Jan. 14, 1964 H. M. SOARS, JR 3,117,343

PELLET MILL

Filed May 17, 1962 2 Sheets-Sheet 1

FIG. 1

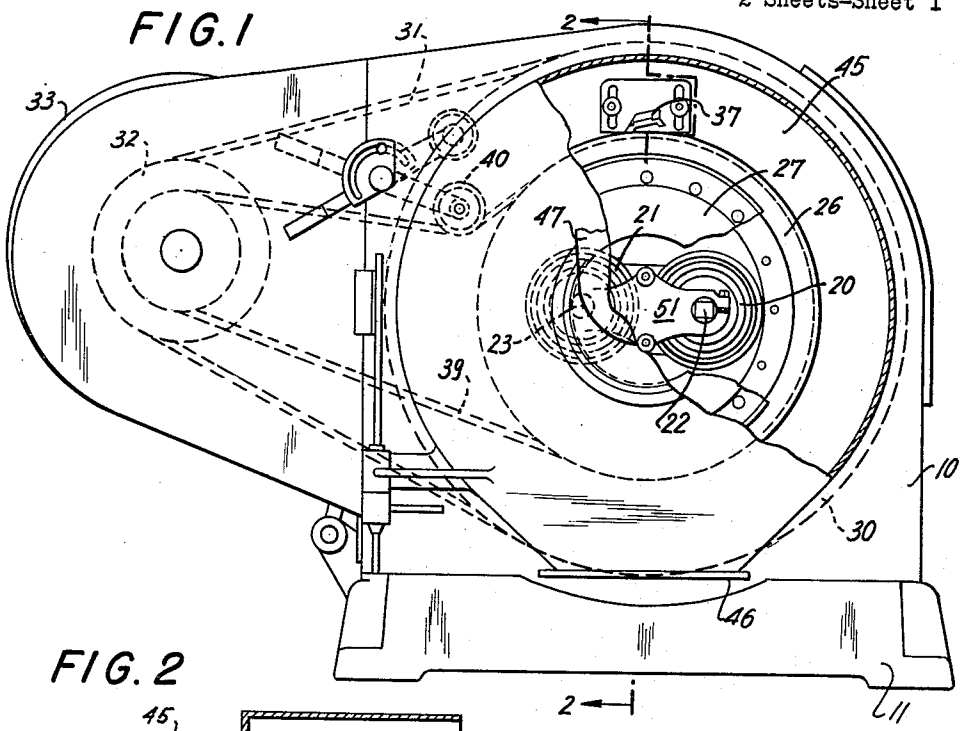
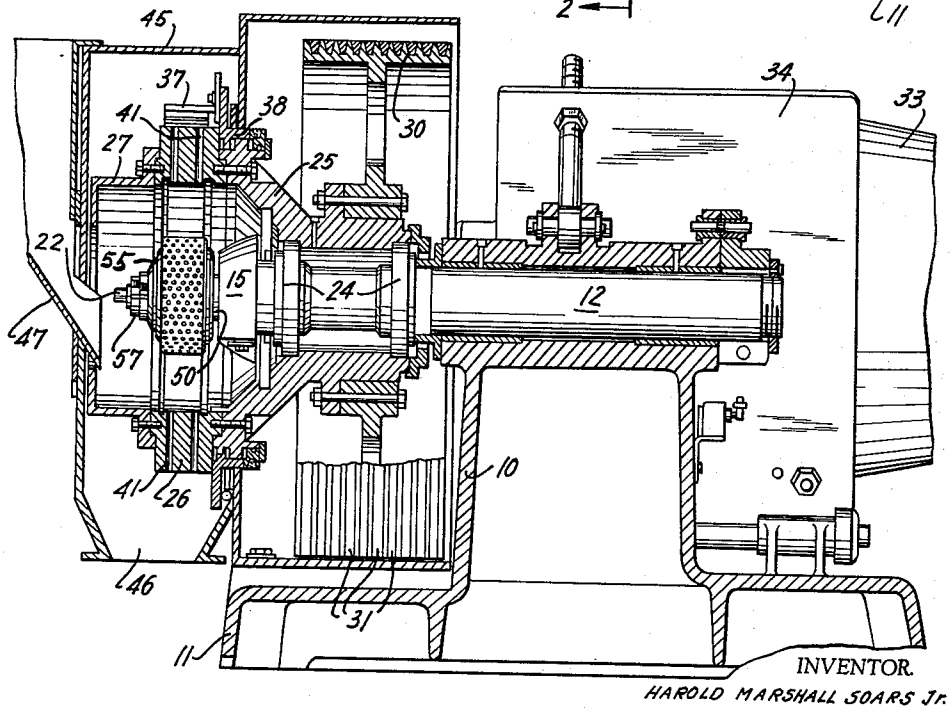


