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F. E. DULMAGE ET AL
GEAR PUMP FOR METERING AND EXTRUDING
HOT ORGANIC THERMOPLASTICS

2,515,201

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2 Sheets-Sheet 1

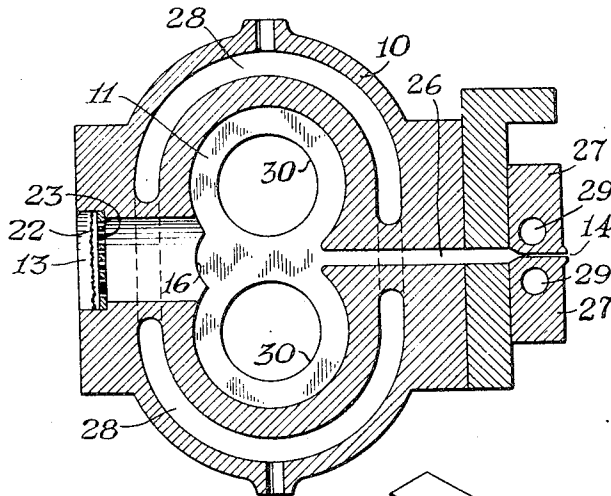


Fig. 1

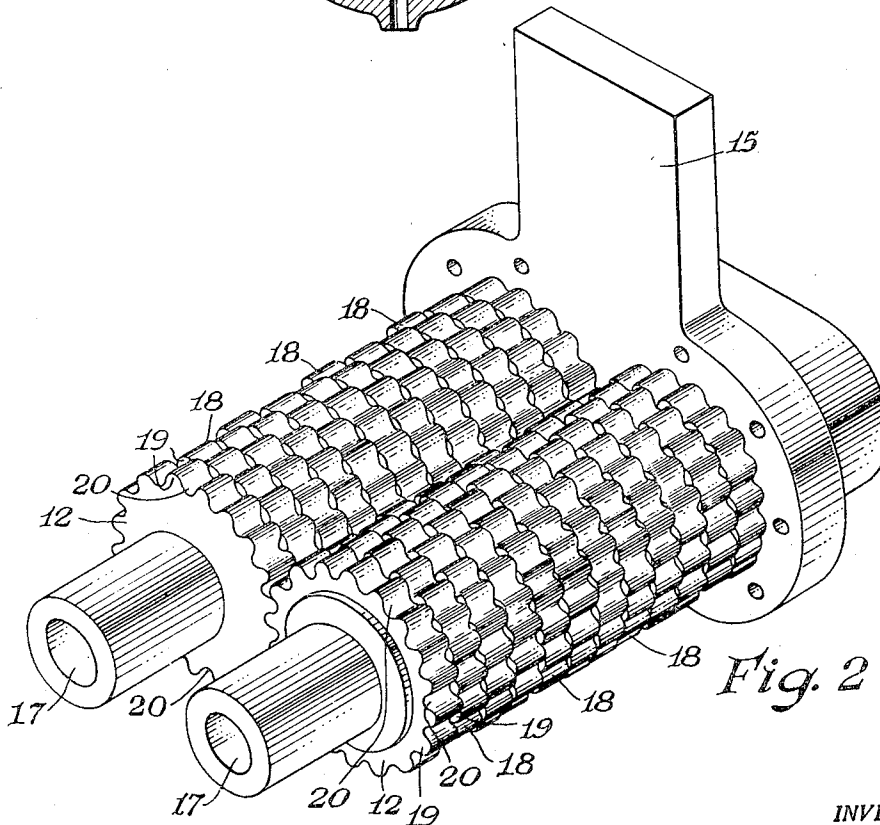


Fig. 2

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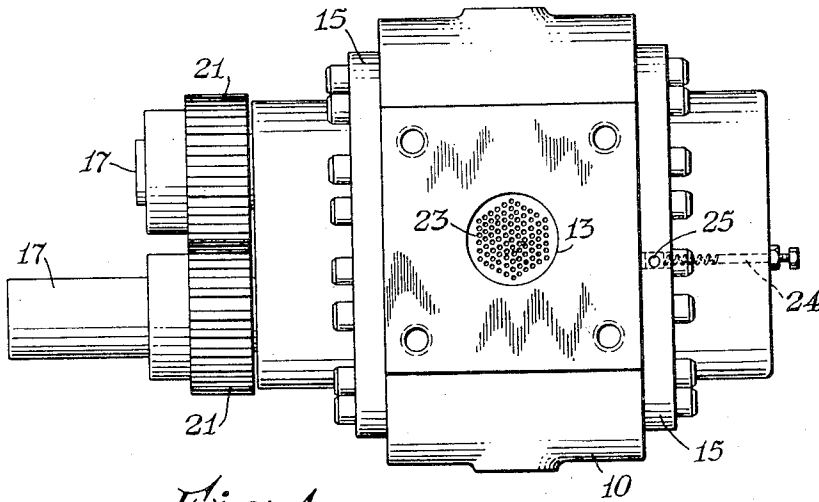


Fig. 4

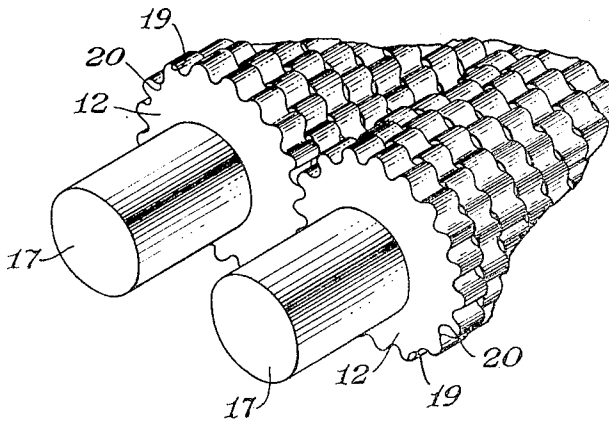


Fig. 3

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GEAR PUMP FOR METERING AND EXTRUD-
ING HOT ORGANIC THERMOPLASTICS

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3 Claims. (Cl. 103—128)

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This invention relates to a non-pulsating gear pump for hot organic thermoplastics. It relates specifically to such a pump capable of delivering the thermoplastic at a constant rate in a sheet free from strain and of uniform width and thickness.

According to the invention, such a pump comprises a heat jacketed pump case with two coacting toothed rotors mounted therein, having a particular arrangement and type of teeth thereon, an inlet for molten thermoplastic and a long narrow discharge orifice, all to be described more fully hereinafter.

The invention will be illustrated by and described with reference to the accompanying drawings, wherein

Fig. 1 is a vertical cross-section through the pump case without the rotor members in place;

Fig. 2 is a perspective view of the rotors, separated from the pump case, showing one preferred arrangement of the gear teeth;

Fig. 3 is a fragmentary view of the rotors, showing another preferred arrangement of the teeth;

Fig. 4 is an external view of the inlet side of the pump showing, as well, the drive shaft for the rotors.

The stationary housing 10 or case of the new pump has a single cavity 11 for mating rotors 12 (to be described later), with an inlet 13 for the hot plastic centered in one wall of the cavity 11 facing the nip between the rotors 12 and an adjustable orifice 14, as long as the rotors 12, to receive the polymer discharged from the said rotors 12 in a plane passing through said nip and said inlet 13. The term "nip" when used herein is intended to signify the horizontal line of contact along which the rotors 12 mate and part during their rotation, in analogy to the more common use of that term to describe the line of contact between a pair of smooth cylindrical pinch rolls. The rotor cavity 11 is in the form of two longitudinally intersecting equal right cylinders whose axes are parallel to one another but spaced apart a distance which is less than their diameters and is equal to the pitch diameter of the equal rotors 12 intended to operate therein. On the inlet side of the rotor cavity 11, extending longitudinally each way from the centrally disposed inlet port 13 to the flat end plates 15, is a distributor groove or channel 16 along which the molten plastic feed may be distributed under pressure to face the entire length of each of the rotors 12 operating in said cavity 11.

