May 14, 1968 T. B. WAYNE 3,382,904

VERTICAL UPFLOW MILL

Filed Oct. 16, 1964 2 Sheets-Sheet 1

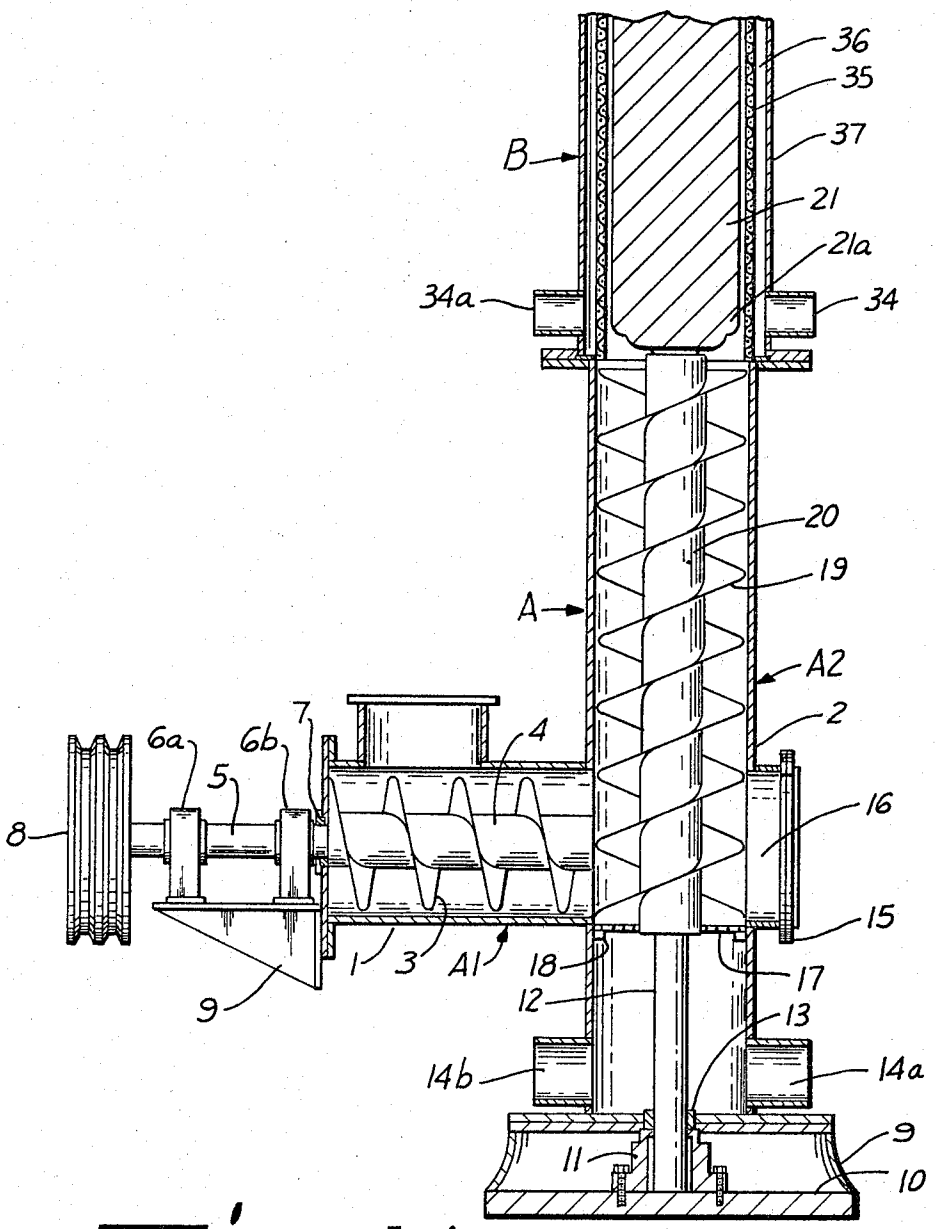


Fig. 1A

TRUMAN B. WAYNE
INVENTOR.