FIG. 2



INVENTOR.
HAROLD MARSHALL SOARS JR.

BY

Greer Maréchal, Jr.
ATTORNEY

Jan. 14, 1964 H. M. SOARS, JR 3,117,343

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Filed May 17, 1962 2 Sheets-Sheet 2

FIG. 3

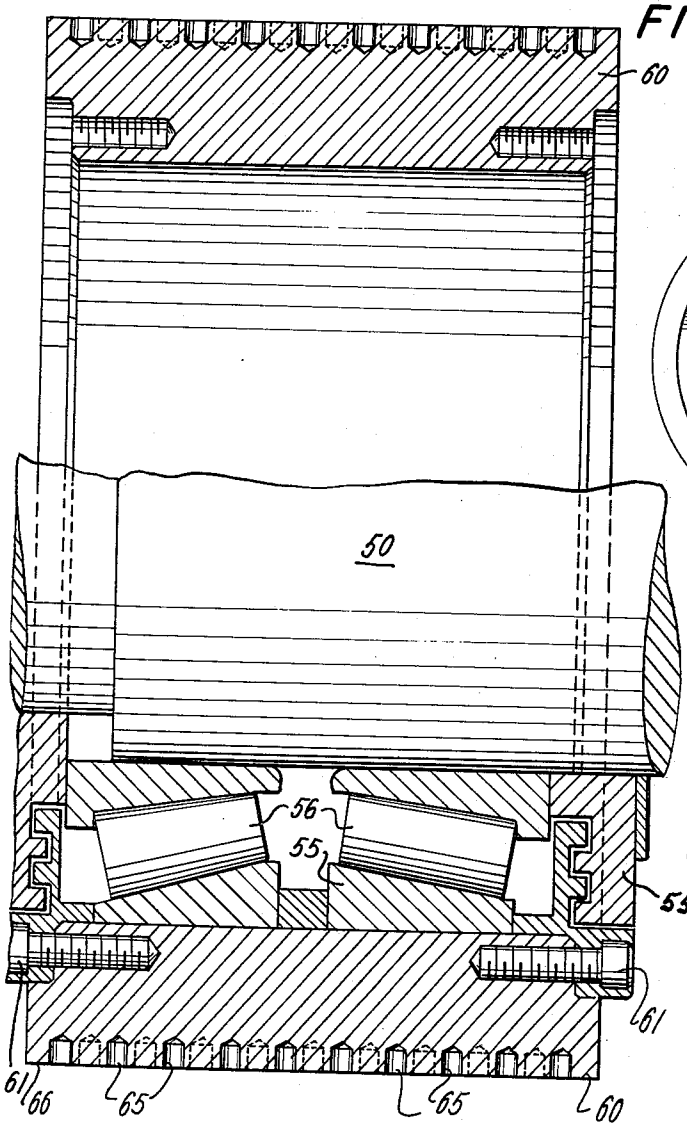
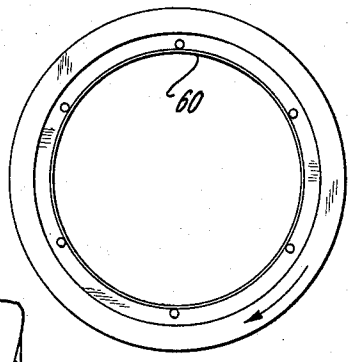


