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Slaby et al.

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[54] **APPARATUS FOR TREATING ELASTOMERIC MATERIALS**

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[21] Appl. No.: **280,336**

Related U.S. Application Data

[63] Continuation of Ser. No. 74,083, Sept. 21, 1970, abandoned, which is a continuation-in-part of Ser. No. 802,029, Feb. 25, 1969, Pat. No. 3,638,921.

[52] **U.S. Cl.** **425/203,** 100/75, 100/117, 100/150, 259/191, 425/208

[51] **Int. Cl.** **B29b 1/10,** B29f 3/02

[58] **Field of Search** 100/74, 75, 117, 127, 128, 100/129, 145–150; 259/9, 10, 191, 192, 193; 425/203, 208

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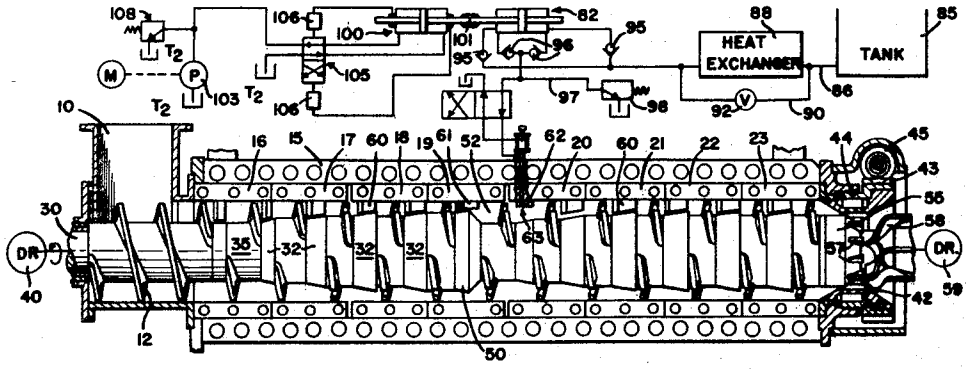
[57] **ABSTRACT**

A machine for adding liquids such as oils to elastomeric materials such as rubber or various synthetic polymers is provided in the form of a continuous screw press with intermediate chambers where the material is worked under pressure. Liquid is supplied near the center of the chamber through injector bars, and is mixed into the material as it proceeds out of the chamber toward the press exit. If the elastomeric material contains water, it is first processed in the press to remove included moisture to a point where oil is compatible with rubber mixture; if the material contains volatile solvents, heated oil is mixed into the material and also used as an agent to promote release of the solvent.