BY Browning, Simmes, Hyer & Eisenrocht
ATTORNEYS

May 14, 1968 T. B. WAYNE 3,382,904

VERTICAL UPFLOW MILL

Filed Oct. 16, 1964 2 Sheets-Sheet 2

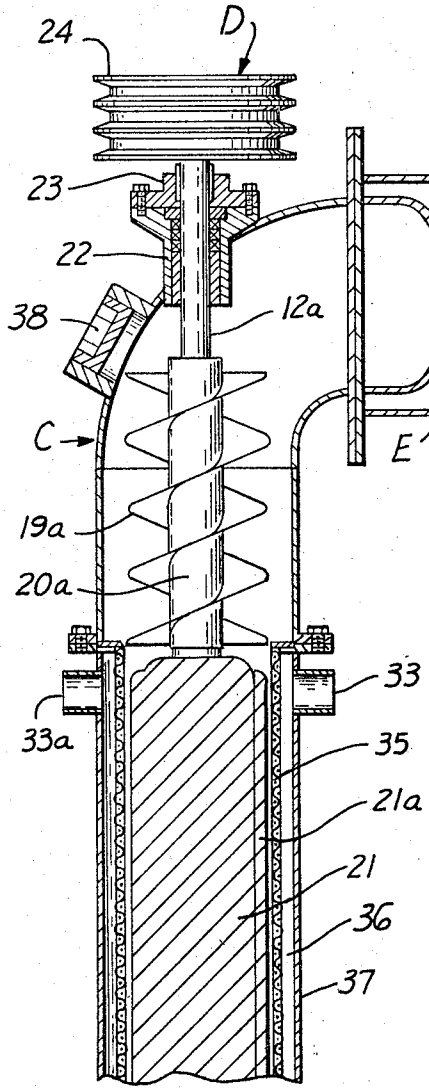


Fig. 1B

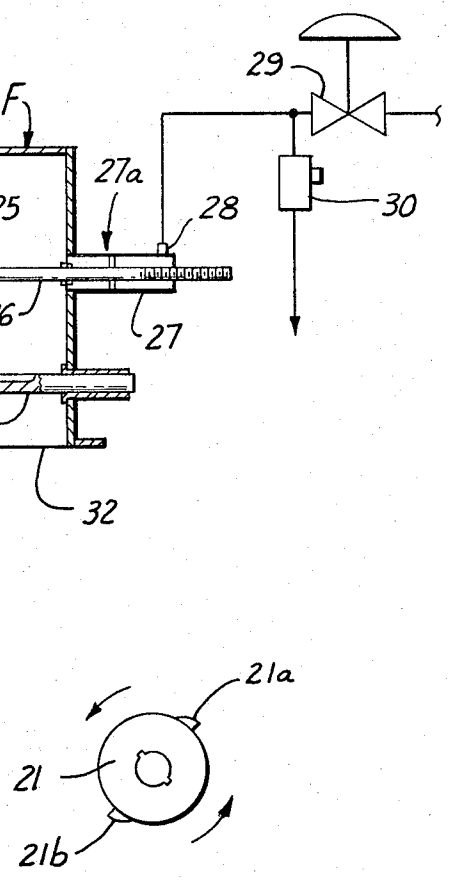


Fig. 2

TRUMAN B. WAYNE
INVENTOR.

BY Browning, Simmons, Hyer & Eisenbrandt
ATTORNEYS

United States Patent Office 3,382,904 Patented May 14, 1968

3,382,904

VERTICAL UPFLOW MILL

Truman B. Wayne, P.O. Box 13086, Houston, Tex. 77019

Filed Oct. 16, 1964, Ser. No. 404,315
10 Claims. (Cl. 146—256)

ABSTRACT OF THE DISCLOSURE

An improved vertical upflow mill for milling grains such as rice and barley. It is particularly adapted for milling brown rice. It may also be used to carry out a solvent extraction process on the grain during the milling operation.

This invention relates to improvements in mills for milling grains of the class of rice and barley. It is particularly useful in milling brown rice, and especially for simultaneous solvent extraction and milling of this grain but is not limited to such use.

In the conventional rice milling process of commerce, the rough, or paddy rice, is first cleaned of dirt, straw and other debris and is sent to stone or rubber shellers which remove the hulls and some loosely adhering bran within the hull enclosure and surrounding the more adherent bran layers over the endosperm.

Rice with its hulls removed is called "brown rice" and retains its light bran coat. This bran coat is made up of seven distinct layers which envelope the starchy interior of the kernel. Most of the six outer layers and part of the seventh, or aleurone layer, are removed in the succeeding operations. Since the aleurone cells are rich in protein and this constituent is present also in the endosperm, only about 10% of the protein of the hulled rice is removed in the milling process. The oil, present largely in the germ, is usually removed to the extent of about 85%, and the proportion of mineral salts is reduced nearly 70%.