The rotary members 12 are each composed of a rotor shaft 17 upon which has been mounted a

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plurality of identical multiple-tooth gear wheels 18, each having a pitch diameter equal to the distance between centers of the rotor shafts 17. These wheels 18 are secured to the rotor shaft and to one another (with no intervening space along the shaft) in such a manner that each tooth 19 on one wheel 18 is offset from those of adjacent wheels 18 on the same shaft 17 by an amount of 0.15 to 0.4, and preferably about .33 times, the circular pitch of the teeth. Thus, when each wheel has 20 teeth, each is offset uniformly by a value of from about 2.7 to about 7.2° and preferably about 6° from the corresponding tooth 19 of each of the adjacent wheels 18 on the same shaft 17.

The offset pattern of teeth 19 along the shaft 17 may be continuously of the same hand, so that the rotor faces present the appearance of having a plurality of helical flights, as illustrated in Fig. 2, but it is found preferable to arrange the wheels 18 with corresponding teeth 19 offset in a repetitive pattern having a resemblance to herringbone gears, as illustrated in Fig. 3. Thus, in the example given above, with each wheel offset 6° from its neighbors, the offset pattern is 0°, 6°, 12°, 6°, 0°, 6°, 12°, . . . It is to be understood that, despite reference above to gear patterns resembling helical flights and those resembling herringbone gears, there is no helical or zig-zag movement of plastic during operation of the pump, since each flute 20 between the teeth 19 on each gear wheel 18 is filled with plastic in passing the supply header or groove 16, and there is no thrust along the pump on any of the matter being pumped.

The shape of the teeth on the rotors is important to successful operation of the pump. Each tooth has a smoothly rounded or semicircular crown, when viewed in elevation, and each interdental flute is an exact fit for the teeth, having a smoothly rounded or semicircular contour of the same radius as that of the teeth. The teeth are not significantly undercut, so that, in mating position, each tooth completely fills its companion flute without clearance and there is no possibility of any of the hot plastic remaining in the flutes for a second trip around the pump. Instead, overheating and burning are eliminated because the plastic makes a single linear pass through the equipment.

The teeth 19 on one rotor 12 are positioned as the mirror image of those on the other rotor 12 so that, in operation, the rotors 12 will mate perfectly at the nip between them when driven in opposite directions. Extensions of the rotor

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shafts 17, through the end plates 15 of the pump case 10 carry companion gears 21 and are driven, by means not shown, so that the pump teeth 19 part on the inlet side of the pump, slide along the adjacent closely fitting wall of cavity 11 toward the outlet side of the pump, and cleanse themselves of plastic due to their perfect fit as they mate on the outlet side of the nip.

The inlet port 13 is adapted to be secured to and fed by the outlet of a continuous, screw-type plastics extruder (not shown) or by any suitable supply of molten plastic under constant pressure. Because of the close fit between the cavity 11 of pump case 10 and the teeth 19 of the contained rotors 12, and the danger of irreparable damage due to any solid particles which might be carried into the pump, the inlet port 13 is guarded by a filter screen 22 supported by a perforate strainer plate 23.

To insure the continuous presence, during operation, of a sufficient supply of plastic on the inlet side of the pump to fill the distributor groove 16 and all interdental flutes 20 on the rotors 12, a positive pressure must be maintained on the inlet side of the pump. To show that sufficient pressure is present to maintain this condition, there is provided a spring loaded relief valve 24 having communication through a small relief port 25 extending from the distributor groove 16 to the outside of the pump case 10, suitably through one end plate 15. In operation, the relief valve 24 is adjusted to permit a continuous discharge of a small stream of hot plastic through the relief port 25 to show that adequate pressure is being maintained. An equivalent adjustment is possible, without changing the relief valve setting, by increasing or decreasing the rate of feed of plastic to the pump rotors 12 to maintain a continuous but minimum stream of plastic bleeding from the relief port 25.

