Nov. 19, 1968 A. W. FRENCH ET AL 3,411,435

APPARATUS FOR RECOVERY OF SUCROSE

Filed Oct. 18, 1966 2 Sheets-Sheet 1

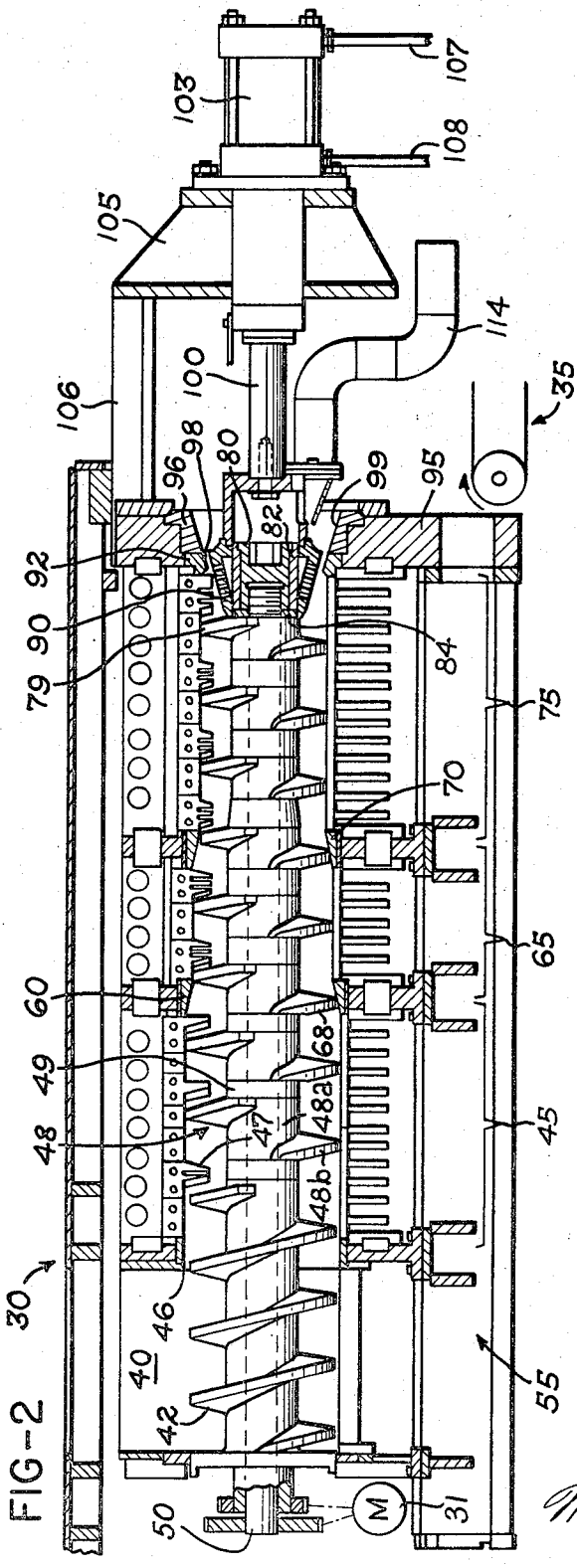


FIG-2

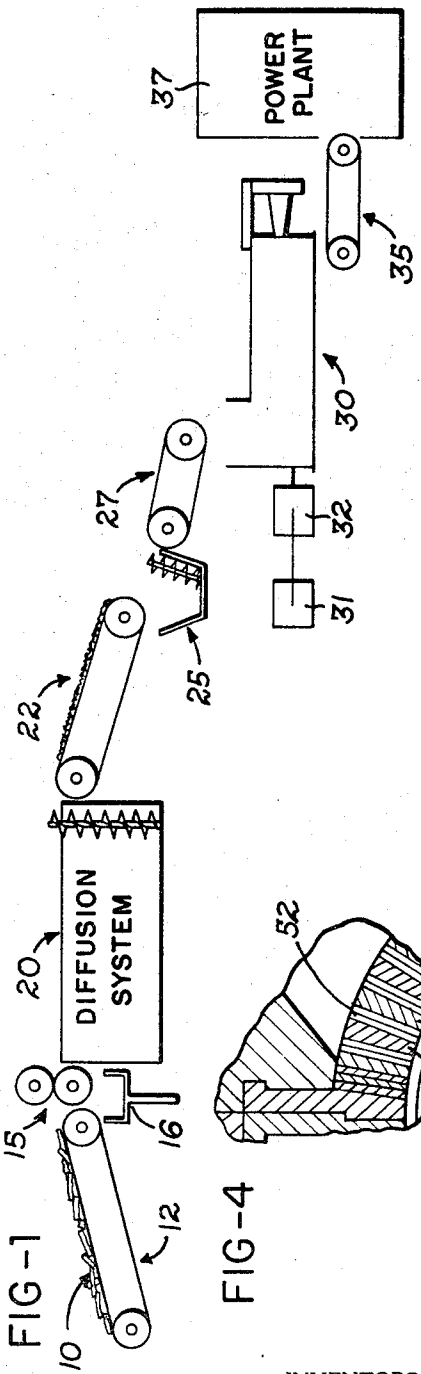


FIG-1

FIG-4

INVENTORS
ALFRED W. FRENCH &
BY FOREST J. STARRETT, JR.