FIG. 4



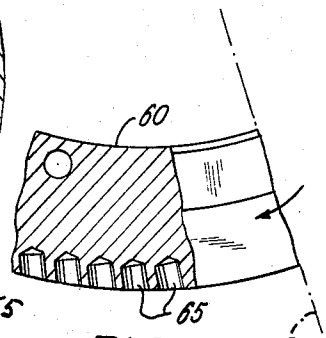


FIG. 6

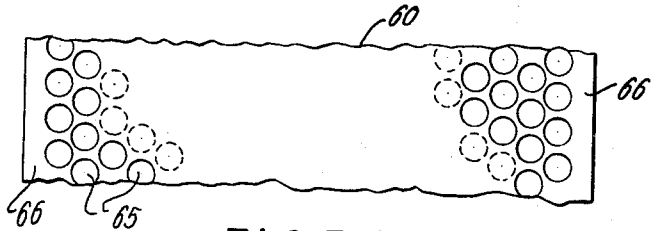


FIG. 5

INVENTOR.
HAROLD MARSHALL SOARS Jr.

BY

Greer Maréchal, Jr.
ATTORNEY

United States Patent Office 3,117,343 Patented Jan. 14, 1964

3,117,343

PELLET MILL

Harold M. Soars, Jr., Muncy, Pa., assignor to Sprout, Waldron & Company, Inc., Muncy, Pa., a corporation of Pennsylvania

Filed May 17, 1962, Ser. No. 195,445
5 Claims. (Cl. 18—12)

This invention relates to extrusion-type pellet mills and like apparatus for forming pellets of a mass or mash of material by extrusion through extrusion openings or passages in a die by the action of pressure rollers contacting the material against the die surface and, more particularly, to an improved configuration for the surfaces of such pressure rollers for minimizing the wear thereof and for increasing the efficiency of the cooperative pelleting action of the rollers and the die.

Pellet mills or pelleting apparatus of the character to which this invention relates are well known, and may generally be considered as utilizing a heavy metal die with extrusion openings or passages therethrough and one or more pressure rollers operating around and against the die surface so that a mass of material to be pelleted is forced by the pressure rollers outwardly through the extrusion openings in the die during the pelleting operation. Particularly among such types of pelleting apparatus are those having an annular or toroidal die with radial extrusion openings or passages through the peripheral or circumferential wall thereof. Material to be pelleted is introduced into the central portion of the die and is forced outwardly through the extrusion openings by one or more pressure rollers moving against the interior annular surface of the die during relative rotating movement between the die and the rollers. Such apparatus has been arranged on either the vertical or horizontal axis and either with the die stationary and the internal pressure rolls rotating or, vice versa, with the internal pressure rolls mounted on a stationary axis and the annular die driven to rotate about them.

As illustrative of such vertical axis pelleting apparatus with a stationary die and pressure rolls driven to rotate may be noted the type of pellet mill disclosed in Patent No. 2,178,009, while the apparatus disclosed in Patent Nos. 2,764,915 or 2,845,036 is generally illustrative of a type of horizontal axis pellet mill where the die is driven for rotation while the pressure rollers are mounted on stationary axes. Regardless of which specific arrangement is being considered, each individual pressure roller is mounted to rotate freely about its own axis, whether such rotation is achieved by driving force imparted to the rollers by the rotating annular die or achieved by rotating the rollers as a group against the die surface. In any case, a rolling pressure is desired between the die and pressure rollers and acting upon the material to be pelleted to force it through the extrusion openings in the die.