The discharge orifice 14 communicates with and receives plastic from the discharge side of the rotor cavity 11 through a heated horizontal passageway 26 having a small vertical dimension but being of the same width as the length of the working faces of the pump rotors 12. The orifice 14 is of adjustable thickness, being provided with movable jaws 27 whereby the extruded sheet of constant full width may be made thinner or thicker as desired up to the vertical dimension of said heated horizontal passageway 26. There is ordinarily no obstruction or other restricting or directing baffle in the outlet passage 26 or the orifice 14, so that no particle of the hot plastic being discharged is diverted from its straight line path from the time it enters the flutes 20 of one of the rotors 12 until it has become immobilized in the cooled and hardened extruded sheet. The advantages of this arrangement are apparent when the extruded sheet is examined under polarized light. It is found to be free from strain and, when made of colored plastic, to be free from striations. By way of contrast, sheets of the same plastics and of the same dimensions, produced by extrusion from a screw extruder directly through a slit orifice invariably show lines of strain and often have visible color striations due to "memory" of variations in the thermal and mechanical treatment of the plastic in various parts of the sheet.

While the preferred form of orifice is the linear slit illustrated in the drawings, it is to be understood that the successful operation of the pump is not dependent upon the use of such an orifice. Extruded strips of other than rectangular cross-

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section may be produced by suitable flaring or "fishtailing," or other variation in the shape of the orifice.

As shown in the drawings, the pump case 10 contains a jacket 28 for circulation of a heating fluid around the inlet port 13, the rotor cavity 11 and the discharge passage 26, to assist in keeping the plastic being pumped at a constant temperature until it emerges through the orifice 14. It is preferred, as well, to heat the jaws 27 of the orifice 14, as by electrical resistance heaters (not shown) which may be installed in sockets 29 bored in said jaws 27. The rotors 12 may be heated, too, by installing electric heaters (not shown) in the rotor shafts 17, connection being made in known manner to an electric source during rotation of these shafts, through brushes slidable on commutators mounted in the end of the shafts.

The bearings 30 for the rotors 12, located in the end plates 15 of the pump case 10, are lubricated by the plastic being pumped and, since that plastic is supplied under positive pressure, there is no contamination of the main body of plastic passing through the pump by any foreign matter from the bearings 30.

In a specific embodiment, a pump was constructed as illustrated in the drawings. The intersecting cylinders forming the rotor cavity 11 each had a diameter of 3.595 inches, and their parallel axes were spaced apart 3.333 inches. The toothed portion of the rotors 12, extending the full distance between the end plates 15, were each 6 inches long. The pump was fed through an inlet port 2 inches in diameter at its inner end and center-bored to 2.25 inch diameter at its outer end, providing a shoulder to support a filter screen 22 and strainer plate 23. The distributor groove 16 was a segment of a cylinder of 1 inch radius whose longitudinal axis was the line of intersection of the two larger cylinders constituting the rotor cavity 11. The horizontal outlet passage 26 was 6 inches wide and 0.375 inch deep, and extended to an adjustable 6-inch orifice 4.5 inches from the vertical center line of the rotor cavity 11. Each rotor shaft 17 was about 1.7 inches in diameter and had mounted thereon 12 gear wheels 0.5 inch thick, having an outside diameter of 3.595 inches, a root diameter of 3.071 inches and a pitch diameter of 3.333 inches. Each gear member 18 had 20 teeth with a radius of 0.131 inch, a chordal thickness of 0.2615 inch, a circular thickness of 0.2618 inch, and a circular pitch of 0.5236 inch, and 20 interdental flutes of exactly the same dimensions and configuration. Adjacent gears 18 were mounted on their common shaft 17 and secured thereto with their teeth 19 staggered or offset from those of the neighboring gears 18 by increments of 6°, following the pseudo-herringbone pattern previously described. The rotors 12 were driven at speeds from 0.5 to 5 revolutions per minute, turning in opposite directions with their teeth 19 sliding along the wall of the rotor cavity 11 from the inlet toward the outlet side, and delivering hot plastic to the outlet passage 26 at the rate of about 0.5 pound per revolution when operating on polystyrene or ethyl cellulose and at slightly different rates, varying with the density, when operating on other thermoplastics. In operation, hot oil, or other appropriate fluid at the required temperature, was circulated through the jacket 28 of the pump case 10 and the rotors 12 were heated internally by electrical resistance heaters.