5 Claims, 5 Drawing Figures



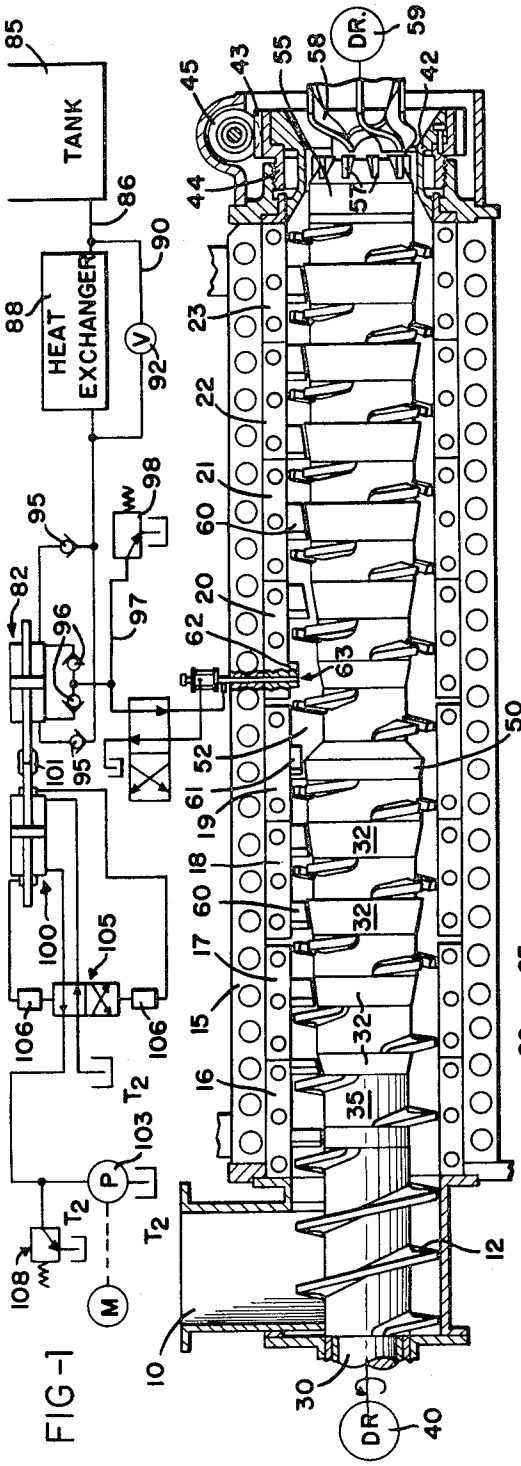


FIG-1

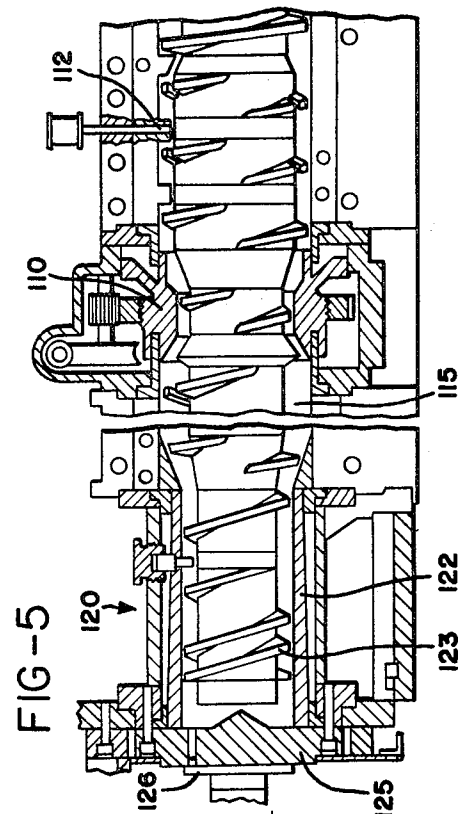


FIG-5

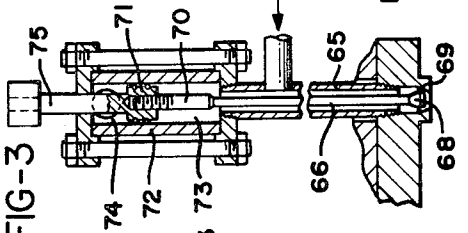


FIG-3

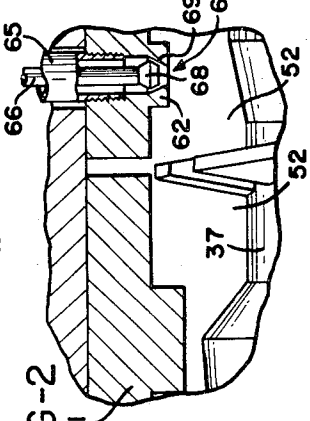


FIG-2

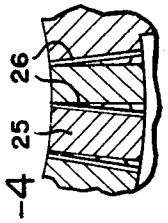


FIG-4

APPARATUS FOR TREATING ELASTOMERIC MATERIALS

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 74,083, filed Sept. 21, 1970, now abandoned, which is a continuation-in-part of application Ser. No. 802,029, filed Feb. 25, 1969, now U.S. Pat. No. 3,638,921, issued Feb. 1, 1972.

