May 5, 1942. W. W. HECKERT 2,281,767

PUMP

Filed July 12, 1940

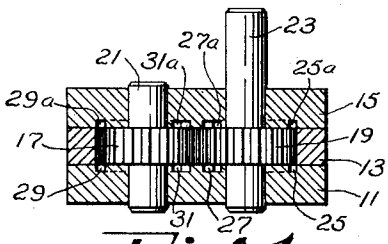


Fig. 1

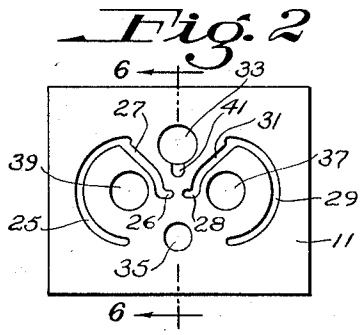


Fig. 2

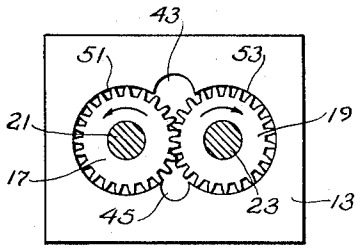


Fig. 3

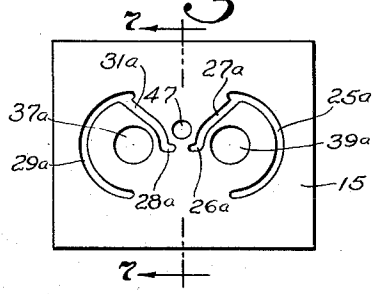


Fig. 4

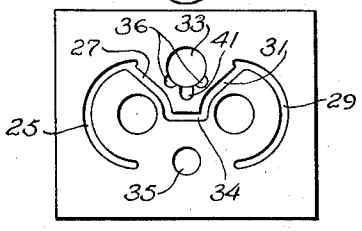


Fig. 8

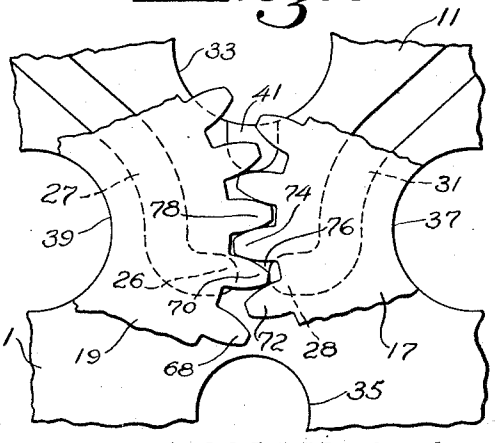


Fig. 5

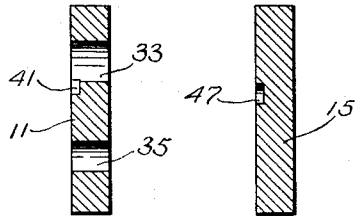


Fig. 6

Fig. 7

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PUMP

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Application July 12, 1940, Serial No. 345,119

1 Claim. (Cl. 103—126)

This invention relates to an improvement in liquid propelling gear pumps. It relates furthermore to an improved method of uniformly metering bubble-containing compositions. It relates particularly to gear pumps of the type commonly used in metering a filament-forming solution to a spinneret in the production of artificial filaments. The invention has particular utility in the spinning of molten organic filament-forming compositions which are subject to bubble formation, whether this formation is a result of the method used for melting or is a result of decomposition of the compositions in their molten state.

In the copending application of George DeWitt Graves, Serial No. 232,314, filed September 29, 1938, there is disclosed a method of producing continuous structures, such as filaments, yarns, ribbons and the like of very uniform denier or gauge, from compositions subject to bubble formation, by a process wherein the film- or filament-forming composition is subjected to sufficient pressure to dissolve the bubbles in the composition and then this bubble-free melt is metered, while being maintained under pressure, to an extrusion device such as a spinneret. This can be accomplished, for example, by the use of two pumps connected in series, the first subjecting the film- or filament-forming composition to pressure and delivering the bubble-free composition so produced to a second pump, which meters the bubble-free composition to a suitable extrusion device.