Because of the close tolerance between the pump cavity 11 and its contained rotors 12, there is a constant volume of thermoplastic discharged from the pump on each revolution of the rotors 12. The pump is accordingly an accurate means of metering the amount of plastic extruded and shaped over any period of time, since it is merely necessary to use any of several known means for counting the revolutions of the geared rotors 12.

The apparatus has been designated as a pump, but this should not be construed in the narrow sense of an apparatus for hastening the flow of the hot thermoplastic from the extruder to the orifice. Rather, it is an apparatus for forwarding the plastic at a steady rate (which may be quite slow), free from the pulsations common in extruders and in many pumps, from a zone of high pressure to the atmospheric pressure outside the orifice 14, and for distributing the plastic across the orifice in a form free from internal strain and striations.

We claim:

1. A gear pump adapted to receive a molten organic thermoplastic under pressure and to discharge it as a continuous sheet, comprising: a stationary case having a cavity therein for mating rotors, said cavity being in the form of two longitudinally intersecting right cylinders whose axes are parallel and spaced apart in a vertical plane a distance equal to the pitch diameter of the rotors operative therein; flat end plates closing said rotor cavity and having bearings therein for a rotor centered in each of said cylinders constituting said cavity; two rotary members extending between the said bearings in the end plates, through said cavity, each comprising a rotor shaft on which is mounted and secured a plurality of identical multiple tooth gear wheels filling the shaft between the end plates with no intervening space along the shaft, each gear wheel having an outside diameter substantially identical with the diameter of said cylinders to provide a sliding fit therein and a pitch diameter equal to the distance between the said parallel axes of the cylindrical portions of the rotor cavity, each tooth on each wheel being offset from those on adjacent wheels on the same shaft by from 0.15 to 0.4 times the circular pitch of the teeth; each two adjacent teeth on each wheel having a flute therebetween; each tooth, in elevation, exhibiting a smoothly rounded semicircular crown with no significant undercut and each interdental flute being smoothly semicircular of the same radius as the crown to provide an exact fit for its mating tooth; the teeth on one rotor being positioned as the mirror image complements of the flutes on the other rotor to provide perfect mating between corresponding wheels on the two shafts; an inlet port through and centered in one wall of the case facing the parting line between the rotors; an internal distributor groove on the inlet side of the pump parallel to and facing the parting line between the rotors extending throughout their length; an orifice extending between the end plates in communication with a horizontal passageway having a uniform small vertical dimension greater than that of the orifice and having the same length as the working face of the rotors, said passageway being in communication with the rotor cavity in the horizontal plane through the mating line between the rotors and on the opposite side of the pump from the said inlet port; means for heating the

case, rotors and orifice; and means for driving the rotors at the same speed and in opposite directions such that the gear teeth on the internal rotors slide along the wall of the rotor cavity from the inlet toward the outlet side of the pump.