As will be understood, particularly when the material being pelleted is of an abrasive character, such arrangements tend to subject the pressure rollers to substantial surface wear. Also, the overall optimum efficiency and production capacity of the pelleting operation may be affected adversely if substantial slippage occurs between the pressure rollers and the die surface and/or if the material being pelleted otherwise is able to escape the full force of the pressure rollers during each revolution. Particularly does this latter factor exercise an important consideration on the pelleting operation in arrangements where the pressure rollers are individually driven by frictional contact with the rotating die surface through the material being pelleted.

It may be particularly desired, especially with pellet mills having a rotating die, that sufficient friction be engendered between the die surface and the rollers so that

the rollers turn at substantially the same surface speed as the die surface, thus forcing virtually all the material to be pelleted into the extrusion openings in the die at each pass of the material between the rollers and the die surface. If, however, the material being pelleted is such that sufficient frictional force is not developed between rollers and die surface, some slippage may occur permitting some of the material to escape the full pressure action of the rollers, and such disadvantage may be particularly noticeable if the pressure rollers have smooth outer surfaces. Similarly, if it is desired to build up a mat of material over the surface of the pressure rollers to act as some insulation against excessive wear of the roller surface, the particular configuration of the roller surface may have a controlling effect on attaining such goal.

If it is attempted to accomplish either of the foregoing objectives merely by providing the pressure rollers with a surface which is roughened in one way or another, certain other disadvantages may be experienced. For example, attempting to enhance the efficiency as by axial corrugations in the roller surface may increase the frictional engagement substantially, although it may also permit some of the material being pelleted to escape axially from the ends of the corrugations and thus avoid the desired concentrated pressure action to force the material into and through the extrusion openings in the die.

Similarly, if it is attempted to provide roughening effects as by embedding hard particles of carbide or other material in the roller surfaces, a situation may arise where final close tolerance finishing of the rollers to provide a completely round roller or completely uniform surface for making contact with the die cannot satisfactorily be accomplished in manufacturing and/or cannot be assured without grinding or machining the finished rollers so as to destroy the roughened surface originally imparted thereto. Somewhat similar difficulties may be experienced with a variety of machining or other operations intended to impart a specific roughened texture to the surface of the pressure rollers. Even the provision of specific machined or other dimpled or indentation textures uniformly in the roller surfaces may not provide the desired driving contact, however much such expedients may increase the tendency of forming a layer of material over the roller surface, and particularly is this true in situations where the rolls are to be driven solely by surface or frictional contact with the rotating die.

According to this invention, however, an arrangement is provided for such pellet mill apparatus in which a substantial portion of the roller surface includes a pattern of a plurality of indentations to provide a roughened surface, but with the various indentations more or less tangentially (or, at least, not radially) directed or arranged and oriented with respect to the desired direction of rotation to provide a tangential moment of force for the desired enhancement of frictional driving force between die surface and roller while also enhancing the formation of a mat of the material to be pelleted around and over the surface of the pressure roller. Although such indentations are preferably provided to cover substantially all of the surface of the pressure roller in the desired pattern, axial edge portions of the roller surface are left free of indentations to provide a smooth rim preventing axial escape of material being pelleted at the ends of the rollers, and the indentations themselves are provided (conveniently by drilling the roller surface) in a manner to be as nearly tangentially directed as practicable and with the axes of the indentations being offset from the radius of the roller to provide the desired tangential moment of force through material acting against the rollers.

With the foregoing and additional objects in view,

this invention will be further described, and other objects and advantages thereof will be apparent from the following description, the accompanying drawings, and the appended claims.