BACKGROUND OF THE INVENTION

The invention has special reference to a system employing a mechanical screw press for introducing liquids such as plasticizers, extenders, or anti-oxidants into elastomeric materials such as natural or synthetic rubbers, preferably during a combined drying or desolventizing process of the material. A typical liquid may be an oil such as a light process oil of the napthenic or slightly aromatic type. This oil serves as in intermolecular softener and lubricant which increases the plasticity and workability of the material so that it can be more easily formed into different shapes later in the processing. An oil is also frequently used as an extender along with carbon black for increasing the bulk of the rubber compound to provide a lower cost product without noticeably reducing any of the significant properties, and in many cases producing superior properties.

SUMMARY OF THE INVENTION

The present invention is directed to improved apparatus for treating elastomeric materials and the like by compressing the material in a first stage of a drainage type screw press to produce an increase in pressure and temperature by friction heat for removing the water (where present) by drainage and flashing off of the moisture. Apparatus of this general type, used for a different purpose in a different way, is disclosed in U.S. Pat. No. 3,111,080. The material is worked under pressure while liquid is simultaneously added. The liquid is readily received by the material, and can be worked and pressed into the material in the second stage of the press where the pressure may be further increased. A multi-stage mechanical screw press not only provides for efficient drying but has been found to provide an efficient, thorough and uniform mixing of the fluid into the material. It is especially desirable for use on natural rubber in which heretofore the mixing of liquids, particularly oils, has presented many difficulties. The press has also been determined to be an efficient device of adding oil or other liquids into synthetic elastomeric polymers instead of mixing in the liquid during the coagulation step, which is the present procedure.

Accordingly, the object of this invention is to provide an apparatus wherein liquid can readily be pressed into the elastomeric material being treated, at the same time using the addition of the liquid to control the temperature of the material, to avoid overheating of the material and damage thereto, or to promote release of volatiles therefrom.

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

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat diagrammatic elevational view of a screw press showing one form of apparatus according to the invention, with one half of the cage removed to expose and illustrate the multi-stage construction, and including a diagram of the circuit for injecting liquid;

FIG. 2 is an enlarged detail view of one of the injector parts shown in FIG. 1;

FIG. 3 is a sectional view showing details of the valve and injector lug for adding liquid to materials processed in the apparatus;

FIG. 4 is an enlarged fragmentary sectional view through a portion of the cage of the apparatus, illustrating the manner in which openings are provided between the bars making up the walls of the chamber; and

FIG. 5 is a view similar to FIG. 1 showing a modified form of press.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, which illustrates preferred embodiments of the invention, FIG. 1 shows somewhat diagrammatically, a continuous duty, interrupted flight, screw-type expressing machine having an inlet hopper **10** through which materials to be worked upon and treated are supplied. The materials are received between the flights of the feed screw **12** and carried thereby from the hopper **10** into the main body of the apparatus, which is made up on an outer cage structure **15** formed by two symmetrical halves which are bolted together. One half has been removed in FIG. 1 to illustrate the interior of the apparatus.

Within this outer cage structure there are a plurality of subassemblies of sections **16, 17, 18, 19, 20, 21, 22** and **23** with sections **16–19** forming the first stage of the press and sections **20-23** forming the second stage. Each of these sections is formed by a framework supporting a plurality of axially extending screen bars **25** (FIG. **4**), in some sections separated by suitable small spacers **26.** Further details of the construction of these subassemblies are illustrated in U.S. Pat. No. 3,126,820. An important point, as far as the present apparatus is concerned, is that those sections of the apparatus where liquid is to be drained are provided with so-called drainage openings defined between adjacent screen bars making up the section, while the sections where injection occurs do not have such openings, at least not near the point of injection.

