

Dec. 18, 1962

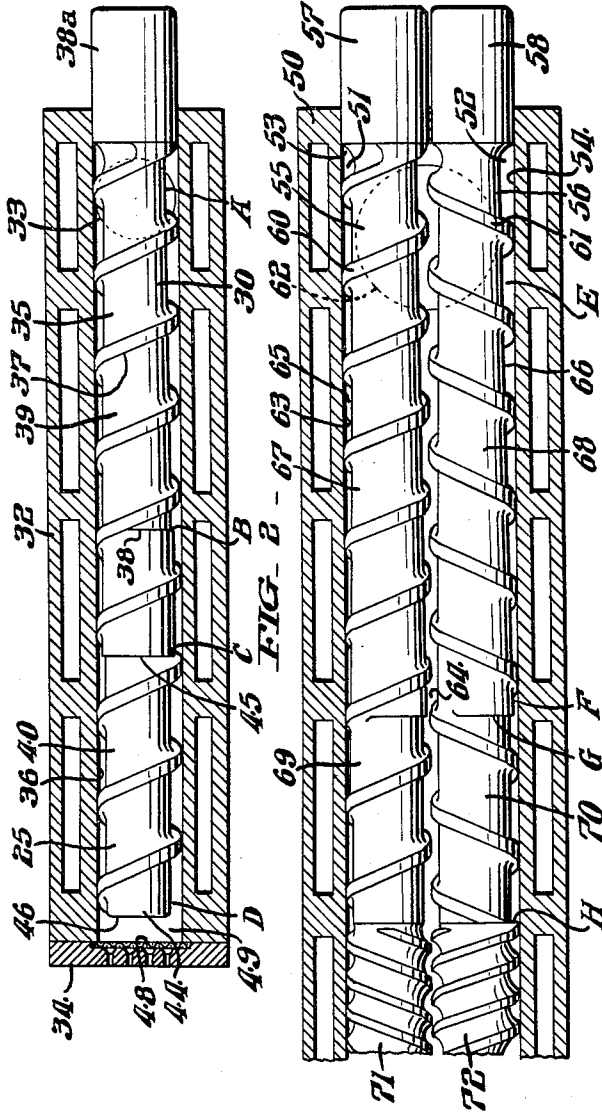
L. F. STREET

3,068,514

MATERIAL TREATING APPARATUS AND METHOD

Original Filed Feb. 23, 1954

FIG. 1 -



1

3,068,514

MATERIAL TREATING APPARATUS AND METHOD

Louis F. Street, Norristown, Pa., assignor to Welding Engineers, Inc., a corporation of Delaware
Continuation of application Ser. No. 411,651, Feb. 23, 1954. This application Aug. 30, 1960, Ser. No. 52,812
4 Claims. (Cl. 18—12)

This invention relates to material treating apparatus of the extrusion type. This application is a continuation of my co-pending application Serial No. 411,651, filed February 23, 1954, now abandoned.

An object of this invention is to increase the rate of flow of material through the material treating apparatus.

Another object of the invention is to extrude the material under a high uniform pressure.

Other and further objects will be apparent from the following description taken in connection with the drawings in which:

FIG. 1 is a sectional view of a typical extrusion apparatus showing the worm and casing combination.

FIG. 2 is a sectional view of a double worm extruder; and

FIG. 3 is a sectional view of the worm and casing of another embodiment of the invention.

Among the various types of worms used for the treatment of materials, the former art has developed the use of worms having a constant helical lead and a constant radial depth, thus being of uniform section throughout. It has also developed worms having a constant depth with the helical lead reducing in the direct flow of the material, or worms having a constant helical lead with the depth reducing in the direction of the material. In the extrusion processing of many materials such as polystyrene, polyvinylchloride and polymethylmethacrylate, the prior art teaches that, for most operations, numerous advantages are to be realized by using an extruder worm having a positive compression ratio. That is, having a reduction in depth or a reduction in lead or a combination of both in the direction of flow of the material. Such a worm operates in a more satisfactory manner in melting down cold granules that are fed to the machine and produces a higher output rate for a given size piece of equipment as well as doing a better mixing job on the material as it progresses through the machine. The term "compression ratio" is commonly based on the relationship of the free volume in a turn of the helix at its largest point at the back or feed end to the volume of a turn of the helix at the front or discharge end. For instance, a compression ratio of 2 to 1 refers to the fact that the free volume at the back end is twice the free volume at the front end. Frequently, a uniform section is maintained for about three turns of the helix at the front end with the intention of improving the uniformity in rate of output of the machine. In the present language of the art, the term, compression ratio, is used to indicate a positive compression ratio; that is, where the free volume in the worm decreases in the direction of flow of the material.

I have found that a negative compression ratio in a portion of the worm realizes a marked improvement for many operations over worms of known design which omit this feature. By negative compression ratio is meant the condition existing when the free volume in the worm is greater at one point than the free volume at a point through which the material has previously passed.