The mills used for removing the bran coats from the endosperm may be of horizontal or vertical type. The horizontal mills in most common use consist essentially of a horizontal cylindrical or hexagonal shell having perforations therein, a rapidly revolving rotor mounted concentrically with the shell and providing an annular space between the rotor and shell through which rice moves. During passage of the rice through this space, the grains are rubbed against the perforated shell and against each other with sufficient force to remove bran from the rice kernels. This surface grinding operation is carried out under time and feed rate conditions which will produce the desired degree of removal of the outer bran layers from the rice kernel. The milling operation is rather severe and breaks a substantial portion of whole rice grains into two or more fragments, this breakage being due to the combination of effects such as impact, mechanical stresses and generated heat. Breakage of rice kernels is, of course, increased in areas of overpacking and overstressing of rice in the mill. The loss of whole head rice kernels varies with the variety, state of curing, handling in the rice dryer and the subsequent storage and the severity of milling. This breakage results in serious economic loss, as broken rice brings only about half the price of the whole head rice.

An inherent defect in the horizontal rice mill, regardless of how carefully and evenly it is fed, is that the pressure between the rotor and the milling stream is never equal at all points around the 360° annulus between the milling rotor and screen. There is a tendency for the rice to be carried under the rotor by gravity and to form a mass of higher density and compaction than

exists in the area above the rotor. The milling pressure in this area is thus increased and there is some tendency toward stagnation in the movement of the rice through the area. This results in a higher degree of milling, but it also results in increased breakage of kernels.

Vertical rice mills have long been exemplified by the so-called "pearling cones." These employ a conical rotor having an abrasive surface which rotates within a conical, perforated stator. The annulus between the rotor and stator may be increased by a simple adjustment moving the rotor or stator with respect to each other. The principal reason for using the conical rotor and stator is to retard the downward travel of rice through the annulus and to improve the effects of centrifugal force operating within the annulus. Machines of this type unless employed in series, have failed to give satisfactory results in the milling of rice, partially because rice has a strong tendency to fall through the annulus so rapidly that it is not properly milled. If devices of this sort are set with sufficient clearance between the rotor and stator to avoid breakage of rice, incomplete milling has resulted, and if set to provide a clearance small enough to insure complete milling of the rice, there has been sufficient breakage of rice kernels that no advantage has been gained over horizontal mills.

It is an object of this present invention to provide a new type of vertical rice mill which can remove bran from rice kernels with substantial completeness, and at high rate of throughput without excessive breakage of rice kernels.

Another object is to provide a vertical rice mill of the above type in which substantially complete removal of bran from the rice grains may be accomplished without overmilling.

Another object is to provide an improved rice mill of the above type in which relative overpacking of a lower section of the milling annulus does not occur.

Another object is to provide an improved rice mill of the above type which is especially adapted for use with simultaneous wet milling and solvent extraction.

Other objects and advantages will become apparent to those skilled in the art from consideration of the following detailed description and the attached drawings.

The mill of the present invention includes a feed section arranged to introduce brown rice, which may, if desired, be wet with an oily miscella or other bran softening agent described in my copending applications Ser. No. 308,560 filed Sept. 12, 1963 and Ser. No. 308,115 filed Sept. 11, 1963, both now abandoned, into a vertical screw elevator disposed to pass the rice upward through a vertical milling section superimposed upon and concentric with the vertical screw elevator. The milling section includes a housing, which preferably is an upward extension of a vertical, cylindrical housing of the screw elevator, a perforate milling screen within, concentric with, and spaced from the housing, and a rotor, preferably mounted with the elevator screw flight section upon a common central shaft, and located within and concentric with the screen. Separate shafts and drive means for the rotor and elevator, respectively, may be used if desired, but this increases the complexity of the construction and operation of the mill without corresponding increase in advantage. The rotor is of such diameter as to provide a selected clearance between it and the screen, effective to agitate the rice and rub the grains against each other and the milling screen, as the rice is passed upward by pressure from the vertical screw elevator through the annulus provided by this clearance.