In the drawings:

FIG. 1 is an elevational end view with some parts broken away of an arrangement of horizontal pellet mill apparatus embodying and for practicing this invention;

FIG. 2 is a vertical axial section through the apparatus of FIG. 1 along the line 2—2 thereof;

FIG. 3 is an axial section through one of the pellet mill pressure rollers embodying and for practicing this invention, with part of the internal mechanism being broken away for clarity;

FIG. 4 is an end elevation view of the pressure roller shell of FIG. 3;

FIG. 5 is a fragmentary view indicating one pattern of arrangement of indentations in accordance herewith over the surface of the pressure roller of FIG. 3; and

FIG. 6 is a fragmentary transverse section of a portion of the roller shell of FIG. 3.

Referring to the drawings, in which like reference characters indicate like parts throughout the several views, thereof, an arrangement for embodying and for practicing this invention is illustrated as being applied to pelleting apparatus generally of the nature disclosed in the above mentioned Patent No. 2,845,036, and of the type of horizontal axis pellet mill in which an annular or toroidal pelleting die is driven for rotation around pressure rollers affixed to stationary axes but individually rotated by frictional contact with the inner die surface. Thus, the apparatus is illustrated as having a main frame 10 mounted on a base 11 and including a main shaft 12 supporting at one end a spider arrangement indicated at 15 by which are carried two pressure rollers 20 and 21, each freely rotatable about its respective axis indicated at 22 and 23.

Also supported on shaft 12 but mounted for rotation therearound as by bearing means indicated at 24 is a conical die carrier 25 to the larger end of which is affixed an annular or toroidal die 26, the outer or left hand annular face of which carries a die cover 27 for forming a pelleting chamber within die 26 to receive the material to be pelleted. Die carrier 25, die 26, and die cover 27 are all driven for rotation about the axis of shaft 12 in known manner as by a V-belt drive comprising the large pulley 30 and belts 31, all driven from drive pulley 32 and motor 33 mounted, as by a suitable adjustable mounting 34, on base 11. A plurality of cut-off knives 37 are mounted on an annular carrier 38 for rotation around the outside of die 26 (as driven by belt 39 with a variable speed adjustment indicated at 40) for cutting pellets extruded through die 26, and extrusion openings 41 therein, into the desired length of pellet. The rotating die and associated mechanism are enclosed within a housing 45, having a discharge opening 46 at the bottom thereof and a central inlet opening through which extends inlet chute 47 for conducting material to be pelleted through casing 45 and into the interior of die cover 27 and die 26.

As will be understood from the foregoing, material to be pelleted, either as a dry mass or somewhat sticky mash, is introduced through inlet chute 47 into the interior of die 26 and die housing 27. With rotation of these members, the material is carried on the annular inner surface of die 26 around and into contact with one or the other of rollers 20 and 21. The axes of these rollers, of course, are maintained stationary by spider 15, although each of the rollers 20 and 21 is freely rotatable on the axis thereof. Thus the material to be pelleted is forced by the rolling pressure of rollers 20 and 21 outwardly through extrusion openings 41 in die 26, to emerge from the outer face thereof as a self-sustaining extruded mass, which is cut to the proper length by cut-off knives 37 cooperating with the outer circumferential face of die 26, all in known manner. In such an arrangement, then, the above noted considerations become apparent as involving the desired cooperative relationship of the rollers 20, 21 with rotating die 26 and the desired frictional driving of the rollers by the moving die surface for effecting extrusion of all the material through the die openings as efficiently and continuously as possible.

The individual rollers 20 and 21 are mounted, as noted, on spider 15 as by shafts 50, the outer ends of which are clamped by member 51, with the axes of the shaft being indicated, as noted, at 22 and 23. As more apparent in FIG. 3, each roller satisfactorily comprises an inner core portion 55 mounted for rotation around shaft 50 as by bearing mechanism indicated generally by tapered bearings 56 in FIG. 3, which the working surface of the rollers being formed by a hollow shell 60 fitting around core 55 and affixed thereto as by a plurality of bolts or cap screws 61. In the drawing, a portion of the shaft 50 and inner core 55 has been omitted from FIG. 3 to clarify the showing of hollow roller shell 60, which may satisfactorily be formed of case hardened steel or like materials adapted to withstand the attrition or abrasive action to which the surfaces of the rollers 20 and 21 are subjected and readily susceptible to such exact or close tolerance finishing or fitting with the surface of die 26 as may be desired.