Marechal, Biebel, French & Bugg
ATTORNEYS

APPARATUS FOR RECOVERY OF SUCROSE

Filed Oct. 18, 1966 2 Sheets-Sheet 2

FIG-3

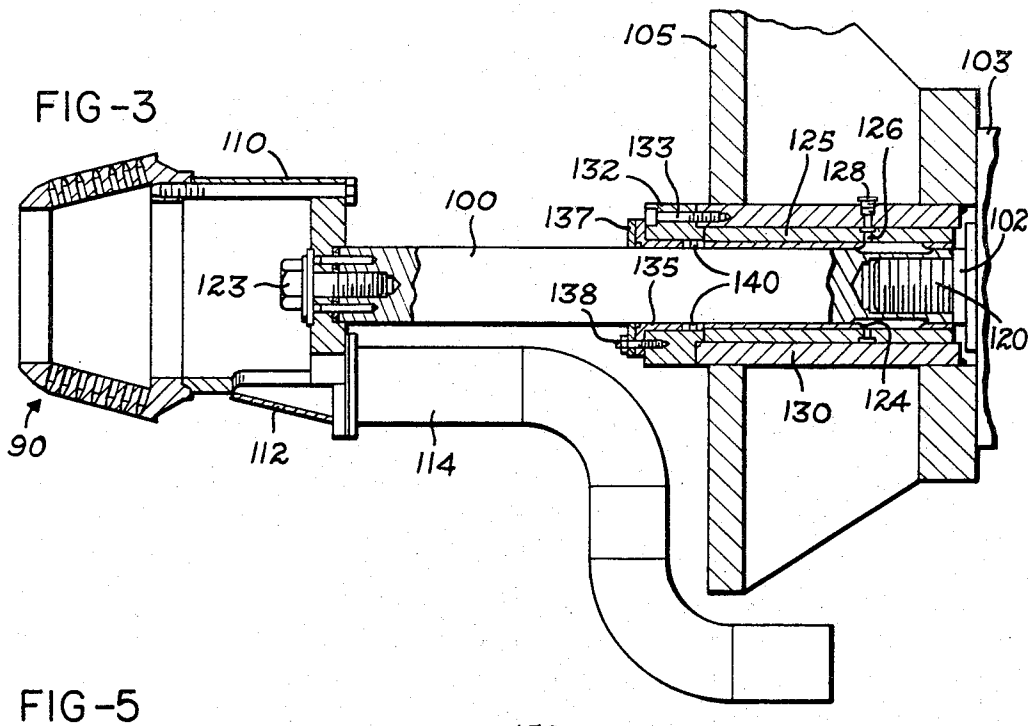
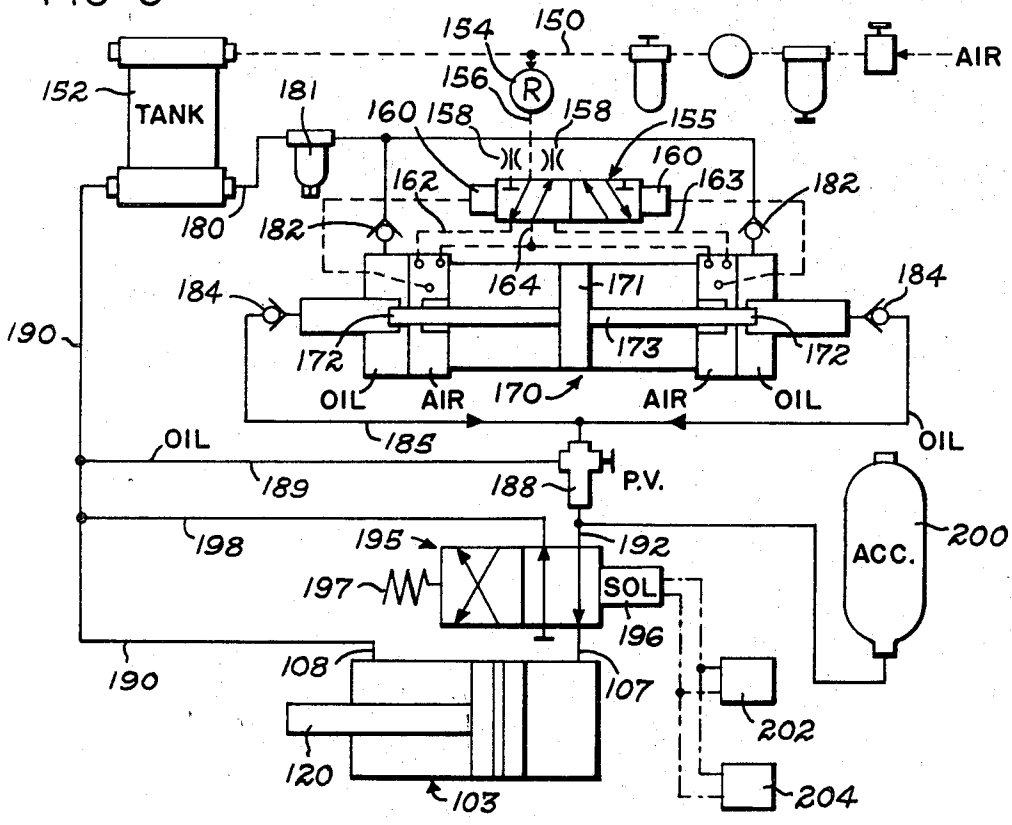


