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MELT SPINNING

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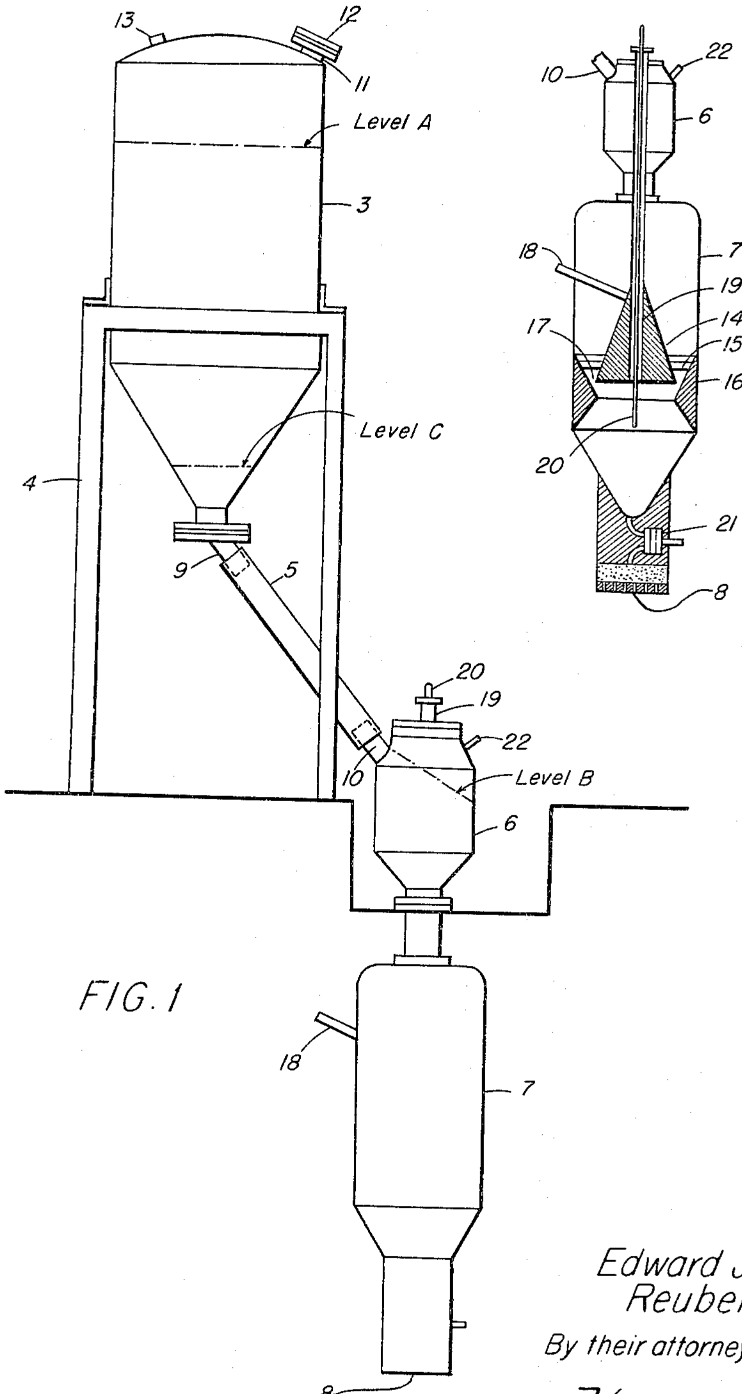

FIG. 1

FIG. 2

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MELT SPINNING

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This invention relates to an improved device for use in melt spinning high linear polymers such for example as the polyamides and polyesters.

The type of apparatus commonly used in melt spinning such polymers comprises a melting vessel communicating with a spinning head. The melting vessel comprises an opening at the top through which chips of the polymer to be spun can be fed, and a melting device onto which the chips fall and on which they pile up. The spinning head comprises a metering pump, filter and spinning jet.

The melting device may have various forms. Thus it may be a grid of spiral or other form, for instance as described in United States Patent No. 2,253,176, or it may comprise a heating element having a sloping surface onto which the chips are directed by means of a conical member as described in United States Patent 2,869,848 dated January 20, 1959. That part of the melting vessel below the melting device is commonly referred to as the sump or reservoir, and is adapted to contain a pool of the molten polymer. At its lowest point, the sump communicated with the spinning head.

One of the difficulties met with in melt spinning is that variations tend to occur in the products which, while they may in themselves be quite slight, nevertheless show up as irregularities in fabrics made from the filaments. This is especially liable to happen in the melt spinning of polycaprolactam, i.e. the polyamide derived from ϵ-aminocaproic acid and usually made by polymerising caprolactam. The reason for this is that when this polymer is kept at a temperature substantially above its melting point for any considerable time its content of monomeric or low polymeric compounds, such as ϵ-caproic acid, caprolactam and dimeric and trimeric derivatives of these compounds, tends to change. The difficulty is, however, also met with when spinning other polyamides, for example polyhexamethylene adipamide, and polyesters, for example polyethylene terephthalate.