The use of two pumps will function to meter a substantially bubble-free composition to the extrusion device but presents mechanical problems, especially at the high temperatures involved in melt extrusion. Pump wear, maintenance, provisions for synchronous drives, etc., make them expensive and tend to make the extrusion apparatus cumbersome. Likewise, the use of two pumps increases the amount of film- or filament-forming compositions which must be maintained in the molten state and hence prolongs its exposure to conditions promoting decomposition.

It is, therefore, an object of this invention to provide an improved method and apparatus for the production of structures from film- or filament-forming compositions which contain bubbles under the conditions of extrusion.

It is another object of this invention to provide an improved method and apparatus for the elimination of bubbles from film- and filament-forming compositions and for metering the resulting bubble-free compositions to a structure-forming device.

Other objects of this invention will appear hereinafter.

The objects of this invention may be accomplished, in general, by using a gear pump so designed that the entrapped composition between the meshing gears is forced, through a passageway in the side walls of the pump, to the composition being propelled, or pumped, by the gears so as to dissolve bubbles present in the propelled molten composition before the latter is forced into the pump outlet.

More particularly, the composition under pressure may be led by means of grooves provided in the pump side walls to a position adjacent to the teeth of the gears in their path of travel from the inlet to the outlet ports. There the composition exerts pressure on the composition being propelled by the gear-teeth, and by this pressure bubbles in the composition being propelled are caused to dissolve.

The invention will be more easily understood by reference to the following detailed description when taken in connection with the accompanying illustration, in which:

Figure 1 is a cross section on the plane of the axes of the gears of a gear pump constructed in accordance with the invention.

Figure 2 is an elevational view of the inside face of one side plate of the gear pump shown in Figure 1.

Figure 3 is an elevational view of the center plate and gears of the pump shown in Figure 1.

Figure 4 is an elevational view of the inside face of the other side plate of the pump shown in Figure 1.

Figure 5 is an enlarged diagrammatic elevational view of a section of the gears projected on a section of the side plate shown in Figure 2.

Figure 6 is a cross-sectional view taken along the line 6—6 of Figure 2.

Figure 7 is a cross-sectional view taken along the line 7—7 of Figure 4.

Figure 8 is an elevational view of the inside face of a modified form of side plate.

Referring to Figures 1 to 7 of the drawing, reference numeral 11 designates the rear side plate of the gear pump and numerals 13 and 15 designate respectively the center plate and front side plate. The three plates are held together by means of suitable bolts or screws (not shown). A pair of meshing gears 17 and 19 are operatively positioned within the center plate 13 and between side plates 11 and 15. The gears 17 and 19

are mounted respectively on drive shafts 21 and 23. The gear drive shafts 21 and 23 are journaled in the side plates 11 and 15, the shaft 21 being positioned in openings 37 and 37a of the respective rear and front plates, and shaft 23 being positioned in openings 39 and 39a respectively of said rear and front plates.

The rear side plate 11 is provided with an inlet opening 33 and an outlet opening 35 for the liquid. Plate 11 is furthermore provided with arcuate grooves 25 and 29, as well as connecting grooves 27 and 31, the latter grooves respectively connecting arcuate grooves 25 and 29 with depressions 26 and 28 which are positioned adjacent the points of inter-meshing of the teeth of the gears 17 and 19 (see Figure 5). The several grooves are positioned on the inside face of the plate as is clearly shown in Figure 1. The arcuate grooves 25 and 29 are concentric with the shafts 21 and 23 and are positioned to overlie a number of gear-teeth between the inlet 33 and the outlet 35. A small groove 41, connecting with the inlet opening 33, is also provided on the inside face of plate 11 (see Figures 2 and 6). The purpose of this groove 41 is to bring grooves 27 and 31 sufficiently close to inlet opening 33 to insure that leakage between the said plate 11 and the center plate, due to excess pressure on the liquid in grooves 27 and 31, will flow to the inlet opening 33 rather than the outlet opening 35. The front side plate 15 is provided, on the inside face thereof with arcuate grooves 25a and 29a and connecting grooves 27a and 31a which are mirror images of the grooves in the rear side plate 11. Plate 15 is also provided with a small circular groove 47 which is positioned adjacent the point where the gears are unmeshing. Groove 47 functions to relieve any vacuum created by the unmeshing gears.