FIG-5



United States Patent Office 3,411,435 Patented Nov. 19, 1968

3,411,435

APPARATUS FOR RECOVERY OF SUCROSE

Alfred W. French and Forest J. Starrett, Jr., Piqua, Ohio, assignors to The French Oil Mill Machinery Company, Piqua, Ohio, a corporation of Ohio

Filed Oct. 18, 1966, Ser. No. 587,454
5 Claims. (Cl. 100—43)

ABSTRACT OF THE DISCLOSURE

A continuously operating mechanical screw press receives bagasse from a diffuser with high moisture content in the order of 85–90% moisture and continuously conveys such material through the press while compressing and continuously working the materal to reduce its volume by passage through several sections of decreasing diameter while subjected to mechanical working, thereby extracting approximately one half of the moisture from the material. This extracted liquid will contain significant amounts of sucrose which can be recovered from the liquid or returned to the diffusion system for use in the diffusion process. A non-rotatable discharge sleeve in the discharge ring is yieldably held against movement out of the press thereby providing for the creation of pressure on the material and automatically avoiding excessive pressure and strain on the press.

In its broadest aspects, the present invention relates to improvements in the apparatus disclosed in U.S. Patents Nos. 3,092,017 and 3,195,446 issued to the assignee of this application. The invention also relates to novel apparatus involving the handling and the removal of surcrose bearing juicies from sugar cane. In a preferred embodiment of the invention, sugar cane is taken in raw cut form from the fields, ground or otherwise broken up into relatively small pieces, and passed through a juice extraction system, which may be one or more roller mills, or a diffuser battery where the cane is acted upon by steam or hot water or other hot fluids to soften and break apart the fibrous material and to remove a substantial portion of the sucrose bearing juice from the cane. The output of this diffuser column is most commonly referred to as diffused bagasse, and the output of the mills is known as mill bagasse, and in many instances this bagasse contains a rather large percentage of liquids. These liquids will include some of the fluids with which the cane was treated in the extraction system and/or some retained juice which has not been removed in the system, but may be present in a dilute state.

The bagasse from a diffuser in many cases has such high moisture content, for example 88% moisture, and is of such a loose nature that it is difficult to form into a blanket which might be passed through a conventional roller mill or the like, and in any event such mills are not satisfactory in removing a substantial amount of the moisture from this diffused bagasse. Furthermore, generally such mills do not operate well on bagasse at temperatures in the range of 140°–180° F., especially if lime has been added in the diffuser.

Accordingly, the present invention provides a novel mechanical screw press construction, with which bagasse can be reduced in moisture content by a substantial amount, for example, to in the neighborhood of 35–45% moisture. The juices so removed can be directed to recovery operations where the sucrose or other chemicals in these juices can be recovered. Additional recovery of sucrose adds to the overall efficiency of the operation, whereas other chemicals may be recovered for entirely different uses outside the sugar industry. In addition, the dewatered bagasse resulting from this operation is used,

as is common in the sugar cane industry, as a fuel. For example, the bagasse may be passed into a furnace used to operate a boiler which in turn heats the water or other liquid that is supplied to a diffuser column, and/or to produce stream for other uses in the sucrose extraction process. By removing a substantial amount of the moisture from the bagasse, its fuel value is increased, since there is that much less moisture to be driven off in the combustion process. This results in a further gain in efficiency in the entire operation.

A further object of the invention is to provide a novel mechanical pressing operation which is arranged to receive continuously a supply of moist bagasse, preferably at an elevated temperature in the range of 140°–180° F., and to subject this bagasse to a compacting, compressing and mechanical working operation which results in extraction of a substantial percentage of the moisture from the bagasse.

An additional object of the invention is to provide a novel mechanical screw press for use in the process of sucrose juice bearing materials, wherein the apparatus is capable of receiving a rather large bulk of the material having a substantially high moisture content, for example, around 85–90% moisture, and wherein the press is arranged continuously to convey the material through operations of compressing and mechanical working in which the volume of the material is reduced as the moisture is extracted therefrom and collected.