Within the elongated cylindrical chamber defined by the casing or cage structure, and mounted on the main shaft **30,** are a plurality of collar members **32** some of which may be tapered as shown so as to decrease the cross-sectional area between the collar and the cage section walls. Intermediate these collars, and also fixed to rotate with the shaft, are pressure worms **35.** These pressure worms are essentially of like constructions, with a worm body **37** and an interrupted flight **38** which preferably is notched at a number of locations, as shown in FIG. **2,** to produce a more thorough shearing and working of the material in the apparatus. The main difference between the various pressure worms **35** is that the worm bodies **37** are of different diameter, progressively increasing generally according to the larger diameter of the preceding collar. The pressure worms take up material forced around the preceding collar, and move the material under pressure over and around the succeeding collar and on to the next pressure

worm. Rotation of the shaft **30**, which produces this action, is obtained from a conventional drive **40**, which may include any suitable form of power together with a gear case or the like by which the desired rotation of the feed worm and pressure worms is obtained.

The cage structure **15** shown is of constant diameter, and has an entrance or feed opening where the feed worm **12** enters the cage structure, and a discharge opening formed by a discharge ring **42** at the opposite end of the cage structure. This ring preferably is fastened to a rotatable helical gear **43** carried on a threaded extension **44** such that rotation of the adjusting worm gear **45** will rotate gear **43** and cause axial adjusting movement of the discharge ring **42**.

The collar members **32** and the bodies of worm members **37** cooperate with the interior walls of the cage structure to provide a through annular passage for the material, with such passage varying in cross-sectional area at different locations. In one embodiment of the invention this passage decreases gradually in cross-section, so that pressure is built up on the material in the first stage up to the space around collar member **50**. This collar member includes a portion which may taper inwardly such that the annular space between it and the cage walls increases on the downstream side of this collar. Therefore, in this section and within the following chamber portion **52** surrounding the next pressure worm, the pressure on the material may be somewhat reduced by reason of the increase in volume permitting expansion of the material within the zone and consequent degassing. In this region the spacers are not used, to prevent drainage. Then, progressing toward the discharge end of the cage, the pressure collars may again increase progressively in cross-section, and the worm bodies likewise correspondingly increase in size, such that pressure is again applied to the material until it reaches the discharge collar **55** which projects at least partially into the discharge ring **42**. Preferably the discharge collar is provided with a set of breaker lugs **57** arranged to cooperate with a rotatable shredder member **58** having a rotary drive **59**. Material passing through the discharge opening is engaged between the shredder **58** and the lugs or teeth **57**, and is cut or torn into relatively small pieces which are expelled through the discharge ring **42** into any suitable collection device.

A feature of the invention, as it applies to removing water or other liquids, concerns the relationship of the drainage or venting openings between the screen bars in the various sections of the cage structure. As the annular cross-sectional area of the passage through the apparatus decreases, the pressure on the material will increase. It is understood that in operation the passage between the rotatable parts and the walls of the cage structure is essentially full of compacted material which is being continuously worked and compressed. This results in substantial frictional heating along with shear action and transfer of shear energy. If desired, this heating may be regulated by flowing heat exchange fluid or liquid through suitable passages such as shown in said U.S. Pat. No. 3,126,820. As pressure on the material increases, the tendency is to squeeze some of the material into the drainage openings between screen bars **25**, therefore it is desirable to attain a balance between the maximum size of opening for the best possible drainage and such reduction in the opening as mentioned above to avoid complete clogging thereof by materials squeezed into the openings. Where pressure on the material is first released, as in chamber portion **52** at the end of the first stage, the drainage opening size is increased, thereby assuring the best possible venting and removal of vapors and liquids. By way of example, in one form of apparatus constructed in accordance with the invention the drainage openings between screen bars **25**, in the section **16**, is approximately 0.060 inch in width. Comparable openings in section **17** are reduced to 0.040 inch, in section **18** the openings are reduced to 0.030 inch, and in the first part of section **19** the drainage openings are further reduced to 0.020 inch in width. In the last part of section **19** the opening size is increased to about 0.060 inch, then there are no openings in section **20**. The size of drainage openings in sections **21, 22** and **23** decreases in size corresponding to the sizes for sections **17, 18** and **19**. It has been found through operation of apparatus of this type that vapors tend to flow to the point of lowest pressure, in other words to the entrance to chamber portion **52**, around collar **50** and by having larger drainage openings at this point it is possible to achieve optimum venting, thereby assuring that all vapors are quickly removed from the chamber.