2. A gear pump adapted to receive a molten organic thermoplastic under pressure and to discharge it as a continuous sheet, comprising: a stationary case having a cavity therein for mating rotors, said cavity being in the form of two longitudinally intersecting right cylinders whose axes are parallel and spaced apart in a vertical plane a distance equal to the pitch diameter of the rotors operative therein; flat end plates closing said rotor cavity and having bearings therein for a rotor centered in each of said cylinders constituting said cavity; two rotary members extending between the said bearings in the end plates, through said cavity, each comprising a rotor shaft on which is mounted and secured a plurality of identical multiple tooth gear wheels filling the shaft between the end plates with no intervening space along the shaft, each gear wheel having an outside diameter substantially identical with the diameter of said cylinders to provide a sliding fit therein and a pitch diameter equal to the distance between the said parallel axes of the cylindrical portions of the rotor cavity, each tooth on each wheel being offset from those on adjacent wheels on the same shaft by about 0.33 times the circular pitch of the teeth; each two adjacent teeth on each wheel having a flute therebetween; the teeth on one rotor being positioned as the mirror image complements of the flutes on the other rotor to provide perfect mating between corresponding wheels on the two shafts; an inlet port through and centered in one wall of the case facing the parting line between the rotors; an internal distributor groove on the inlet side of the pump parallel to and facing the parting line between the rotors and extending throughout their length; an orifice extending between the end plates in communication with a horizontal passageway having a uniform small vertical dimension greater than that of the orifice and having the same length as the working face of the rotors, said passageway being in communication with the rotor cavity in the horizontal plane through the mating line between the rotors and on the opposite side of the pump from the said inlet port; means for heating the case, rotors and orifice; and means for driving the rotors at the same speed and in opposite directions such that the gear teeth on the internal rotors slide along the wall of the rotor cavity from the inlet toward the outlet side of the pump.

3. A gear pump adapted to receive a molten organic thermoplastic under pressure and to discharge it as a continuous sheet, comprising: a stationary case having a cavity therein for mating rotors, said cavity being in the form of two longitudinally intersecting right cylinders whose axes are parallel and spaced apart in a vertical plane a distance equal to the pitch diameter of the rotors operative therein; flat end plates closing said rotor cavity and having bearings therein for a rotor centered in each of said cylinders constituting said cavity; two rotary members extending between the said bearings in the end plates, through said cavity, each comprising a rotor shaft on which is mounted and secured a plurality of identical multiple tooth gear wheels filling the shaft between the end plates with no intervening space along the shaft, each gear wheel having an outside diameter substantially identical with the di-

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ameter of said cylinders to provide a sliding fit therein and a pitch diameter equal to the distance between the said parallel axes of the cylindrical portions of the rotor cavity, each tooth on each wheel being offset from those on adjacent wheels on the same shaft by from 0.15 to 0.4 times the circular pitch of the teeth; each two adjacent teeth on each wheel having a flute therebetween; each tooth, in elevation, exhibiting a smoothly rounded semicircular crown with no significant undercut and each interdental flute being smoothly semicircular of the same radius as the crown to provide an exact fit for its mating tooth; the teeth on one rotor being positioned as the mirror image complements of the flutes on the other rotor to provide perfect mating between corresponding wheels on the two shafts; an inlet port through and centered in one wall of the case facing the parting line between the rotors; an internal distributor groove on the inlet side of the pump parallel to and facing the nip between the rotors and extending throughout their length; a pressure-actuated relief valve in a port extending from the distributor groove to the outside of the pump; an orifice extending between the end plates in communication with a horizontal passageway having a uniform small vertical dimension greater than that of the orifice and having the same length as the working face of the rotors, said passageway being in communication with the rotor cavity in the horizontal plane through the mating line between the rotors and on the opposite

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side of the pump from the said inlet port; means for heating the case, rotors and orifice; and means for driving the rotors at the same speed and in opposite directions such that the gear teeth on the internal rotors slide along the wall of the rotor cavity from the inlet toward the outlet side of the pump.

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