A further object of the invention is to provide such a stationary discharge sleeve construction wherein the sleeve is urged into its normal position within the pressing outlet by a hydraulic cylinder to which hydraulic fluid is supplied at a predetermined pressure, such that the force of the cylinder holding the sleeve in position is available up to a predetermined maximum force which can be overcome by an excess of pressure within the press, in which event the force of the hydraulic cylinder can be overcome allowing the discharge sleeve to withdraw and thereby prevent excessive pressures on the material within the press.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings—

FIG. 1 is a schematic diagram of a sugar processing system incorporating the features of the present invention;

FIG. 2 is a view which is generally a vertical sectional view taken through the press which is shown in the system of FIG. 1;

FIG. 3 is a detail view of portions of an adjustable discharge sleeve incorporated in the press shown in FIG. 2;

FIG. 4 is a detailed partial sectional view showing the general arrangement of the drainage openings provided in the walls of the chamber of the press; and

FIG. 5 is a schematic diagram showing the hydraulic and pneumatic systems used to maintain the discharge sleeve in its normal position within the outlet of the press.

Referring to the drawings, which illustrate preferred embodiments of the invention, in FIG. 1 a system according to the invention is shown schematically. The sugar cane is indicated at **10** flowing into the system on a conveyor **12** which carries the cane to a crusher **15**. This may be in the form of cooperating toothed rolls, or similar equipment, which receives the raw sugar cane, or like sucrose bearing fibrous material, and tears the cane (although the cane is not subjected to much pressure at this point) thereby reducing the size of the cane and exposing its fibers, and as a consequence of this action an initial flow of juice from the cane generally occurs. This juice is collected in the tank **16** and piped to the equip-

ment (not shown) which performs the extraction of the sucrose from the juice. In some cases the cane is merely shredded thoroughly without extraction of juice.

In the system shown in FIG. 1 the shredded cane is then fed into a diffusion battery **20** which may be constructed in any one of several different types, as shown in the art. For example, one form of diffusion battery incorporates a number of individual cells, which are roughly in the form of large pressure cookers, and these are charged with the cane in sequence, and are subsequently discharged once the cane has been subjected to hot water or similar liquids which tend to wash and/or leach the juice from the cane and carry the juice away as a solution of juice and water. In a typical diffusion cell, the amount of juice in the extracted liquid flowing from the cell is a minor portion, but nevertheless significant. A number of these cells are used so that they can be charged and emptied in sequence, thereby producing an essentially constant operation. Other forms of diffusers are known wherein the diffusion process is carried on continuously, the cane being supplied at one end of the apparatus and being discharged after diffusion at another point. The product discharged from the diffusion battery is generally known in the art as diffused bagasse. In FIG. 1 a conveyor **22** is shown as carrying the diffused bagasse from the battery **20**.

This bagasse is conveyed through a collection tank **25** which serves to even out the flow of bagasse, particularly where a batch type diffusion battery is employed. The diffused bagasse thus is carried from the tank **25** as an essentially continuous stream over the conveyor **27**, from which the diffused bagasse is emptied into the inlet hopper or receiving section of the mechanical pressing device, details of which form an important part of the invention. This continuous pressing device is indicated in FIG. 1 by the general reference numeral **30**, and it includes a drive motor **31** and drive gear case **32**. Further details of the press are shown in FIGS. 2 and 3. The bagasse discharged from the press empties onto a conveyor **35** which in turn can carry the bagasse to the boiler or other power plant in the system, where the bagasse is generally used as a fuel. This power plant is indicated by the general reference numeral **37**.

In the system shown in FIG. 1 the diffused bagasse passing over the conveyor **27** to the press **30** may contain substantial moisture, for example in the order of 85–90%, and this moisture is in the form of some retained juice as well as liquid absorbed by the bagasse during the diffusion operation, and retained in the fibrous bagasse material as it is carried to the press. The mechanical press can extract a substantial amount of this moisture, for example at least one half of it such that the moisture contents of the bagasse leaving the press is in the range of 35–45%. The liquid extracted in the mechanical press will contain juice which in turn contains a significant amount of sucrose, and therefore this liquid can be returned to the extraction equipment for recovery of this sucrose, or this liquid can be piped to other recovery equipment. As another alternative, if the sucrose content of the material extracted in the press is not of sufficient amount to warrant passing it to the extraction equipment, it can be returned to the diffusion battery **20** and employed as a portion of the liquid used in the diffusion process.