The center plate 13 contains two circular openings 51 and 53 into which the gears 17 and 19 fit with a minimum of clearance yet permitting free rotation of the gears. The gears 17 and 19 are shown mounted on their respective shafts 21 and 23. These are designed to be driven in the direction shown by the arrows. The enlarged recessed spaces 43 and 45 connect with the inlet 33 and outlet 35 respectively and serve as liquid conveying openings for the gears.

The mechanism whereby the filament-forming composition is entrapped between the gears, subjected to pressure, and fed into the grooves in the side plates is shown more clearly in Figure 5. The gears 17 and 19 at the point where the teeth engage and entrap the liquid overlie the depressions 26 and 28 at the ends of grooves 27 and 31. The tooth 70 of gear 19 has just reached a position relative to the teeth 72 and 74 of gear 17 where it has completely entrapped the filament-forming composition in the space 76 between the teeth 72 and 74 and is beginning to subject it to pressure. The depression 28 at the end of groove 31 in the rear side plate 11 is so located that the entrapped filament-forming composition is forced into the groove 31. A similar action occurs simultaneously at the corresponding depression 28a at the end of the groove 31a in the front side plate 15 (not shown). Simultaneously, the tooth 74, as shown, has just completed forcing the filament-forming composition, entrapped between teeth 70 and 78, into the depression 26 at the end of groove 27. The tooth 72 is shown entering the space between teeth 68 and 70 and will force the entrapped composition into depression 26 and groove 27, and, of course, the oppositely disposed depression 26a and groove 27a of front side plate, not shown in Figure 5. The composition forced into grooves 27 and 31, and 27a and 31a will be forced into the respective arcuate grooves 25 and 29, and 25a and 29a, and thence into the spaces between the gear-teeth to which the arcuate grooves are contiguous. The additional pressure imparted to the composition being propelled from the inlet to the outlet opening will cause a dissolution of any bubbles which may be contained therein.

It is usually preferred to so design the gear-teeth that a somewhat larger quantity of filament-forming composition is entrapped and fed through the grooves than is theoretically required, thus insuring that the teeth delivering the bubble-free filament-forming composition are completely filled. This is especially desirable since the rate of bubble-formation is often inconstant and hence the bubble content of the filament-forming composition is non-uniform so that provision must be made to dissolve the maximum quantity of bubbles present at any time. For this reason, provision must be made for the release of the excess quantity of this material. In general, it is preferred that this be fed back to the inlet of the pump, especially if the quantity is non-uniform, since if fed to the outlet, it would defeat the purpose of uniform metering. This release can be accomplished in a number of ways. In some cases, the natural slip between the gear-teeth and the center plate 13 will accomplish it or the clearance may be increased slightly to increase the slip. Likewise, slip between the faces of the gears and side plates 11 and 15 will permit return of the excess to the inlet. When this occurs, it is important to insure either by location of the inlet and outlet ports relative to the grooves and/or by supplementary grooves or recesses, that the resistance to slip between the grooves and the inlet port at their closest point is less than that between the grooves and the outlet port at their closest point. It will be noted that in Figure 2 the inlet port 33 is located closer to the grooves 27 and 31 than is the outlet port 35. The return of the excess to the inlet port may be further insured by an enlargement 41 of the inlet port as shown in Figure 2. This enlargement 41 need be only recessed in the plate 11; however, it may be recessed in both side plates 11 and 13.

The presence of this enlargement shortens the distance of closest approach of the connecting grooves 27 and 31 to the inlet port and thereby facilitates escape of excess composition to the inlet port across the face of the gears, between them and the plates 11 and/or 15. If desired, small passages may be recessed in the plate giving direct communication between the grooves carrying filament-forming composition to the teeth and the inlet port, the width and depth of the recessed passages being determined to maintain the desired pressure.

Although the length of the arcuate grooves 25 and 29 is shown to be approximately 180° in the drawing, many modifications of this length are possible in the scope of the invention. The criteria for selection of the proper length are: the concentration of bubbles present in the composition under the conditions of extrusion, the viscosity of the composition extruded and the precision of metering desired. As will be readily appreciated by one skilled in the art, one factor to be taken into account in determining the length of the grooves is the length of time the

composition must be subjected to pressure to effect solution. A limit to the length of the grooves is imposed by the necessity of providing a sufficient distance between the end of a groove and the outlet port to prevent slip of the composition from the groove to the outlet. Such a slip would destroy the metering feature of the pump of this invention. Another limit to the length of the grooves is the necessity for provision of an ungrooved or only slightly grooved space between the inlet port and the grooves as has been indicated above in discussion of release of excess composition from the grooves. It is preferred that the arcuate grooves be sufficiently long to overlie a plurality of gear-teeth.