In accordance herewith, the outer circumferential surfaces of roller shells 60 are provided with a pattern of indentations as indicated in FIGS. 3–6, with satisfactory results being achieved by drilling the various indentations 65 into the shell surface. Preferably the axes and/or walls of the indentations are provided generally more or less tangential to the circumferential surface of the rollers such that, with the roller oriented with respect to the direction of rotation desired, a maximum frictional driving force and a substantial tangential moment of force are imparted to the roller in indentations 65 by the action of the mass of material being pelleted as it passes between the roller and the mating surface of the die. When the indentations 65 are formed by drilling into the circumferential surface of roller shell 60, however, a truly tangential direction may be difficult or impractical to obtain with the usual manufacturing or machine shop operations.

Accordingly, with drilled indentations 65, satisfactory results have been achieved by aiming a drill bit as nearly tangential as reasonably practical on the cylindrical roller shell 60. More specifically, satisfactory results are achieved with a roller shell 60 having an outside diameter of about 8⅛" if the axis of each of the various indentations 65 is drilled approximately 1" removed from the radius to which such axis is parallel. Such an arrangement gives the desired substantial tangential force or thrust from the orientation of indentations 65, while yet providing an arrangement susceptible to convenient drilling with a drill bit attacking the circumferential surface of roller shell 60 at an angle. As further illustrative of the foregoing, note FIG. 6 where the axis of the right hand indentation 65 is approximately parallel to the dot-dash radius R of roller shell 60 yet approximately 1" offset therefrom. As also indicated on FIG. 6 by the curved arrow, the angling of indentations 65 with respect to the radius of roller shell 60 and the circumferential surface thereof is arranged as shown when roller shell 60 is to rotate in the direction indicated by the curved arrow.

In this manner, as the die rotates and forces material to be pelleted between the die surface and roller shell 60, such material is packed into indentations 65 and, because of the angled or offset orientation of the indentations, transmits to the surface of roller shell 60 an increased moment of somewhat tangentially directed force to augment the frictional driving of roller shell 60 in the desired direction of rotation. Similarly, the engagement of a mass of material to be pelleted in the various indenta-

tions 65 provides a substantially continuous layer or mat of material to be pelleted over the circumferential surface of roller shell 60 in a manner which also exercises some insulating effect on the surface of roller shell 60 to decrease abrasive wear thereof.

As will be understood, the particular size and number of indentations 65 over the surface of roller shell 60 and the angle of offset placement thereof may all vary over wide ranges and be determined in large measure by the particular material being pelleted, the relative sizes of the rollers and die, the desired speed of operation, and the inherent tendency of undesired slippage under various operating conditions. As specifically illustrative of an arrangement with which satisfactory results have been achieved with a variety of pelleting materials or mashes, however, a roller shell 60 of the above noted 8⅛" diameter was provided with indentations 65 arranged substantially as indicated in FIG. 5 and in 19 rows of indentation around the roller shell with 100 indentations per roll to give a total of 1900 indentations over the entire circumferential surface of the roller shell. In such case, the indentations were drilled 3/16" deep and with 3/16" diameters offset from the parallel radius by about 1" as noted and arranged in the staggered pattern of FIG. 5.