One precautionary measure which is taken to promote uniformity in the product is to keep the level of the molten polymer in the sump, and therefore the average time between the melting of any particular part of the polymer and its extrusion, as constant as possible. Various methods of doing this have been used, one of which makes use of a sensing member or "probe" extending into the sump by means of which the supply of heat to the melting device can be controlled in accordance with the level of the melt in the sump. A form of probe which has been found to be very effective is described in published British patent specification 839,201 and comprises a hollow tube which opens below the normal operating level of the surface of the pool of melt in the sump, and through which a stream of nitrogen or another inert gas can be passed; means are then provided whereby the rate of supply of heat to the melting device is controlled by variations in the rate at which the gas escapes from the probe or the pressure needed to enable it to do so.

We have now found that the uniformity of filaments, yarns and other melt spun products can also be improved by keeping the height to which the chips pile up above the melting device approximately constant, and thus keeping substantially constant the pressure exerted on the chips which at any time are actually in contact with the melting device. This is not done when using present day melt

spinning devices in the ordinary way, since the practice is to feed the chips in batches and at intervals into the melting vessel or into a hopper leading to the melting vessel, so keeping communication between the outside air and the interior of the melting vessel to a minimum. In addition fluctuations in pressure produce variation in the molten polymer level at interfaces where chip touch the melting device. This causes a high level mark to be formed and then recession of the level causes a static film of polymer which deteriorates. During subsequent fluctuations of the polymer level, particles of the film become detached and join the main stream of polymer. Maintaining a constant height of polymer chips minimises this undesirable effect.

The invention therefore comprises a melt spinning apparatus of the kind in which chips or other particulate solid material to be spun is fed into a melting vessel and onto a melting device contained in the vessel, wherein the material is supported on the melting device as a pile of substantially constant height. This pile may be wholly within the melting vessel, but preferably it extends upwards and out of the melting vessel into a separate storage vessel opening into the top of the melting vessel.

The invention comprises a form of apparatus by the use of which the said process can be carried out simply and efficiently, and which also has other advantages. This apparatus comprises essentially a melting vessel, a spinning head adapted to be fed from the lower part of the melting vessel, a melting device in the melting vessel, a main storage vessel for the solid material to be spun, and an inclined tubular passage leading from the main storage vessel to conduct material from the main storage vessel to the space above the melting device, the said passage entering the said space laterally. Preferably the apparatus also includes an intermediate storage vessel above and communicating with the top of the melting vessel, into the side of which the inclined tube leads, though the tube may lead directly into the side of the melting vessel if desired. The apparatus may also incorporate a device which reduces the danger of air reaching the system. A suitable device for this purpose is a counterflow chip purge tube which eliminates the use of vacuum to remove air.

A form of apparatus in accordance with the invention which has been found to be particularly useful is illustrated in the accompanying drawing, in which—

FIGURE 1 is a side view of the apparatus as a whole, and

FIGURE 2 is a side view in section showing diagrammatically the internal arrangement of the melting chamber and the intermediate storage vessel.

Referring now to the drawing, the apparatus comprises a main storage vessel or hopper **3** carried on a support **4** at a level above the remainder of the apparatus and connected by means of an inclined tube **5** with an intermediate storage vessel or hopper **6**. This intermediate hopper, which may be much smaller than the main hopper **3**, feeds into the top of a melting vessel **7** which in turn feeds to a spinning head **8**. The tube **5** enters the intermediate hopper **6** near the top and at one side thereof, and may suitably comprise a piece of rubber or like tubing of the desired diameter, one end of which fits over an angled discharge pipe **9** extending from the bottom of the main hopper, and the other over a short feed pipe **10** extending at the desired angle from one side of the intermediate hopper **6**. The tubular passage formed by the tube **5** is at an angle of inclination from the horizontal greater than the angle of repose of the solid material flowing therethrough. The main hopper **3** is provided at its upper end with an opening **11**, provided with a removable airtight closure **12**, for the introduction of chips of the polymer to be spun, and also with a small gas outlet

13 through which blanketing gas can leave the apparatus.

