The present application relates to a crop wafering machine, to the novel fibrous feed product thereof, and to the overall fiber chopping and wafering process involved.

The invention is particularly adapted for the production of a dense, handy-sized roughage feed product, with the longer ones of the chopped fibers therein retaining sufficient length to promote normal peristaltic action when consumed by livestock so as to avoid diarrhea and gastric disturbances such as dieters wholly of grain meal pellets, for instance, would induce. The instant product, therefore, has this objective distinction as compared to the kindred product produced by what is known as the feed pellet machine. A good subjective distinction between the wafers hereof and a pellet is that the latter is limited to bulk size and smaller; in the present specification, the term wafer or wafer size when referring to the feed product, means an article larger than the bulk size and, in fact, enough large for the dimensions readily to include longer fibers for the roughage purposes just discussed.

The machine, according to this invention, utilizes strictly rotary mechanism internally thereof so that the operation is continuous without reliance upon reciprocatory or stomping action. A centrally located component of the rotary mechanism consists of a multi-bladed feed drum which is surrounded by a plurality, or, if desired, a single worm of the screw conveyor type having a fixed longitudinal axis about which it turns disposed parallel to the feed drum. The drum and the worm have a common support housing providing an overhead chute and the worm continuously turns within a stationary cylinder supported within that housing. A window cut in the tabular wall of the cylinder admits loose material which is fed by the feed drum into the cavities defined between the worm and the inside wall of the cylinder. A fixed cutter bar adjacent the window cooperates with the drum blades to chop the material admitted which is thereafter forced by the worm longitudinally along the inside of the cylinder.

At a point between the feed drum and the worm, a liquid binder is introduced into the loose material so that, in effect, the feed drum has combined function of feeding, chopping, and mixing the material being worked, and the actual chopping and mixing process continues in the moving worm cavities within the cylinder. These cavities have the further functions of rotating and compacting the loose material into a mass as it longitudinally advances through the stationary cylinder. At or adjacent the discharge point of the compacted mass, the inside wall of the stationary cylinder, though unobstructed, nevertheless through friction provides a constriction for slowing the tangential rotation of the mass whereby the turning worm forces the fibrous material into a cylinder together and further provides an offset whereby the mass develops transverse cleavage lines along which pieces of such cylindrical mass separate into individual round wafers. It is this form of solid round wafer that is discharged.

It is apparent from the foregoing that all processing is performed within the single machine. Moreover, the provision of two power input drives and a set of transport wheels thereon enables the present machine to have use immediately in the fields as a so-called "field wafering machine" and also as a "barn wafering machine" for the processing of material already in the mow.

This invention results in various advantages, more than one of which are unattained by ordinary hay-baling methods and more than one of which are unattained by crop-pelletizing machines referred to, namely:

- Chopped fiber length preserving excellent roughage value;
- Enhanced food value;
- Reduced susceptibility to mildew and weathering or other spoilage;
- No injurious heat to grasses being processed;
- All processing occurs in the single machine;
- Equipment is relatively inexpensive and economical to operate;
- Substantial compression ratio resulting in a high-density product; and
- Stable furred-in dimensions without reexpansion or spring-back.

In connection with the last two advantages enumerated, the hardness resulting therefrom does not in any way detract from the edibility of the wafers which are readily masticated and digested as a feed and which, in fact, are quite willingly devoured by livestock. This hardness of the product, once compressed to the high density attainted by my machine, makes it fracturable without appreciably deforming. Thus, the wafer does not tend to compress when stowed in mows or bins and yet the structural integrity or strength under those circumstances is such as to prevent appreciable fracturing. Therefore, though not specifically enumerated above, the advantage is to be appreciated that the ventilation characteristics of my wafers are excellent with a reduction in or with no tendencies toward spontaneous combustion to which slightly moist piles or mows of stacked hay and sometimes bales, for instance, have known susceptibility.

A machine according to the present invention is primarily adapted for processing feed products from farm crops and fodder, in general, and particularly grains, grasses, meal, and the clovers as well as straw. In connection with the grains, I have satisfactorily made wafers consisting of ground feed and the unground grains alone, such as oats; and I have also made wafers consisting of corn with or without the chopped cobs and/or the cornstalks, along with a non-toxic binder. I have made satisfactory wafers of alfalfa and of timothy hay alone and further wafers of the two in various proportions mixed, along with a binder as just noted. Thus, the entire production of stock feed can be processed in my machine; and because of its carbohydrate value, I generally use molasses as the binder. To improve the coat and add weight to the livestock, I sometimes add minor amounts of beef tallow to sorghum molasses in a 10%-90% weight ratio, for instance, and both the unadulterated and this latter mixed binder have proved entirely satisfactory to hold the fibers cohesivey together so that they do not fall apart in the hand or in storage.