The housing enclosing the milling screen is liquid tight, and a means is provided for introducing miscella through nozzles in the housing to flush the surfaces of the per-

forate milling screen. A means for draining the flushing miscella and bran solids from an annular space between the screen and housing also is provided. A second section of vertical screw elevator is arranged in an upper part of the housing to receive milled grain from the milling section and deliver it to a discharge nozzle. The discharge nozzle is fitted with means to maintain and regulate a back pressure on the rice, preferably a pressure discharge gate responsive to a means for maintaining a regulating pressure on the discharge gate, and a discharge housing is provided for receiving the milled products from the discharge gate and discharging them from the mill.

While this mill is particularly useful in the solvent extractive milling of rice, it may be used for milling other cereal grains when it is desired to remove the external bran coat and germ fractions while substantially preserving the remaining endosperm portion in its unbroken original form. My invention includes a milling process comprising introducing husked grain retaining its bran coat into a mill, introducing an extractive solvent or an oil-containing miscella into the mill in quantity to form a solid-liquid slurry with grain; passing the slurry upward through the mill; milling bran from the grain during its upward passage through the mill; withdrawing miscella and bran from the mill; passing the grain upward above a level from which miscella is withdrawn to a point of discharge from the mill and maintaining a selected back pressure on the grain. It is believed that the invention may be more clearly understood from consideration of the following detailed description and the attached drawings wherein:

FIG. 1A is an elevational view in section of the lower portion of the apparatus containing the feed screw assembly.

FIG. 1B is an elevational view in section of the upper portion of the apparatus containing the milling section and discharge section.

FIG. 2 illustrates an end view of the milling rotor.

The embodiment illustrated in the drawings comprises a feed screw and screw elevator section A, an intermediate wet milling section B, a discharge head C upon which is mounted the drive assembly D, a discharge nozzle E and a discharge housing F.

Section A comprises the complete feed screw assembly designated as A–1 which includes a screw housing **1** attached to housing **2** of the screw elevator assembly A–2 by welding, bolted flanges or in any other suitable manner. The screw housing **1** may enter the housing **2** as a straight intake at an angle of 90° as illustrated, or as an offset or tangential intake as desired. The feed screw includes a spiral **3**, which may be standard or short pitch, and single or double flight as desired, firmly attached to a central pipe or solid shaft **4**. A drive shaft **5** is coupled to shaft **4** and is mounted through double outboard bearings **6***a* and **6***b* and also stuffing box or liquid mechanical seal **7** and is driven by means of drive sheave **8** or alternate means which is operated by a suitable propulsion unit. The entire assembly is supported by the bracket **9** which is in turn properly supported on a structural member as desired.

The screw elevator assembly A–2 contains a base **9** having a base plate **10** in which is bolted a replaceable step bearing **11**. A vertical shaft **12** projects into step bearing **11** and is held in running position by a set collar **13** which is keyed to the shaft, or otherwise rigidly attached thereto. The housing **2** has liquid inlets **14***a* and **14***b* which may be half pipe couplings welded into the wall of the housing **2**, and a flanged combination clean-out door and sight glass **15** mounted on flange nozzle **16**. The liquid inlets **14***a* and/or **14***b* may also function as liquid drains under conditions of countercurrent flow. A means for allowing free upward circulation of liquid while preventing entry of large grain particles into the section below, illustrated as perforated metal plate **17** having oblong perforations therein, is supported within housing **2** on a suitable support illustrated as ring **18**. The plate **17** preferably is made up of two 180° plate sections so that they may be readily removed and replaced through the clean-out door **15**.

A helical flight **19**, which may be standard or short pitch single or double flight, as desired, is firmly attached to a pipe or solid shaft **20**. Shaft **20** may be a continuation of solid shaft **12** but it preferably is of pipe construction which may be joined to shaft **12** by welding or preferably by any suitable means so that shaft **12** may be a short end shaft which is easily replaceable. However, when sections B and C are short, the shaft **12** may continue through the milling rotor **21**, helical flight **19***a*, pipe shaft **20***a* and stuffing box **22**. A preferred arrangement, particularly when sections B and C each exceed 24 inches in length is to couple pipe shaft **20***a* to the upper end of an extension of shaft **12** through rotor **21**. Shaft **12***a* is coupled or otherwise attached to the upper spiral flight comprising pipe shaft **20***a* and flight **19***a*, and extends through the stuffing box housing **22**, bearing **23** and sheave **24**. The revolving components through which shafts **12** and **12***a* pass are locked on the shafts by suitable bolted or threaded couplings or keys, keyseats and set screws to provide the required attachment and to maintain proper alignment.