Referring to FIG. 2, the screw press **30** has an inlet hopper **40** over the rotating feed worm **42** which picks up the bagasse fibers as they are dropped into the hopper and carries them forward through the hopper, to the right as viewed in FIG. 2, into the first section **45** of the press. It should be noted that the portion of the feed worm **42** extends into this first section, in order to assure that the material is carried into the section past the lip **46** of the inlet hopper. The diameter of the worm **42**, at least that portion of it which extends into the section **45**, should be sufficiently less than the internal diameter of section **45** where the feed screw revolves within it to provide a substantial clearance between the edge of the feed screw and the walls of the press section or chamber. A clearance in the order of one-half to three-quarters inch, is normally used at this point, and is considered advantageous to assure proper feeding of the stringy tough fibers. The motor **31** drives separate gears which rotate the feed worm **42** at a substantially higher speed than the rotatable shaft **50**, which in turn drives the expressing worm means **48**. Details of this arrangement are explained in U.S. Patent No. 3,246,597, which is assigned to the assignee of this application.

At the end of the feed worm **42** within the first press section **45** the material is forced past a breaker bar **47** and toward the first of several working and pressure worms **48**. These worms include a body **48***a* which is connected to rotate with the internal main drive shaft **50**, and a worm flight **48***b* which is of such outer diameter that it comes into close relation wtih the walls of the section **45**, normally with a clearance of a few thousandths of an inch. In the first section **45**, as shown, there may be two or more screw flight portions **48**, separated by collar members **49**, and spaced outwardly from these collar members there are stationary breaker bars or lugs **47** which tend to resist rotation of the material with the material being carried and urged forward by the preceding screw flight. These lugs preferably are slotted, as of the type disclosed in copending application Serial No. 558,854 filed June 20, 1966, now U.S. Patent No. 3,366,039. This action tends to work the fibrous material and assist in breaking open the cells of the fibers, as well as exerting mechanical pressure on the material to extract liquid therefrom. The walls of the press section **45** are constructed to have drainage openings for permitting the extracted liquid to flow outwardly and be separated from the fibrous material. A detail of a section of this wall structure is shown in FIG. 4, wherein it will be seen that adjacent bars **51** are separated by small spacers **52**, which can be separate pieces or integral projections on the bars, in order to define the drainage openings. These openings are of relatively small cross-section, so that only the finest of the fibers will be liable to pass through the openings, and the fibrous material is thus retained in the press structure, and continually carried through it, while the expressed liquid flows through the drainage openings and falls into the pan **55**, from whence the liquid can be piped to whatever location is desired.

At the end of the section **45** there is a tapered section **60** which may be formed either as a continuous bushing, or has an assembly of short bars having spaces therebetween for drainage openings. In either event, this bushing (or the equivalent section made up of bars) has an internal surface which tapers inwardly from a diameter corresponding to the internal diameter of the press section **45** to the smaller diameter of the next press section **65**. Thus, the mass of the material being carried through the press is compressed and compacted as it passes through the bushing **60**, and this in turn provides for a further expression of liquid from the material. It should be noted that the worm flight **68** (which in other respects corresponds in structure to the worm **48**) has a correspondingly tapered outer surface so that this worm maintains a close clearance with the internally tapered surface of the bushing **60**, or the bars making up the same piece. Thus, the screw flight **68** carries the material through the section of decreasing diameter, and assures that the material continues to move through the press at this point.

It will be noted from FIG. 2 of the drawings that the section **65** is of generally the same configuration as the previous section **45**, and terminates in a bushing **70**, or equivelent bar assembly as mentioned, in which bars are used having inwardly tapered outer surfaces. Drainage may or may not be provided, as desired.

This bushing opens or discharges into the next press section **75**, into which the tapered worm flight carries the materials. Again, the structure of the parts is essentially

the same as in the preceding section, but the section has a smaller diameter. At the end of the main shaft, which serves to drive the worm members, there is provided a nut **80** that holds the parts assembled on the shaft. Around this nut is a sleeve or bushing **82** which is pressed against a washer **84**. The outer diameter of the sleeve **82** and washer **84** correspond to the diameter of the body of the preceding worm.

Tapering outwardly toward the discharge end of the press, and fitted around bushing **82**, is a discharge sleeve **90** which may have either a solid imperforate surface, or preferably, drainage openings for the purpose of admitting expressed liquid to the interior of the non-rotatable discharge sleeve **90**. The final cage bushing **92** surrounds this sleeve at the end of the section **75**, and it is held in place in the end frame member **95** next to a discharge ring **96**, preferably bolted or otherwise removably secured to the end frame. The inner surface **98** of the bushing **92** tapers first inwardly toward sleeve **90**, then outwardly to the inner surface **99** of the ring **96**. The material thus experiences a final compression as it is forced between bushing **92** and sleeve **96**. Preferably the sleeve is normally positioned with all but approximately one to one and one-half inches of its length projecting into chamber **75**.

The non-rotatable discharge sleeve **90** is mounted for reciprocating movement on a movable rod **100** which is attached to the piston rod **102** of a hydraulic cylinder **103**. This cylinder is in turn bolted through supporting structure, such as shown in FIG. 2, to a supporting bracket **105**, and this bracket in turn is fastened to arms **106** carried from the end frame member **95**. The supply hydraulic actuating fluid to the cylinder **103** is provided through the conduits **107** and **108**. The stationary sleeve **90** has its interior opening into a hollow sleeve **110** which is secured to the backside of the member **90**, and is therefore movable with it. This sleeve opens into a collector or spout **112** carried on the rear of the sleeve **110** and opening into the drainage tube **114**. Therefore, expressed fluids passing through the perforated sleeve **90** will flow through sleeve **110** and spout **112** and through the tube **114**, regardless of changes in the position of the discharge sleeve **90**.