Many modifications of the shape of the grooves are possible. For example, in Figure 8 the connecting grooves 27 and 31 are extended to join each other by the groove 34. Similarly, while the grooves have been shown in both the front and rear plates they may be placed in only one plate if desired. Obviously, other modified constructions for return of excess composition to the inlet opening can be devised. In Figure 8, recessions are shown at 36 in addition to that shown at 41 to facilitate this action.

Although this pump is especially adapted for the melt spinning of synthetic linear polyamides, it is obviously applicable to the melt spinning of any organic filament-forming composition, which is subject to the formation of bubbles, for any reason, under the conditions just prior to and during the spinning thereof provided the gases redissolve under pressure and the decomposition is slow enough to permit metering before sufficient gases are formed to exceed the solubility under the conditions of temperature and pressure. As examples of such filament-forming compositions in which bubble-formation may be present, the following may be mentioned: Synthetic linear polyamides, that is, synthetic linear polymers containing —CONH— units in the linear chain; synthetic linear polymers such as polyesters, polyethers, polyacetals and mixed polyester-polyamides such as may be prepared by condensation reactions as described in U. S. Patent No. 2,071,250 may also present problems of bubble-formation which can be remedied by the process of the present invention. Other types of synthetic polymers such as ethylene polymers, vinyl polymers, polystyrene and polyacrylic acid derivatives may also be spun with advantage, in accordance with the present invention.

The filament-forming material used in accordance with the present invention may contain modifying agents, e. g., luster-modifying agents, plasticizers, pigments and dyes, antioxidants, resins, etc. The present invention may also be used to advantage in extruding film- or filament-forming compositions in which the bubble formation is caused by the presence of a modifying agent.

Although this pump has been described with reference to the extrusion of film- or filament-forming compositions, it is also applicable to the metering of bubble-free compositions in the spinning of bristles and the coating of wire, etc.

This pump may also be used to advantage in the spinning or extrusion of other types of filament-forming solutions, for example, cellulose xanthate or other cellulose derivative solutions, when gas bubbles present a problem. Also, these solutions may be metered advantageously by this pump if they contain bubbles caused by the presence of modifying agents or from any other cause.

This pump also finds application in the pumping of liquids at or near their boiling points so that liquid only is metered without the presence of gases. In this connection, this pump has utility as a dispensing device. This pump may also be used to meter liquids undergoing decomposition with the evolution of gases.

By the practice of this invention it is possible to produce structures of very uniform properties particularly yarns of very uniform denier from filament-forming compositions having a tendency to form bubbles during the extrusion thereof. This is accomplished by a simple inexpensive and compact apparatus the maintenance of which is low and the power consumption small. The uses of this apparatus are particularly advantageous in the spinning of molten composition. An important advantage in melt spinning is the fact that less work is done on the molten material than with compression between two pumps thereby reducing the temperature of the pump block and permitting the use of higher temperatures in melting the solid filament-forming composition without raising the temperature of the pump block to a temperature which would promote too rapid decomposition.

Gear pumps constructed according to this invention tend to show less wear in use than previously known gear pumps. This is due to the equalization of pressures of the liquid being metered over a large segment of the gear-teeth and to the fact that in this pump pressure of the composition on both sides of the gear arbors is balanced.

Obviously many changes and modifications can be made in the above-described structures without departing from the nature and spirit of the present invention; it is therefore to be understood that the invention is not limited to the specific structures above-described except as set forth in the following claim.

I claim:

In a liquid propelling gear pump of the type in which a pair of meshing gears, housed in a center plate and between side plates, propels the liquid from an inlet opening to an outlet opening in cooperation with the peripheral surface of the center plate surrounding said gears, an arcuate groove in at least one of said side plates, said groove positioned to overlie a plurality of gear-teeth engaged in propelling liquid from the inlet opening to the outlet opening, a second groove in said side plate, said second groove positioned between said arcuate groove and a point overlying the meshing gear-teeth, and groove means in said side plate projecting only from said inlet opening towards, but not in direct connection with, said second groove whereby to induce leakage to said inlet opening upon reaching excessive pressure.

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