The internal construction of the intermediate hopper 6 and the melting vessel 7 is shown in more detail in FIGURE 2. In the particular embodiment of the invention illustrated, the melting device is similar to that described in detail in the said Patent 2,869,848 and comprises a cone 14 supported axially in the melting vessel by legs 15, the bottom of the cone being narrowly spaced from an annular heating element 16 having an inwardly sloping surface, to form with it an annular slot 17. A pipe 18 through which gas can escape from the interior of the cone leads from its upper end and out of the vessel 7. A vertical tube 19 passes through the cone from top to bottom, opening into the space below the cone and extending above the cone through and out of the intermediate hopper 6. Through this tube 19 there passes a tubular probe 20 for the passage of a current of inert gas such as nitrogen as described in the said British specification 839,201. In its operating position the probe 20 may extend about one-third of the way into that part of the melting vessel 7 which is situated below the melting device and serves as a sump, and it may conveniently be made so that it can be completely withdrawn when desired. The probe 20 should of course make an airtight fit in the tube 19 along the whole or at some part of the length of the latter. The lower part of the melting vessel 7 connects with a spinning pump 21 in the usual way and this in turn feeds to conventional filters and spinning jet (not shown). An inlet 22 for inert gas is provided near the top of the intermediate hopper 6. A fuller description of the melting vessel, except for the precise arrangement of the probe, will be found in the said Patent 2,869,848.

In operation the heating element 16 is brought to the working temperature, and the air in the whole apparatus is replaced by nitrogen, streams of which are then passed continuously through the inlet 22 into the intermediate hopper and also through the probe 20. The polymer chips are then fed into the main hopper 3 through the opening 11, for instance until the hopper has become filled up to the level indicated by the reference A. By the time this operation is complete, the chips will have filled the space in the melting vessel 7 above the annular slot 17, and also the intermediate hopper 6, to the level indicated approximately by the dotted line B, the precise slope of which will depend on the angle of repose of the chips; they will of course also fill the tube 5. As the chips are melted further chips move down the tube 5 into the melting vessel, and the level B remains substantially unchanged. A valuable feature of the apparatus is that owing to the relatively small cross-sectional area of the tube 5, the ascending current of blanketing gas from the intermediate hopper 6 carries away any oxygen that may still be in contact with the chips with exceptional efficiency, so that the provision of an air lock to the chip feed opening 11, or the use of any other special precaution to exclude oxygen from the main hopper 3, is unnecessary, though naturally the closure 12 will be kept in position except when the hopper is actually being charged. Suitable dimensions for the tube 5 have been found to be for example a length of about 18 inches to 3 feet and a diameter between about 1½ and 2½ or 3 inches. Generally the narrower the tube in relation to its length, the less is the volume of blanketing gas which must be passed through it in a given period to secure efficient removal of all oxygen. As the pressure exerted on the chips which are actually in contact with the heating element 16 is kept substantially constant by the maintenance of the constant level B in the intermediate hopper, the level of the chips in the main hopper 3 may be allowed to fall quite low, for example to the level shown

at C, without causing any variation in the rate of melting. Thus the main hopper 3 need be recharged only at comparatively long intervals.

The apparatus as described can be modified in various ways. For example, if desired a valve may be inserted between the outlet from the main hopper 3 and the inlet to the intermediate hopper 6, though it is an advantage of the invention that owing to the effective purging of gas from the chips in the tube 5, it is not necessary to interrupt communication between the main hopper and the intermediate hopper even when the former is being charged. Similarly other forms of melting device and probe may be employed, for example a melting device of the well known grid type, and a probe operated by the temperature to which its tip is raised when the level of the melt in the sump rises high enough to submerge it. If desired the probe may be dispensed with entirely and the level of the melt allowed to rise above the grid, so reducing the efficiency of heat transfer from the grid to the solid chips in the known way.

The apparatus of the invention may be used for the manufacture of yarns, monofilaments and other articles from polyamides, such as polycaprolactam and polyhexamethylene adipamide, polyesters such as polyethylene terephthalate, and other high linear polymers which are capable of being melt spun by conventional methods.

What we claim is:

1. Apparatus for melt spinning comprising a melting vessel, a spinning head adapted to be fed from the lower part of the melting vessel, a melting device in the melting vessel, a main storage vessel for the solid material to be melt spun, and an intermediate storage vessel arranged above, communicating with the top of the melting vessel and containing therein the normal top level of the material being melted, in combination with a pressure absorbing block between the bottom of the main storage vessel and the side of the intermediate storage vessel at the mentioned top level of the material being melted, comprising an inclined tube having a diameter to length ratio of 1 to at least 6 leading from the bottom of the main storage vessel into the side of the intermediate storage vessel at an angle of inclination from the horizontal greater than the angle of repose of said solid material, said tube being open to the influence of gravity for the passage of said material to the intermediate vessel when called for by the normal top level of the material in the intermediate vessel; whereby pressure changes on said solid material in the main storage vessel are not transmitted to the intermediate storage vessel and a substantially constant level of said material is maintained in contact with the melting vessel by means of said tube.

2. Apparatus as claimed in claim 1 wherein the inclined tubular passage has a diameter to length ratio of between 1:6 and 1:24.

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