The discharge nozzle E is attached to the discharge head C by suitable means such as flanged or screwed connections. It contains a concentric or preferably an eccentric swaged fitting having its smaller end beveled where it contacts discharge gate **25**. The gate **25** is attached rigidly or with a ball and socket or swivel attachment to shaft **26** which is an extension of a piston rod in an air or hydraulic cylinder **27**, attached to a piston movable therein.

To illustrate the operation of the cylinder by means of air, although an analogous hydraulic fluid system is contemplated as an equivalent thereof, control air is admitted to cylinder **27** through inlet **28**. Air pressure regulator **29** provides air at any desired pressure between 0 and 40 p.s.i. The pressure on the piston of the air cylinder is set by operation of flow control device **30** which is normally closed. However, if the rice pressure against the discharge gate **25** exceeds the pressure imposed by the pneumatic cylinder at the selected control air pressure, or the air pressure downstream of air pressure regulator **29** exceeds the control air pressure setting, the flow control device **30** will open and discharge air to the atmosphere until the pressure has returned to the pressure which it is desired to be maintained on the air cylinder. Other equivalent means for maintaining selected pressure on the gate **25** may be other forms of linear actuators as, for example, hydraulic cylinders, spring loaded adjustable pressure devices, ball screw actuators, linear induction motors and other forms of mechanical transducers which are capable of transmitting a predetermined and fully adjustable amount of pressure to the discharge gate.

The milling pressure within the apparatus is thus controlled by maintaining sufficient pressure against the discharge gate **25** to partially oppose or counteract the discharge pressure within discharge nozzle E, and which will produce the desired degree of milling as observed by means of the sealed sampling device **31**. The milled rice together with some of the freed bran coat co-mingled therewith are discharged from the apparatus nozzle **32** to any desired bran separation and solvent recovery apparatus.

The operation of the improved milling process of the present invention utilizing the apparatus assembly described above is as follows:

Brown rice, which is the rice kernel with its original bran coat and germ in the form from which it emerges from a shelling or husk removing operation, is admitted through a spout or chute into feeder section A–1 where it is conveyed into the screw elevator section A–2. The brown rice is contacted and wetted with recycled strong

miscella, or a more dilute miscella or solvent, as soon as it enters the feeder section and travels upward through the screw elevator section. The miscella, which consists of an extractive solvent containing rice oil, is recycled from a settler or other subsequent extraction step or apparatus (not shown) which receives miscella from a previous milling or extraction cycle, is admitted through either or both nozzles **14** and **14***a* and rises in the apparatus to at least the overflow level of nozzles **34** and **34***a* where it leaves the apparatus and returns to the miscella settler.

The screw elevator when used on free flowing materials becomes a semi-positive displacement unit only after it is primed in much the same manner as a centrifugal pump, i.e., the casing and screw flight must be filled in solid cross section with the material to be elevated before it will operate. Thus, it is in principle a pump. In order to elevate materials it must revolve at a sufficiently high rate as to overcome the force of gravity upon the material. Otherwise, a free flowing material will trickle down between the screw flight and casing, and slide down the helical flight, and thus lose prime and fail to elevate. However, once primed and operated at sufficient r.p.m. it will discharge the material at the same rate that it is fed into the screw. This operation is quite distinct from that of a horizontal screw conveyor which operates strictly as a positive displacement device except for a minor degree of slippage, and will convey at far lesser speeds than will a screw elevator.

The rice will enter the vertical screw elevator from the feed screw as the solid component of a rice miscella slurry. The rice tends to settle rapidly from the slurry when agitation slows down beyond the point at which it will maintain the slurry in suspension. Under conditions of slow rotation of the elevator much of the rice will settle down the annulus between the screw flight and the housing. It is also probable that there will be some sliding of grain down the spiral flight until a consolidated solids column is produced. However, this will occur more slowly and to a lesser extent than were the solids in the dry state in air instead of in a liquid.