As shown in FIG. **1**, stationary breaker lugs, indicated by the general numeral **60**, are provided to prevent rotation of the material with the collars **32** and to cooperate with the notched worm flights **38** to obtain a tearing, shearing and working action of the material. However, a feature of the invention is provided by the specific construction of the breaker lug **62** (FIG. **3**). The breaker lug **62** is spaced outward from the collar within the chamber portion **52**. A controlled injection nozzle **63** (FIG. **2**) is mounted in lug **62** for directing a plasticizing oil or other compounding liquid downstream of chamber portion **52** and substantially into the middle of the mass of material at a point where the material again is under substantial pressure.

Details of one nozzle are shown in FIG. **3**. The tubular body **65** is fitted into the lug, and a valve stem **66** carries a head **68** which cooperates with a seat **69** to control flow into the chamber. The stem has a threaded part **70** which is received in a piston **71** movable in a cylinder **72**. Oil under pressure is supplied to the stem side chamber **73** when it is to be injected. This automatically opens the nozzle. Valving the oil under pressure to the opposite chamber **74** will shut off the nozzle. The projecting stem **75** provides a means for locking the nozzle closed if desired, and also gives a visual indication of nozzle position.

The liquid to be mixed with the material is supplied to a pipe or manifold **80** from a positive displacement reciprocating cylinder pump **82**. Particularly in the treatment of natural rubber and the like, a liquid such as oil may be used to provide a so-called "oil extended" rubber product. This oil is provided from a suitable tank **85** connected through pipe **86** to a conventional controlled heat exchanger **88** which heats and maintains the oil to a desired temperature. In the case of removing water, this temperature of the oil preferably is somewhat less than the temperature of the material encountered in the chamber portion **52** of the press, such that the oil tends to absorb some heat from the frictionally heated rubber material and thereby provide a cooling effect on the rubber. At the same time, the warmed oil is thoroughly mixed into the rubber material by reason of the mechanical working of the material from the

notched pressure worm flights and the interaction of these flights with the collars and breaker bars. A bypass **90** is provided around the heat exchanger **88,** and a control valve **92** is included in the bypass, whereby cool oil from the tank can be supplied directly to the cylinder **82** if additional cooling effect should be needed.

The cylinder **82,** as shown in FIG. **1,** is of the reciprocating double-acting type, which receives the oil to be injected through the check valves **95** and delivers the oil through check valves **96** into a manifold **97** which leads to the entrance tubes **75** of the injectors. A pressure relief valve **98** is provided, which will bypass oil back to the tank **85** if the pressure increases beyond a predetermined limit. This arrangement provides positive displacement pumping at relatively high pressure, to assure that the oil is effectively injected into the material within the press.

The pump **82** is driven by a double-acting reciprocating motor **100** which is connected to the pump through a coupling **101.** A separate hydraulic circuit for driving the motor **100** includes a tank T2 from which hydraulic fluid is pumped through pump **103** to a conventional servo-operated reversing valve **105.** This valve has pilot cylinders **106** at its opposite ends connected to the opposite heads of the motor **100,** thus as the motor piston reaches one limit of its stroke, the build-up pressure will cause the appropriate pilot **106** to shift the valve **105** thereby reversing the pressure connections to the motor **100** and reversing its direction. At the same time the return connection to tank T2 is likewise reversed. An adjustable bypass valve **108** is connected to the outlet side of pump **103,** and by adjusting the pressure of the pump outlet through this valve, it is possible to increase or decrease the reciprocating speed of the motor **100,** thereby controlling the rate of displacement of the pump **82.**

FIG. **5** illustrates a modified form of apparatus which may be used in accordance with the invention, particularly to remove volatile solvents from elastomeric polymers such as solution polymerized SBR, or material of generally the same nature. These materials contain a volatile solvent, such as hexane, but do not contain water. It is necessary to remove this solvent, preferably in a gaseous state, and it is often desirable to compound other materials, such as oil, into the polymer. The present arrangement provides for these operations in a continuous and practically simultaneous process.