It is also to be emphasized that the indicated pattern of indentations 65 is specifically arranged on the circumferential surface of roller shell 60 so as to leave intact full diameter rim sections 66 around each end of roller shell 60, which indentation-free rims are provided to avoid or minimize the possibility of the pelleting material escaping beyond the edges of roller shell 60 and thus avoiding the pressure extrusion action desired. When it is realized that actual contact with the inner surface of die 26 may be provided against the circumferential surfaces of roller shell 60 at each contacting nip between rolls 20 and 21 and die 26, it is apparent that rims 66 will avoid or reduce the possibility of pelleting material escaping the desired pressure action. Similarly, notwithstanding such close fitting of roller shell 60 and die 26, still the above mentioned insulating mat or effect of the material being pelleted is achieved as all the hundreds of indentations 65 are filled with the material, and in a manner to aid in the rotational driving of roller shell 60 as desired as additional material is forced through the nips between the rollers and the rotating die surface. Even in the type of pelleting apparatus where it is the rollers (through spider 15) which are driven for rotation against a stationary die surface, the angled orientation of indentations 65 still enhance the frictional contact desired and the uniformity of an insulating layer of pelleting material on the surface of roller shell 60, although in such a case the driven rollers may be oppositely oriented regarding the angled offset of indentations 65 and the direction of rotation from that noted in FIG. 6.

As will be understood from the foregoing, the angled orientation of indentations 65, as well as the proximate placement thereof, may vary considerably as the size and depth of the indentations vary, both from the standpoint of obtaining optimum results in accordance herewith and of the facility of forming the indentations if they are drilled. Even when the various indentations 65 or pattern thereof are formed by some method other than drilling (as by molding or casting or the like), it is still preferred to have the indentations offset in the manner noted above and with respect to the radius of shell 60 and properly oriented as to the direction of rotation of the roller. It is also preferred to have such indentations of symmetrical configuration, and preferably round, for optimal engagement of and with the material being pelleted.

Accordingly, there are provided in accordance herewith rollers (or roller shells) having on the surface thereof a pattern of specifically oriented and arranged indentations for enhancing both the frictional driving force imparted to the surface of the rollers and the forming thereover or therein of a protective or insulating mat or body of the mass of material to be pelleted. Furthermore, these advantages are achieved while still maintaining a solid axial rim portion of the surface around both ends of the rollers to prevent material escaping beyond the ends of the roller and avoiding the desired pressure action for forcing the material through the extrusion openings 41 in die 26 with maximum efficiency and productive capacity during each rotation of the die and the rollers with respect thereto.

Similarly, such indentations are readily applied to the surface of the rollers and, with the use of roller shells as illustrated, a variety of different sizes or patterns of indentations can readily be provided to be changed on the pelleting apparatus if desired according to the particular characteristics of the material being pelleted. Such replacement of roller shells does not interject particular complications into the use of the apparatus because, as well understood, the die 26 is frequently and routinely changed (even several times a day) to accommodate different materials being pelleted and/or to provide different sizes or shapes of pellets.

Since neither the sizes nor number nor pattern of indentions 65 is necessarily related to the size or number or shapes of extrusion openings 41 in die 26, however, there is no necessity for changing roller shells 60 each time die 26 may be changed, and one particular pattern or arrangement of indentations 65 (such as that specifically described above as illustrative) produces satisfactorily enhanced results with a wide variety of materials to be pelleted. Even where certain materials may not absolutely require an indented or textured surface of roller shells 60 in order adequately to transmit the friction driving force desired, still the shells as illustrated above achieve desired results, so that a single arrangement of the improved roller surface in accordance herewith produces satisfactory and enhanced results with a wide variety of material to be pelleted throughout a wide range of operation conditions for the pelleting apparatus and even with a wide variety of different dies with different extrusion openings therein.

While the structures and apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise structures and apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A pressure roller for cooperative driven relation with the surface of an extrusion die in pelleting apparatus in which material to be pelleted is forced through extrusion passages in said die under the action of said pressure roller on said material on said die surface, which comprises in combination a shaft for supporting said roller disposed in operative relation to said surface of said die, means for mounting said roller on said shaft for rotation with respect thereto as driven by said surface of said die, a pattern of uniformly spaced indentations in the circumferential surface of said roller and extending substantially entirely over said surface for engaging and entrapping material to be pelleted as said roller contacts said material on said surface of said die, and the individual transverse axes of said indentations being disposed at a substantial angle to that radius of said roller which intersects each said indentation axis for providing a substantially tangential moment of driving force for said roller from said die surface and through said material to be pelleted entrapped in said indentations.

