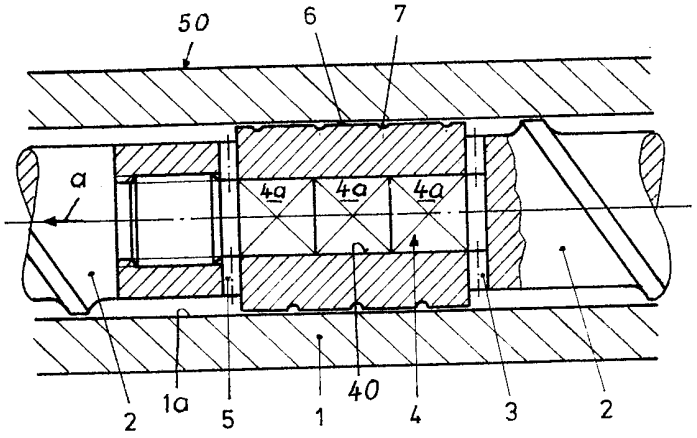

Fig. 1

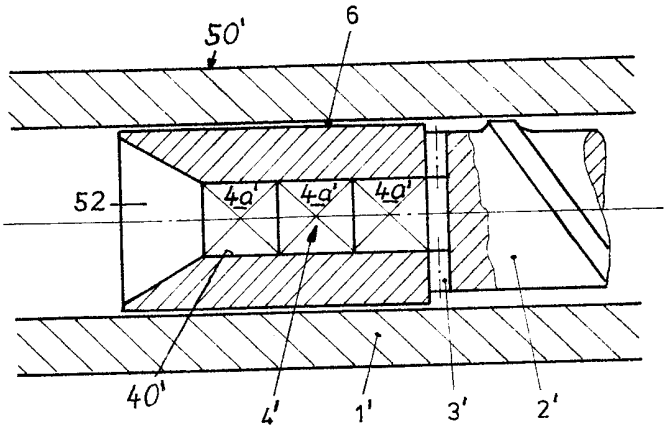

Fig. 2

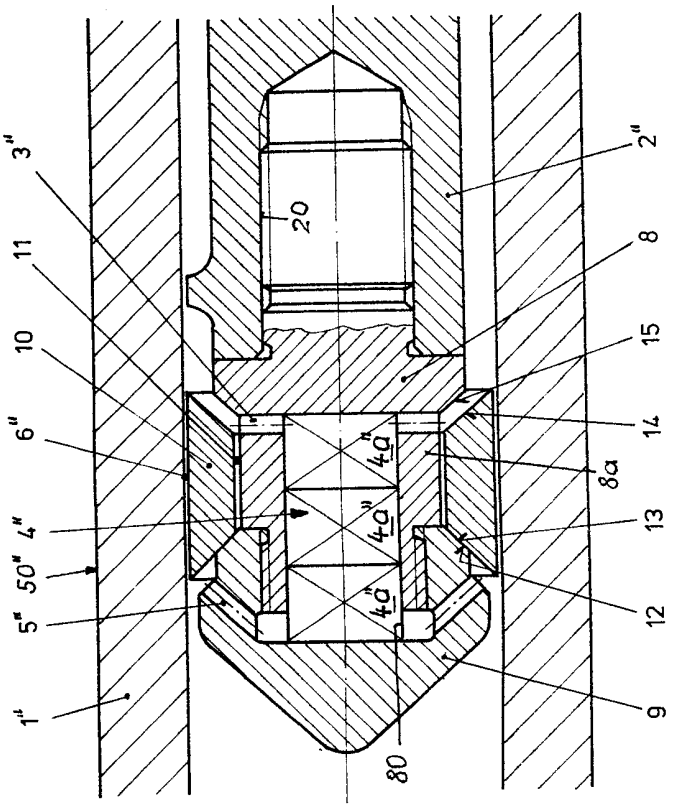

Fig. 3

1564340 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

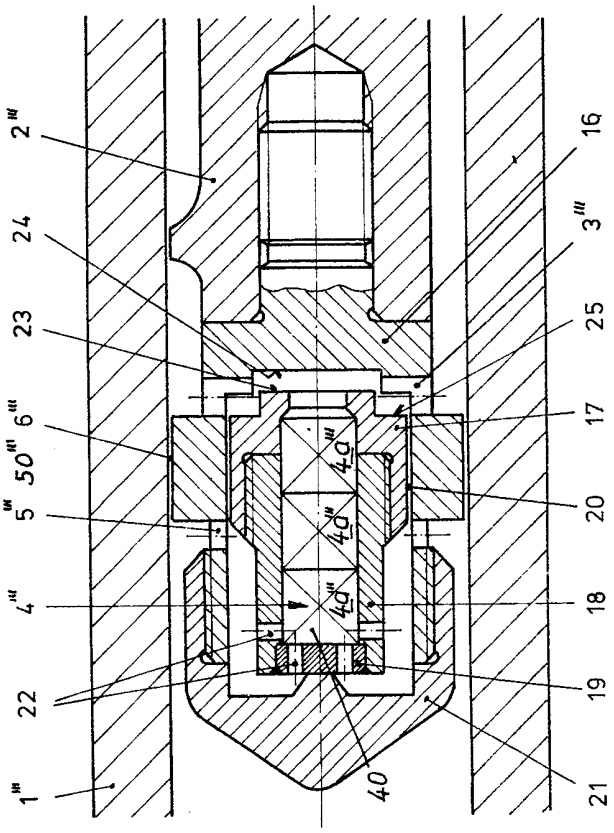

Fig. 4