In FIG. 1 a typical worm is shown at 30, surrounded by casing 32 having a feed opening 33 at one end and a discharge die 34 at the other end. Jackets are provided in the casing to permit temperature control of the inner wall of the casing. Other heating means such as the ap-

2

plication of electrical heater coupled with the use of water or other cooling means could be used. The worm is rotated by driving at hub 38a. The processing portion of the worm has flights 37 operating with a close running clearance with the inner bore 36 of the casing. Stem 35 of the worm cooperates with the flights 37 and the cylindrical inner bore 36 of the casing to create a helical space in which the material is treated. In the embodiment illustrated, the lead of the helical flights 37 is uniform throughout, but a positive compression ratio or reduction in free volume exists because the diameter of the stem 35 of the worm 30 increases in the direction flow of the material, thus leaving a greater free volume at A than at B. From B to C at 38, the depth of the worm remains constant but at C, the diameter of the stem 35 decreases, thus giving a negative compression ratio and leaving a greater free volume at D than at B. In operation, material is fed through hopper 33 and the action of the rotating worm advances the material toward the die 34. As the material starts to move forward in the machine, it is melted from the heat absorbed from the external heating means and from the frictional heat generated in the material through the pressure and kneading by the worm. As the material goes forward, it is considerably restricted by the time it reaches the intermediate point 39 in the worm and most materials are sufficiently plasticized at this point so that they act as a plastic mass, although there may still remain unplasticized particles which are carried along in this mass. The material continues to move forward along the worm and passes point B and point C. The relatively narrow clearance at 38 between the stem 35 of the worm and inner bore 36 of the casing that exists between points B and C is well adapted to insure thorough plasticizing of the material and pass a properly heated mass of plastic material forward into the next section of worm present from C to D. The deeper flight space of this forward portion 40 of rotary member 30 is better adapted to the forcing through the die 34 of a plasticized material than in the restricted portion 38. Since the front portion 40 of the worm generates much or all of the pressure necessary to extrude the material through the die, the back pressure which must be overcome by the worm flights in areas 38 and 39 is correspondingly reduced and thus these latter portions of the worm are capable of plasticizing and advancing more material.

At C the stem may be stopped abruptly increasing the depth at the discharge end of the restricting portion. The restricted portion or intermediate restriction may or may not extend axially a substantial distance at 38 along the rotary member. Examples of the depths of a worm with a two inch diameter and a helical lead of two inches are a depth on the radius of five-sixteenths of an inch at A, one tenth of an inch between B and C and a depth of fifteen hundredths from C to D.

The depth between A and B need not decrease uniformly, but may remain constant for two or three turns of the flight then decrease uniformly. The depth may decrease to point C eliminating the axial length of the restricted portion at 38 between B and C or at an intermediate point between B and C reducing the axial length of the restriction. In each instance there is a step or shoulder 45.

The tip 44 has a rounded or beveled edge 46 and is spaced from the screen 48 on the inner surface of the die 34. The rounded edge provides a continuous and smooth transfer of the material from the rotary member to the chamber 48 between the die 34 and the tip 44.

In FIG. 2 the casing 50 has double barrels or double bores 51, 52 with cylindrical walls 53, 54 and rotary members 55, 56. The worms 55, 56 are rotated in op-

posite directions through the hubs 57, 58, each having a portion fitting in the ends of the bores 51, 52. The flights 60, 61 of worms 55, 56 cooperate to move the material from the feed opening 62 to the restrictions 63 and 64. The stems 65, 66 are spaced from the respective bore walls 53, 54 to form the helical annular spaces having a variable depth as in FIG. 1.

The first portions 67, 68 of the rotary members have a positive compression from E to F. The restrictions 63, 64 extend axially from a substantial portion of the rotary member and discharge the material to the second portions 69, 70. There is a negative compression ratio between depths G and H due to the reduction of the diameter of the stems at G. The second portions 69, 70 discharge the material into and through the rotary restriction portions 71, 72 providing back pressure against the forward feed of flights 60, 61. In the embodiment illustrated the rotary restriction is shown as a reverse helical flight member but restrictions of other designs can also be used.

In FIG. 3 a rotary member 75 is in close clearance in the bore 76 of the casing 77 and has a flight 78 with a constant lead or pitch which in the embodiment illustrated is approximately equal to the outside diameter of the rotary member or the diameter of the bore. The stem 79 is tapered to gradually reduce the cross sectional area or depth of the annular space from J at the feed opening 84 to K at the restriction 86. The stem then gradually reduces in diameter and increases the depth of flight 78 from the shoulder K to L at the discharge end 82. The worm is turned by the hub 83 having a portion fitting in the end of the bore. The flight receives material from the opening 84 and forces the material forward through the narrow depth K at the step 81 and then extrudes the material through a die (not shown). The depth J at the opening is greater than the depth at K and may be equal to approximately three-sixteenths of the outside diameter of the worm. The stem then gradually increases in diameter in the direction of movement of the material until the depth of the annular space K is half to one quarter the depth at J or three-thirty seconds to three-sixty-fourths of the outside diameter of the worm. From the step 81 the depth increases to L where it is twenty-five to seventy-five percent greater than at K. The die end or tip 82 is rounded to increase the ease of flow of the material from the flight through the die thereby increasing the extrusion pressure.