The pressed bagasse discharges from the ring **96** onto the conveyor **35**, where it may be carried to the power plant, or to any other suitable place of disposal. As previously mentioned, the action of the expressing press on the wet bagasse removes a substantial amount of moisture or liquid from the bagasse, and apparatus of this type has been successfully employed to provide bagasse at the discharge, i.e. onto the conveyor **35**, with a moisture content of around 45% or less.

The mounting structure for the discharge sleeve, therefore, must be sufficiently rigid to prevent it from rotating, and to maintain it in alignment (assisted by the bearing sleeve **82**). This structure is shown in FIG. 3, where the rod **102** of the hydraulic cylinder **103** is threaded, as shown at **120**, into the end of the rod or shaft **100**. A forward end of this shaft is in turn fastened by bolt **123** to the rear of the cylinder **110**, to cause movement of the rod **100** to be directly coupled to the discharge sleeve **90**.

The rod **100** has a spline **124**, and is slidably mounted in a splined bearing bushing **125** which includes a passage **126** to admit lubricant from the grease fitting **128** into the spline. The sleeve bushing **125** in turn is supported in a larger tube **130** which is welded or otherwise suitably fastened to the mounting bracket. A suitable key (not shown) prevents rotation between the splined bushing **125** and its mounting tube **130**.

At the forward end of the cylinder **130** there is a cap **132** which is fastened to the cylinder by a number of bolts, one being shown at **133**. Within this cap there is a gland **135** held in place by a washer **137** and one or more bolts **138**, and the gland in turn holds suitable packing **140** in place to retain the lubricant.

A suitable circuit for controlling the operation of the hydraulic cylinder **103** is shown schematically in FIG. 5. The pneumatic circuit is illustrated by dash lines, and the hydraulic circuit by solid lines. A regulated source of air pressure is indicated at **150**, and this may include conventional pressure regulating valves, etc., of conventional type. This line is connected to the top of a hydraulic reservoir or tank **152** which preferably has an internal diaphragm baffle (not shown) to prevent mixing of the pressure air with the oil while maintaining the hydraulic fluid or oil under enough pressure to insure it is forced into the pumping system. The air source is also connected through a pressure regulator valve **154** to a reciprocable double pilot valve **155**. This valve receives pressure air at its central inlet **156** from the regulator **154**, and the outlets from the other two ports in the active position are provided with suitable restrictors **158**. The pilot chambers **160** of this valve control the shuttling of the valve body, such that the inlet line **156** is connected alternatively to outlet lines **162** and **163**, while the central outlet port **164** is connected to one or the other of the restrictors **158**.

The lines **162** and **163** extend to opposite sides of a double acting reciprocating booster pump **170**, which incorporates a central piston **171** and small hydraulic pistons **172** formed at opposite ends of the rod **173** which moves with the piston **171**. It will be seen that when air under pressure is supplied to one side of piston **171**, the other side is connected to the exhaust line **164**, and the corresponding pilot **160** is likewise connected to tend to move the shuttling valve **155** into the opposite position from which it is then urged. Therefore, the air valve **155** supplies pressure air alternatively to opposite sides of piston **171**, causing it to reciprocate and the hydraulic pistons **172** function as hydraulic pumps as follows.

The inlet line to the hydraulic system is through line **180** and filter **181**, to check valves **182** which are connected into the chambers at each end of the pump **170** surrounding the piston **172**. The outlets of these chambers are through further check valves **184** which are connected to the outlet manifold **185** of the booster pump. Thus, as the piston **171** reciprocates, one of the hydraulic pistons **172** will retract to draw oil through its inlet check valve **182**, while the other forces oil out through its check valve **184**, and on the return stroke the opposite conditions occur. Therefore, hydraulic fluid or oil under pressure is supplied to hydraulic pressure regulating valve **188**.

Fluid in excess of the capacity of this valve is returned through line **189** to the return manifold **190** and from that manifold back to tank **152**. The outlet of the pressure regulating valve **188** is connected to the oil supply line **192**, which leads to a spring-loaded solenoid operating control vlave **195**. Its control solenoid is shown at **196**, and the valve itself is shown in the position it occupies when the solenoid is de-energized, and the valve body positioned by the spring **197**. In this position of the valve, hydraulic fluid under pressure is admitted to the head end of the hydraulic cylinder **103**, and the rod of the end of this cylinder is connected to the return manifold **190**. If solenoid **196** is energized it acts against the spring to shift valve **195**, and the valve then blocks the pressure inlet **192** and connects the head end of the cylinder through line **198** to the return manifold **190**.