While, as just indicated, this machine is primarily adapted for the entire production of stock feed, the principles of the processing are applicable to granular and to fibrous material useful in wafer size for other purposes, such as fuel. This consideration should be borne in mind in the choice of binder. Thus, where the wafers are to be employed as a feed product, the non-toxic binder selected preferably adds food value of its own as well as having bonding properties, and sorghum molasses and tallow or the like are suitably used alone or in the combinations referred to. Where the wafers are to be used as fuel, tar, which is combustible, is desirable as the binder used but not necessarily so. For instance, wafers made of tree leaves, sawdust, wood chips, or wood shavings...
ings are very fragrant in an indoor fireplace if the binder used consists of sorghum molasses at least in part. Further features, objects, and advantages will either be specifically pointed out or become apparent when, for a better understanding of the invention, reference is made to the following written description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a plan view of a machine which embodies the present invention and from which the feed chute appearing in subsequent figures is omitted for simplicity;

FIGURES 2 and 3 are plan and side elevational views of the rotary processing mechanism of the machine and exemplifying the single worm type;

FIGURES 4 and 5 are transverse and longitudinal sectional views taken along the respective section lines IV—IV and V—V of FIGURE 2;

FIGURE 6 is a sectional view of the single worm detail taken along section lines VI—VI of FIGURE 2;

FIGURE 7 corresponds to FIGURE 6 but shows the feed window opening for the worm of FIGURE 6 adjusted to maximum size;

FIGURE 8 is a modified showing corresponding to FIGURE 4 but illustrative of plural worm rotary mechanism; and

FIGURES 9 and 10 complement one another as a conception of what the wafier-size product of the present machine and process would look like if so dissected in a sectionalizing process to keep the fibers intact.

More particularly, a wafering machine is shown in FIGURE 1 having a rotary processing mechanism 12 which is centrally located on a transportable platform 14. A chassis 16 which supports the platform 14 carries a pair of transport wheels 18 at the rear and at the front carries a towing lug 20 for attachment to a tractor hitch.

The rotary mechanism 12 comprises a longitudinal shaft 22 which carries a feed drum 24 and a parallel shaft 26 which carries a helical worm 28 fast thereto constitutes a worm element of the screw conveyor type. The drum 24 and the worm 28 are operatively arranged together below a common hopper chute 30.

The feed drum shaft 22 is journaled at its opposite ends in bearings 32; and at one of these ends, it is aligned with and coupled at 34 to an available power take-off shaft 36. A three-phase electric motor 38 provides a separation of power, being connected by a coupling 40 through a speed reducer gear box 42 to the feed drum shaft 22. An electric cord 44 enables the operator 36 to run from an outlet service box located in a barn or other building and the motor draws sufficient current through the cord source to furnish twenty horsepower.

The worm shaft 26 is journaled in a fixed pair of thrust-resisting outboard bearings 46 and carries a sprocket 48 at its fixed extremity. A sprocket chain drive 50 feeds into the input side of the feed drum shaft 22 and drives the sprocket 48 and shaft 26 in the same unidirectional sense and at the same speed of rotation as the input shaft 22.

The worm 28 is inside a hollow stationary cylinder 52 having a rectangular feed window 54 cut in the tubular wall thereof. A longitudinally extending cutter bar 56 is disposed between the window 54 and the feed drum 22 and cooperates with the latter to chop the material and deliver it through the window 54. A valve-controlled manifold 58 is connected at one end to a tank 60 holding binder liquid and at the other end the manifold 58 applies the liquid to the material being worked by means of a plurality of open nozzles 62. The hollow or tubular cross section of the window opening 64 of the compounded facing-together material through an offset extension 66 having the same inside diameter as the cylinder 52.

In FIGURES 2, 3 and 4, the hopper chute 30 has a frusto-pyramidal shape and at its smaller lower end is secured to an upright generally rectangular housing 68 of hollow construction for supporting the rotating mechanism. A fixed ring 70 through which the cylinder 52 passes at one end is welded to that end of the housing 68 and a clamping ring 72 through which the cylinder 52 passes at the opposite end of the housing is affixed by bolts 74 to that end of the housing 68.

Five web-shaped arms 76 in the form of helical blades extend radially from the feed drum shaft 22 and at the outer end each arm 76 carries a transverse extension 78 which is directed circumferentially outwardly from the extreme edge of the helical blade. The leading edge of each blade drags past the straight edge of the longitudinal cutter bar 56 with a unidirectional shearing action.