For this reason, I prefer to use a high rotation speed for the vertical screw conveyor. Once the fluid column rises sufficiently to form a continuous column in the screw elevator section A, the fast turning screw flight will act as a screw pump if the liquid column is maintained throughout the casing from liquid inlet to the liquid discharge point. If this liquid discharge point is one or both of the lower pair of nozzles **34** and **34***a*, or of the upper pair of nozzles **33** and **33***a*, on the milling section, and there is no liquid above such point, the screw pump effect ceases at this point. If the liquid inlet shown at the bottom of the housing should be shut off, the spiral flight and the milling rotor act merely as agitators since the elevation of liquid above the overflow point cannot occur without losing the prime below that point. When the latter occurs, the liquid level simply falls to again form a solid column. Except at much higher r.p.m. than I contemplate using, the liquid level will not tend to lift and lose prime, so that the screw flight and the rotor will merely act as an agitator for the liquid.

If instead of simply a liquid column there were a solid-liquid slurry, the screw flight will elevate the solids through the liquid column on more nearly a positive displacement principle than if the liquid were not present. The solvent wet rice is somewhat more cohesive than the free flowing rice would be under similar conditions of feed rate and r.p.m. and it will pass through the solvent column and be elevated by the upper screw flight section and packed into the discharge head, apply pressure against the discharge gate and be discharged from the apparatus without the necessity for maintaining the pressure of a full liquid column against the discharge gate. Substantial draining of the milled rice is thus obtained before the rice is discharged.

The rate of discharge of the rice solids under these circumstances is the same as the feed rate once the column is established. Therefore to regulate the milling rate, the feed screw will have a variable speed drive. The degree of milling is regulated by pressure imposed on the discharge gate by the air or hydraulic cylinder, or an equivalent means for regulating the discharge pressure.

I have found that machines constructed as described above and operated as described may be operated at extremely high rates of production when compared with production rates of conventional dry milling machines. Their capacities will vary with such factors as feed rate, revolutions per minute of the vertical screw flight and milling rotor, the degree of milling as determined by discharge gate pressure and to some extent according to the gallons per minute of miscella pumped through the apparatus. One of these machines, however, will do the milling work ordinarily requiring several horizontal rice mills of the types commonly used in rice milling.

Simultaneously with the travel of the brown rice upward through the milling section B where it is agitated and rubbed against perforating milling screen **35** by milling rotor **21**, miscella is admitted through nozzles **33** and **33***a* or similar smaller nozzles placed concentrically with casing **37** to spray miscella on milling screen **35** to keep its perforations open and to wash the solids from the milling operation from the annulus **36** between milling screen **35** and casing **37**. The suspension of solids in the miscella is then discharged through nozzles **34** and **34***a* together with the recycled miscella which was introduced through nozzles **14***a* and/or **14***b*, and is transferred to the miscella settler above-mentioned but not shown in the drawings.

The milled rice which has had its bran coat and germ removed in the milling section B, but which is not completely free of loosely adhering bran particles, is then moved upward into the discharge head C by means of a spiral **19***a* and is accumulated in discharge nozzle E against discharge gate **25** through which it is released into discharge housing F and then leaves the apparatus as previously described.

An alternate method of operation is to maintain a full liquid column throughout the apparatus so that the spiral conveyor sections will act as screw pumps and convey the rice-miscella slurry to the discharge nozzle E and thence out of the apparatus to discharge gate **25** and discharge housing F. The miscella will, in addition, to or in lieu of, flowing through nozzles **34** and **34***a*, and/or **33** and **33***a*, be discharged with the rice through nozzle **32** to a separator reel or vibrating screen (not shown) which effects the separation between the rice and miscella and the bran solids derived from the milling operation before the miscella bran solids slurry returns to the miscella settler previously mentioned. A second alternate method of operation is to introduce the miscella through nozzle **38** and/or through nozzles **33** and **33***a* instead of through the lower nozzles **14** and **14***a* to provide a countercurrent flow. The discharge may occur at discharge nozzle E when containing a full liquid column, and/or at nozzles **34** and **34***a*. Nozzles **14** and/or **14***a* may be used to provide part of the drainage under operation or may be shut off entirely except when used to drain all miscella from the apparatus.

The apparatus is adapted to easy dismantling for insertion of various designs, lengths and types of milling rotors and milling screens; also for extensions of the discharge head C and its screw flight by interposing a section of conveyor casing between milling section B and discharge head C so that apparatus may function as a screw elevator beyond the milling section B to elevate the milled products to any desired discharge elevation. If the total height of the apparatus exceeds 12 feet it is advisable to install internal stabilizers to prevent excessive shafting run-out and whip which may occur in long shaft assemblies. The stabilizer consists of the screw conveyor hanger with a replaceable bearing which is mounted and housed in an access opening (not shown) in the hous-

ing A–2. This is a standard fixture which is used in tall screw elevators and no claim of novelty is made for this particular element. One such stabilizer at each ten to twelve foot increment of shaft length is sufficient. The interposition of the hanger bearing at such points involves an interruption of the continuity of the flight so that the hanger should be designed for maximum strength with a narrow contoured surface to present least interruption and resistance to the continuity of solid flow at hanger locations.