A hydraulic accumulator **200** preferably is connected into line **192**, so that if valve **195** is in its de-energized position, and the solenoid **196** is energized, hydraulic fluid under pressure is immediately available from the accumulator in sufficient quantity to advance the hydraulic cylinder **103** immediately, tending to move the discharge sleeve **90** into its restricting position.

By control of the hydraulic pressure regulator valve **188**, the force tending to hold the discharge sleeve **90** against the flow of compressed bagasse can be regulated, and the discharge sleeve can fluctuate slightly in response to slight increase or decrease in the flow of material from the press. Thus, this control tends to maintain a constant back pressure within the press and contributes to a

uniform expression of liquids from the material. If there is an overload on the press, or if the supply to the press is substantially decreased for some reason, the control system provides for withdrawal of the discharge sleeve **190** to permit the pressure in the press to remain within predetermined limits, and also to avoid clogging of the discharge end of the press.

For this purpose, the solenoid **196** is controlled by conventional meter relays **202** and **204**, respectively, which sense the amount of electrical current drawn by the press drive motor **31**. For example, the relay **202** may be set to close whenever the current drawn by the motor decreases below a predetermined minimum and the relay **204** may be set to close only if the current drawn by the motor exceeds a predetermined maximum. In either event, if the current is outside of the range established by setting these relays, the solenoid **196** will be energized and valve **195** will shift. This equalizes the pressure on opposite sides of the piston, to permit the pressure of material against the discharge sleeve **90** to force it outward of the discharge ring **96**.

In the case of the relay **204**, it is of course desirable to avoid exceeding a certain predetermined pressure upon a material. If there should be a blockage or unexpected build-up of pressure, this will reflect in an increase in power demand on the motor **31**, and the consequent increase in current will cause the relay **204** to trip, whereupon the discharge sleeve **90** can withdraw and the pressure within the press will drop as the restriction at its discharge is increased. Preferably, this relay is set to keep the solenoid **196** energized for a sufficient time to permit the press to reach an equilibrium at a pressure below the maximum corresponding to the setting of relay **204**.

If the supply of material to the press should be interrupted for any substantial length of time, the amount of current drawn by the motor will decrease below the minimum to which the relay **202** is set. It has been found that as the press tends to evacuate itself under these conditions, a certain amount of bagasse will remain between the final worm **79** and the discharge sleeve **90**, and this bagasse will tend to be worked and heated to the point where it hardens and twists around the discharge sleeve and adjacent structure. To avoid this condition, it is desirable to withdraw the sleeve under these conditions and thus relieve pressure on the material and permit the material to be expelled from the press.

The operation of the apparatus is such that relatively wet or moisture-laden bagasse, which consequently occupies a rather large volume, is fed into the hopper **40** and carried by the faster rotating feed worm **42** into the first press section **45**. As the bagasse is carried through this and subsequent press sections it is subjected to mechanical pressure and working, by reason of the action of the interrupted screw flights and the breaker bars past which the flights move the bagasse. These bars are preferably of the type disclosed, to minimize damage due to foreign material entrained with the bagasse. At the same time, the bagasse is forced into press sections of decreasing cross-sectional area, which contributes to the mechanical compression of the bagasse. Expressed liquid flows outwardly between the screen bars **51**, through the spaces provided by the spacer members **52** which occupy only a small amount of the space between the bars, and which may in fact be provided as integral bosses or protrusions from the bars themselves. As the pressed bagasse reaches the final press section **75**, it passes the final worm **79**, which preferably is decreased in pitch with respect to the preceding worms, and forced around and past the non-rotatable discharge sleeve **90**. It is at this location that the mechanical pressure on the bagasse is highest. In order to provide optimum drainage area, both the surrounding walls of the press cage and the walls of the sleeve **90** are capable of conducting away expressed moisture, which may include some vapors as well as liquids.

The cylinder **103** and its associated hydraulic system control the position of the discharge sleeve **90** as to movement in and out of the discharge ring. This also provides a safety feature in that if the pressure exerted against the sleeve **90** increases beyond a desired maximum, the resultant force transmitted through the connecting shaft **100** will overcome the preset force exerted on the piston of the hydraulic cylinder, and the sleeve **90** will move outwardly of the press discharge opening by an amount sufficient to relieve the condition which caused the excess pressure on the bagasse. If pressure in the head end of cylinder **103** exceeds the pressure to which valve **188** is set, there will be reverse flow through this valve and into the tank return line **189** until the pressure in the head end of the cylinder drops to the predetermined value. As soon as this condition is relieved, the sleeve automatically will tend to assume its original position, hence under normal operating conditions equilibrium will exist at the desired pressure.

It should be understood that other controllers responsive to the power demands of the press drive can be employed. For example, when a steam turbine is used to provide driving power, suitable pressure responsive devices can be used to sense the chest pressure in the steam chest at the turbine supply, and the position of the sleeve **90** will be changed in corresponding fashion, according to the power demands on the turbine reflected as a rise or drop in chest pressure.