In this embodiment the diameter gradually increases to the restriction 86. The restriction 86 is axially short with the stem then tapering inwardly to progressively increase the free volume.

When the depth at K is shallow, such as from one-fortieth to one-twentieth of the outside diameter, the depth at L will increase a greater proportional amount over the depth at K. When the depth at K is relatively deep such as one-fifteenth to one-twelfth of the outside diameter of the worm, the depth at L will increase a smaller proportional amount over the depth at K.

This combination of a positive compression ratio followed by a negative compression ratio greatly increases the capacity of the worm to treat and extrude material without any increase in the size of the worm or the extruder in general. Thus, with one extruder machine the capacity was increased to over 200 pounds of material per hour whereas previous extruders without the negative compression ratio had a capacity of 125 to 150 pounds of material per hour.

Various modifications and changes may be made in the above embodiments without departing from the scope of the invention. The tapers of stem diameters for the positive compression ratio and negative compression ratio may be combined in various manners with different types of restrictions. The various modifications and embodiments are applicable to single rotary member as well

as double rotary members and to the extrusion of material through a die or orifice as well as through a rotary restriction.

Another variation comprises the tapering of the bore or employment of different diameters in the bore of the casing and appropriate design of worm to produce a negative compression ratio throughout the desired portion of the worm.

Having thus described my invention, I claim:

1. An extruding apparatus comprising a stationary casing having a generally cylindrical bore, means providing an inlet opening in said casing for introducing material into said casing, a rotary worm having a central stem and a plurality of generally helically arranged flights arranged around said stem, providing a winding passage for said material, means for revolving said worm thereby forwarding said material along in a downstream direction inside said winding passage, a first section in said casing extending downstream of said inlet having a root diameter which increases in a downstream direction whereby said material fills up the passage between the flights of said worm, means forming an abrupt shoulder on said stem at the downstream end of said first portion in an area wherein said casing is completely closed, providing a sudden reduction of the stem diameter, said first section having a shallow portion immediately preceding said shoulder, a second section downstream of said shoulder having a substantially constant root diameter which is substantially less than the diameter of said shoulder, and a third section downstream of said second section forming a resistance for said material.

2. An extruding apparatus comprising a stationary casing having a generally cylindrical bore, means providing an inlet opening in said casing for introducing material into said casing, a rotary worm having a central stem and a plurality of generally helically arranged flights arranged around said stem, providing a winding passage for said material, means for revolving said worm thereby forwarding said material along in a downstream direction inside said winding passage, a first section in said casing extending downstream of said inlet having a root diameter which increases in a downstream direction whereby said material fills up the passage between the flights of said worm, means forming an abrupt shoulder on said stem at the downstream end of said first section in an area wherein said casing is completely closed, said first section having a shallow portion immediately preceding said shoulder, said shoulder extending substantially completely around said stem, a second section downstream of said shoulder having a substantially constant diameter which is substantially less than the diameter of said shoulder, and a third section downstream of said second section forming a resistance for said material, said stem and said casing being so related that, upstream of said shoulder, the flight depth is in the range of $\frac{1}{40}$ to $\frac{1}{32}$ of the outside diameter of the worm, and downstream of the shoulder the increase in depth of the flight space is in the range of 25% to 75%.

3. In a method of extruding a material which exhibits a decrease of apparent viscosity when it is subjected to an increased rate of shear to advance against resistance through an elongated treating chamber substantially filled with said material, the steps which comprise advancing the material in generally ribbon formation thereby subjecting it for a time to a predetermined rate of shear and then, while continuing the advancement of the material, subjecting it suddenly to a rate of shear that is much lower than said predetermined rate of shear, thereby raising the apparent viscosity of the material, and then while maintaining the increased viscosity, further advancing the material through resistance.

4. In a method of treating thixotropic material incident to advance against resistance through an elongated treating chamber substantially filled with said material, the steps which comprise continuously advancing the material

5

thereby subjecting the material for a time to gradually increasing rate of shear and decreasing apparent viscosity, then, while continuing the advancement of the material, subjecting the material to a substantially uniform and predetermined rate of shear, then, while continuing the advancement of the material, subjecting the material to a rate of shear that is much lower than said predetermined rate of shear, thereby raising the apparent viscosity of the material, and then while maintaining the increased viscosity, further advancing the material through resistance.

5

10

2,289,264
2,496,147
2,511,203
2,733,051
2,765,490

649,187
860,261

6

References Cited in the file of this patent

UNITED STATES PATENTS

Hawk ----- July 7, 1942
Brillhart ----- Jan. 31, 1950
Gliss ----- June 13, 1950
Street ----- Jan. 31, 1956
Zona ----- Oct. 9, 1956

FOREIGN PATENTS

Germany ----- Aug. 5, 1937
Germany ----- Dec. 18, 1952