In FIGURE 5, the worm 28 is a right-hand screw so that when rotated in the direction indicated it forms with the cylinder 52 inside cavities that move past the feed window 54 leftwardly as viewed in FIGURE 5. The extreme left end of the worm 28, as seen in FIGURE 5, was in one physically constructed embodiment of the invention made undersize to give room to metallically build up the peripheral web pieces thereof with an antifriction layer of deposited SAE bearing bronze. Thus, the free end of the shaft 26 works bearing-free and yet the worm 28 is piloted at that end because it effectively journals itself directly to the inside of the cylinder 52 with a self-centering action. One effect of this bearing-free construction is that there is a driving action not only from the feed drum operation but also it occurs within the fixed cylinder 52 due to the contact of the wear edges of the worm therewith. Another beneficial effect is that the bearing-free end of the worm 28 as it discharges the material from the moving cavities causes the material to compact itself in a unitary cylindrical mass with a solidly filled core owing to the fact that the shaft 26 terminates adjacent its discharge end and thus there is neither bearing nor shaft obstructing the path so as to displace the mass from compacting.

The cylindrical mass, because of the absence of displacement metal as just referred to, completely fills the outlet space between the extension 66 of the stationary cylinder and the free end of the worm 28. Friction established by the walls of the outlet section of the cylinder constrains passage of the cylindrical mass so that it not only compacts but loses its rotational component with the result that the free end of the worm 28 in passing frictional forces the fibers of the mass into an oriented relationship in which they are substantially tangentially disposed both in the core and outwardly throughout the body of the solid cylindrical mass.

The offset extension 66 further constrains passage of the cylindrical mass and, in addition, causes it to undergo lateral displacement as it progresses. Though not unfailingly so, transverse slip planes usually develop which intersect one another to form transverse lines of cleavage along which portions of the cylindrical mass separate within the extension into individual round shapes 64 of water size which are individually discharged from the extension 66. The extension 66 had a developed length of 3 1/4" and was curved on the arc of a circle.

The cylinder 52 is journaled within the fixed ring 70; and in vicinity of the clamping ring 72, the cylinder 52 carries a transverse flange 80 made fast to the end thereof. Release of the bolts 74 to the clamping ring 72 makes the cylinder 52 capable of limited angular movement by hand for purposes of making minor adjustments to the effective size opening of the feed window 54.

In FIGURE 7, the effective size opening of the window opening 54 is shown adjusted to its maximum open position with respect to the cutter bar 56 for receiving the general run of ensilage which, has a fairly coarse stalky consistency for a good part of its weight. Adjusting the machine for the proper size opening is largely a matter of experience and depends, among other things, on the choice of binder, ambient temperature, the presence of granular material
or not, moisture content, and the coarseness of the fibrous materials, if any.

It is noted that the backwardly turned, circumferential extensions 24 on the radial blades of the feed drum physically confine the just-chopped or the just-ground material pretty largely in the space between the drum and the worm 28 and so for the necessary time interval they insure that the material will be forced to fall through the feed window 54 and be trapped in the passing worm cavities.

In the modified rotary processing mechanism 82 shown in FIGURE 8, a plural worm arrangement is shown about the common feed drum 14. Thus, each of worms 28a and 28b turns concentrically within an appropriate stationary cylinder 52a and 52b; moreover, a series of cutter bars 56a and 56b is individually engaged by different ones of the cutting blades to deliver the chopped or ground material through the feed windows (not shown) into the cavities defined by the worms within the stationary cylinders. The support housing 63 is preferably, if changed at all in this embodiment, made slightly larger than in the preceding embodiment to provide increased material-holding capacity and better access to the feed windows.

In the conception of FIGURE 9, the present invention comprises a solid-core round wafer. A wedge has been cut from one edge of the wafer as represented to show that the fibers remaining are generally tangentially oriented in helically overlapping layers so as to interlace in the body of the wafer. The near end of the wafer 64 as clearly brought out in this view shows the result of the counterclockwise rotation of the free end of the worm 28 as it correspondingly helically orients the fibers completely down into the core without twisting or kinking them.

As represented in FIGURE 10, which shows the missing wedge from FIGURE 9, the fibers of the material are shown, according to a greatly exaggerated concept to bring out their degree of helical overlap from which it will become apparent that transverse fracture lines can readily form owing to the limited length to which the fibers are effectively twisted. This limitation on the lengths also prevents kinking, twisting and matting which would occur if the fibers were longer and no attempt were made to keep them oriented. Due to the interlacing, there is little or no tendency for springback or reexpansion of the wafer-size product after it is processed in the present machine.

Variations within the spirit and scope of the invention described are equally comprehended by the foregoing description.