When milling rice, a satisfactory clearance between the ribbed projections 21*a* and 21*b* on the milling rotor 21 and the perforate screen 35 is ¼ inch, but may range between 3/16 inch and 5/16 inch without material loss of milling efficiency. While only one type of rotor is illustrated, it is to be understood that many variations in rotor type may be made if desired. Instead of having two milling ribs arranged vertically, two or more ribs in continuous or broken spirals may be used. When wet milling under the conditions herein described, much of the bran removal and polishing of the milled kernels is accomplished by friction between the kernels. The rotor and perforate stator milling section is therefore of lesser importance in this type of operation than in dry milling machines and even in certain wet milling machines disclosed in other of my pending patent applications.

Screw elevators ordinarily operate at speeds ranging from 275 r.p.m. for a sixteen inch diameter flight to 500 r.p.m. for a four inch diameter flight in casings providing ¼ inch to ½ inch clearance from the spiral flight. I prefer to use four inch or six inch diameter flights attached to shafts made of two inch pipe and 1½ inch couplings in the upflow solvent extractive milling machines described and to operate them within the range of about 500 to 600 r.p.m.

As is evident from the preceding description, the course of the solvent-wet rice is always upward, but the solvent or miscella used to cool the rice, extract the fatty substances and coloring matter and to separate the milled bran coat from the kernels may be concurrent, countercurrent or even in mixed flow with the flow direction of the rice.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus and process.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. An improved mill for rice and barley comprising in combination a vertical milling section, including a housing, a perforated milling screen within and spaced from the housing, and a milling rotor concentric with the milling screen providing a vertical, annular space between the rotor and milling screen; elevator means spaced below said rotor and connected to the housing, for passing grain upward through the annular space between the rotor and milling screen; a discharge head above the milling section connected to receive grain from the space between rotor and milling screen having a discharge nozzle in connection therewith; and means for maintaining a selected back pressure on grain at said discharge nozzle.

2. The mill of claim 1 wherein the elevator means is a screw elevator.

3. The mill of claim 2 wherein the rotor and a screw flight of the screw elevator are mounted on a common central shaft.

4. An improved mill for rice and barley, comprising in combination a vertical milling section, including a housing, a perforated milling screen within and spaced from the housing, and a rotor concentric with the milling screen providing a vertical annular space between the rotor and the milling screen; a screw elevator beneath the milling section, including a housing attached to the housing of the milling section, a central vertical shaft within the housing and a screw flight on the shaft, said screw elevator communicating with the annular space between the rotor and milling screen; a discharge head above the milling section connected to receive grain from the space between the rotor and milling screen, means for maintaining a selected back pressure on grain cooperative with said discharge head; an inlet for solvent in a lower part of the screw elevator and an outlet for solvent in a lower part of the milling section.

5. The mill of claim 4 wherein an additional inlet for solvent is provided in the milling section.

6. The mill of claim 5 wherein the additional inlet for solvent is located above the outlet for solvent providing countercurrent flow of grain and solvent in the milling section.

7. The mill of claim 5 wherein a plurality of inlets for solvent are located in upper parts of the mill and a plurality of outlets for solvent are located in the milling section.

8. The mill of claim 5 wherein a feed section including a substantially horizontal screw conveyor having a liquid tight housing is connected to introduce grain into a lower part of the screw elevator.

9. The mill of claim 5 wherein the means for maintaining a selected back pressure on the grain includes a discharge gate movable to and from seated position on a discharge nozzle in said discharge head and a fluid actuated piston connected to said discharge gate.

10. The mill of claim 9 wherein the fluid actuated piston is pneumatically actuated.

References Cited

UNITED STATES PATENTS

403,389	5/1889	Seck	146—279 X
406,931	7/1889	Moore	146—279 X
489,723	1/1893	Titus	146—285 X
1,188,151	6/1916	Champan	146—285 X

W. GRAYDON ABERCROMBIE, *Primary Examiner.*