2. A pressure roller for cooperative driven relation with the inner annular surface of an annular rotative extrusion die in pelleting apparatus in which material to be pelleted is forced through extrusion passages in said die under the action of said pressure roller on said material on said die surface, which comprises in combination a shaft for supporting said roller disposed in operative relation to said surface of said die, means for mounting

said roller on said shaft for rotation with respect thereto as driven by said surface of said die, a pattern of uniformly spaced circular indentations in the circumferential surface of said roller and extending substantially entirely over said surface for engaging and entrapping material to be pelleted as said roller contacts said material on said surface of said die, the individual transverse axes of said indentations being disposed at a substantial angle to that radius of said roller which intersects each said indentation axis for providing a substantially tangential moment of driving force for said roller from said die surface and through said material to be pelleted entrapped in said indentations, and rim portions around the axial edges of said circumferential surface of said roller which are free of indentations and have a diameter at least equal to the greatest outside diameter of said roller for preventing escape of material to be pelleted axially outwardly along the surface of said roller as said roller contacts said die surface.

3. A pressure roller for cooperative driven relation with the inner surface of an annular rotating extrusion die in pelleting apparatus in which material to be pelleted is forced through extrusion passages in said die under the action of said pressure roller on said material on said die surface, which comprises in combination a shaft for supporting said roller disposed in operative relation to said surface of said die, means for mounting said roller on said shaft for rotation with respect thereto as driven by said surface of said die, a hollow roller shell forming the working surface of said roller, a pattern of uniformly spaced circular indentations in the circumferential surface of said roller shell and extending substantially entirely over said surface for engaging and entrapping material to be pelleted as said roller shell contacts said material on said surface of said die, the individual transverse axes of said indentations being disposed at a substantial angle to that radius of said roller shell which intersects each said indentation axis for providing a substantially tangential moment of driving force for said roller shell from said die surface and through said material to be pelleted as packed into said indentations, and rim portions around the axial edges of said circumferential surface of said roller shell which are free of indentations for preventing escape of material to be pelleted axially outwardly along the surface of said roller shell as said roller contacts said die surface.

4. A pressure roller for cooperative relation with the

inner surface of an annular rotating extrusion die in pelleting apparatus in which material to be pelleted is forced through extrusion passages in said die under the action of said pressure roller as driven by said die surface and said material thereon, which comprises in combination a shaft for rotatably supporting said roller disposed in operative relation to said surface of said rotating die for driving engagement therewith, a pattern of uniformly spaced indentations in the circumferential surface of said roller and extending substantially entirely over said surface for engaging and entrapping material to be pelleted as said roller contacts said material on said surface of said die, the individual transverse axes of said indentations being disposed at a substantial angle to that radius of said roller which intersects each said indentation axis, and said axes of said indentations being inclined away from said intersecting radii in the peripheral direction of rotaton of said roller for providing a substantially tangential moment of driving force for said roller from said die surface and through material entrapped in said indentation.

5. A pressure roller for cooperative relation with the surface of an extrusion die in pelleting apparatus in which material to be pelleted is forced through extrusion passages in said die under the action of said pressure roller working against said material on said die surface, which comprises in combination a shaft for rotatably supporting said roller disposed in operative relation to said surface of said die, means for driving said roller for rotation over said surface of said die, a pattern of uniformly spaced indentations in the circumferential surface of said roller and extending substantially entirely over said surface for engaging and entrapping material to be pelleted as said roller contacts said material on said surface of said die, the individual transverse axes of said indentations being disposed at a substantial angle to that radius of said roller which intersects each said indentation axis, and said axes of said indentations being inclined toward said intersecting radii in the peripheral direction of rotation of said roller.

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