I claim:

1. In a machine of the character described, rotary processing mechanism comprising feed drum and worm elements arranged side by side in a parallel operative disposition, means for rotating said feed drum and worm elements, a housing supporting said elements in the operative disposition described, means rotatably carrying said worm element so as to define a fixed axis therefor including a cylinder element which is held in said housing and in which the worm element is piloted at one end by journaling itself directly to the inside of said cylinder element, said cylinder element having an open discharge portion through which material being processed in the machine is ejected, a chopper bar fixed in said housing to define one side of a feed path for material opening into a window formed in said cylinder element, which cylinder element for a majority of its length being otherwise window-free, said drum element rotating means being adapted to rotate said feed drum element with respect to the fixed chopper bar to chop the material being fed in said path, and adjustable means for holding said cylinder element in said housing in different rotary positions to adjust the effective size of said window opening with respect to the chopper bar, said worm element rotating means being adapted to rotate said worm element with respect to said chopper bar to define worm cavities moving past said window to receive the chopper material from said feed path.

2. In a machine of the character described, mechanism as claimed according to claim 1 in combination with nozzle means for discharging a binder in the general direction of said chopper bar for application to the material being fed in said feed path.

3. In a machine for wafering loose material to a wafering process, the combination comprising a feed drum and a worm element arranged adjacent one another in operative relationship so that said worm element is in operative relationship to receive material from said feed drum, means for rotating said feed drum and said worm element, housing means for supporting said feed drum and said worm element in the operative relationship aforesaid in a position to receive material to be processed, means with a feed window therein cooperating with the worm element to define longitudinally moving cavities into which the feed drum feeds the material as said worm element rotates and comprising a cylinder element concentrically surrounding said worm element as the worm element rotates about a fixed axis in said housing means, said cylinder element having an open discharge portion through which the material is ejected, said cylinder element being journalled at spaced points to bore means defining a fixed axis about which said cylinder element is capable of limited rotation with respect to the housing means to adjust the effective size of said window opening, said cylinder element having a free end extending beyond the corresponding end of said worm element and said housing at that end, said worm element having a shaft portion which is free of connection enabling the worm to be piloted in the cylinder element by journaling itself directly thereto at that end.

4. A machine for wafering workable material comprising a feed drum element having blade means, a worm element arranged adjacent said feed drum element in operative relationship so that said worm element is in position to receive material from said feed drum element, means for rotating said feed drum and worm elements, an overhead chute common to said drum and worm elements, housing means for supporting said elements in the operative relationship aforesaid in a position below said chute to receive material to be worked therefrom, a cylinder in concentric surrounding relationship to and journalling said worm element for rotation about a fixed longitudinal axis within said housing means, said cylinder element having a shaft portion through which the material is ejected, said cylinder element being structurally adapted for rotation, adjustable means for retaining said cylinder in position, the wall of the cylinder having an opening formed therein at a point exposing an adjacent portion of the worm element within said cylinder, and a longitudinally extending chopper bar between said feed drum element and said opening and having a straight edge which cooperates with said blade means upon rotation of said feed drum element to provide a unidirectional shearing action, said chopper bar with the cylinder element forming a feed window through which chopped mater from the feed drum element enters the cavities defined between the worm element and its surrounding cylinder, said adjustable means permitting setting the rotative position of said cylinder so as to adjust the effective size of the feed window opening.

5. In a machine for wafering workable crop material, the combination comprising a feed drum element having blade means, a worm element arranged adjacent said feed drum element in operative relationship so that said worm element is in operative relationship to receive material from said feed drum element, housing means for supporting said elements in the operative relationship aforesaid in a position to receive material to be worked, a stationary cylinder in concentric surrounding relationship to and journalling said worm element for rotation about a fixed longitudinal axis
within said housing means, said cylinder having an open discharge portion through which the material is ejected, said cylinder having a feed window, a cutter bar between said feed drum element and said feed window and having a straight edge which cooperates with said blade means upon rotation of said feed drum element to provide a unidirectional shearing action, said cutter blade forming one side of a path of travel for material between said feed drum element and said worm element, and power means connected for simultaneously rotating said elements for forcing the feed drum element to move the material continuously into the longitudinally moving cavities defined between said rotating worm element and the stationary cylinder within which the said worm element is journaled.

6. A machine for wafering fodder, meal, and like workable material comprising a drum element and a worm element arranged adjacent one another in operative relationship so that said worm element is in position to receive material from said feed drum element, means for rotating said drum and worm elements, overhead feed means common to said drum and worm elements, means for supporting said elements in the operative relationship aforesaid in a position below said overhead means to receive material to be worked therefrom, a stationary cylinder in concentric surrounding relation to and journaled said worm element for rotation about a fixed longitudinal axis within said supporting means, said cylinder having an open discharge portion through which the material is ejected, said cylinder having a feed window, said drum element comprising a unidirectionally rotating plurality of radially disposed blades each provided with a backwardly directed circumferential extension thereon, and fixed cutter means between said drum element and said window and cooperating with said blades and with the circumferential extensions thereon to define a confined path from which chopped material is forced into the longitudinally moving cavities defined between said worm and the stationary cylinder within which it is journaled.

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