It should be understood that while the invention has been described with respect to bagasse which is the product of a diffusion extraction system, the novel apparatus disclosed herein is equally useful in other systems for extracting juice from sugar cane. For example, the press shown in FIG. 2 may receive what is known in the art as "mill bagasse," the product of one or more roller type mills or equivalent, where the bagasse fibers are usually longer and stringier, and in most cases do not contain as much moisture when received at the press.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of 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. Apparatus for removing liquid from material such as sugar cane bagasse, comprising a pressing machine having a feed cage and at least one expressing cage connected to said feed cage, said feed cage having a larger inner diameter than said expressing cage, a first ring member mounted between said feed cage and said expressing cage and having a tapered inner surface providing a wall of gradually decreasing diameter to guide material from sad feed cage into said expressing cage, means defining drainage openings for expressed fluids in the walls of said feed cage and said expressing cage, an inlet hopper connected to said feed cage for supply of wet material, a rotatable feed worm mounted in said feed cage to carry the material toward said expressing cage, a discharge ring defining an outlet on said expressing cage, expressing worm means rotatably mounted in said expressing cage including a worm flight having a tapered periphery corresponding to the tapered inner surface of said first ring member, a discharge sleeve member having a tapered outer surface, means mounting said discharge sleeve for movement between an inner position wherein a major portion of said sleeve is located within said expressing cage and an outer position wherein said sleeve is substantially withdrawn outside said ring, drive means including separate drives for rotating said feed worm at a higher speed and said expressing worm means at a lower speed to force the material through said cages and outward through the space between said ring and said discharge sleeve whereby the material is compressed and fluids are expressed from the material to flow through said drainage openings, and means yieldably urging said discharge sleeve towards its

said inner position causing said sleeve to resist the discharge flow of material up to a predetermined pressure and to yield and enlarge the space between said sleeve and said ring when the pressure on the material exceeds said predetermined pressure.

2. Apparatus as defined in claim 1 wherein said expressing cage includes a first expressing cage section and a final expressing cage section at the discharge end of which said discharge ring is mounted, a second ring member having a tapered inner surface and mounted at the entrance to said final expressing section to provide a passage of gradually decreasing diameter thereto, said final cage section having an inner diameter less than said first cage section, and a further tapered worm flight incorporated in said expressing worm means and mounted in closely spaced relation to said second ring member for carrying the material therethrough into said final cage section.

3. Apparatus as defined in claim 2 wherein said expressing worm means comprises a plurality of alternately arranged form members and sleeve members and a drive shaft supporting said members coaxially of said expressing cage, said worm members being connected to rotate with said shaft and having a minimum clearance in the order of a few thousandths of an inch between the periphery thereof and the inner wall surface of the expressing cage, and breaker bars extending inwardly of the walls of said expressing cage toward said sleeve members and terminating a substantial distance from said sleeve members, whereby said breaker bars will resist rotation of the material forced around said sleeve members while leaving a substantial space between the inward ends of the breaker bars and the sleeve members through which foreign material such as rocks or pieces of metal can pass without damaging said breaker bars.

4. Apparatus as defined in claim 1 wherein said yieldable means positioning said discharge sleeve includes a hydraulic cylinder having an output rod connected to said discharge sleeve, a hydraulic pressure fluid supply connected to said cylinder to drive it in a direction advancing said discharge sleeve toward its inner position, and a control establishing a maximum hydraulic fluid pressure within said cylinder whereby a force on said discharge sleeve in excess of the force exerted by said hydraulic cylinder will automatically move the discharge sleeve toward its said outer position and thereby decrease the resistance to the flow of said material around said discharge sleeve and through said discharge ring.

5. Apparatus as defined in claim 4 wherein automatically operable valve means are provided for interrupting the supply of hydraulic pressure fluid to said cylinder and connecting said cylinder to a lower pressure such that material advancing against said discharge sleeve can readily push said sleeve toward its outer position to relieve the pressure upon the material by said expressing cage to a minimum.

References Cited

UNITED STATES PATENTS

1,769,658	7/1930	Veenhuyzen	100—145
1,851,191	3/1932	Lang	100—47
2,178,714	11/1939	Anderson	100—43
2,280,880	4/1942	Anderson	100—43
2,340,009	1/1944	Meakin	100—148 XR
2,422,895	6/1947	Habenicht	100—127 XR
2,817,287	12/1957	Onarheim et al.	100—147 XR
3,003,412	10/1961	Vincent	100—148 XR
3,062,129	11/1962	Wandel	100—43
3,085,502	4/1963	Hurtig	100—43
3,092,017	6/1963	French et al.	100—93
3,111,082	11/1963	Larsson et al.	100—147
3,140,652	7/1964	Williams	100—43 XR
3,143,956	8/1964	Hurtig	100—43
3,195,446	7/1965	French	100—41 XR

BILLY J. WILHITE, *Primary Examiner.*