The press structure is similar to the type disclosed in greater detail in copending application Ser. No. 753,647, filed Aug. 19, 1968 entitled MECHANICAL SCREW PRESS, now U.S. Pat. No. 3,574,891 which is assigned to the assignee of this application. It differs from the apparatus shown in FIG. **1** in several respects. There is an adjustable intermediate choke ring **110** in the chamber of the press, downstream from the injector nozzle **112,** which can be of the same construction as shown in FIG. **3.** The cage structure from the inlet, past the injector, to and around the adjustable ring **110,** is closed or imperforate. Downstream of ring **110** the diameter of the worm body is decreased, providing an expansion chamber **115** in which pressure on the material is reduced. This chamber is surrounded by spaced screen bars, allowing the volatile solvent to escape into a surrounding collection housing (not shown).

In place of the shredder structure shown in FIG. **1,** an extruder section **120** is provided at the discharge end of the press, including an imperforate extruder sleeve **122** which in this embodiment is of smaller diameter than the intermediate diameter of the press chamber, and a double helical extruder worm **123** operates within the sleeve **122.** At the discharge of the sleeve **122** there may be a die plate **125** through which the material is discharged, and a rotating knife **126,** driven from a separate motor (not shown) cuts the material extruded through the die into relatively small particles.

The solvent containing polymer is fed into the press cage and worked in the closed press section upstream of the ring **110,** while hot oil is injected through the injector **112.** In this case, the temperature of the oil is sufficiently high to promote heating of the polymer to a temperature higher than that at which the solvent changes to vapor form. However, since the material is compacted and worked mechanically within this section of the press, the hot oil is at this point merely mixed into the polymer-solvent mixture, which is increased in temperature.

As this material is forced through the ring **110,** and enters the expansion chamber, the pressure on the material is reduced substantially, to the point where the pressure is quickly lower than the vapor pressure of the solvent. The solvent therefore vaporizes and flows as a gas through the vent openings of the expansion chamber into the aforementioned collection housing. The hot oil tends to promote this operation and to displace the solvent as the solvent escapes from the polymer. The change in phase of the solvent from liquid to vapor also functions to absorb some heat from the material, thereby assisting in keeping the polymer at a temperature below which damage, such as formation of gel, will occur.

The ring **110** preferably is adjustable longitudinally of the cage in order to provide control over the thickness of the annular orifice formed between the ring and the collar which it surrounds. This in turn provides a control over the pressure in the preceding section of the press, and assures that the material is not overworked to the point where undesirably high temperatures might be encountered.

This form of apparatus, therefore, provides a continuous system in which hot compounding liquids such as oil are added to polymerized elastomeric materials, and at the same time the volatile solvents are thoroughly removed from the material, with a high percentage of the solvent being collected and recoverable for further use in the process upstream of 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.

What is claimed is:

1. An improved screw press apparatus for continuous processing of elastomeric material and for mixing of a fluid into the material during the processing operation, comprising wall means defining an elongated chamber, means dividing said chamber into first and second stages each having an entrance and a discharge end, conveying and working means including a shaft rotatably mounted within said chamber and adapted to be power driven and a plurality of successive collars and worm bodies having flights thereon and mounted on

said shaft with at least said worm bodies connected for rotation with said shaft, stationary breaker lugs extending between said worm flights for cooperating with said flights to provide a shearing and working action on the material, said conveying and working means having in each of said stages progressively increased size to decrease progressively the surrounding volume of the chamber in each of the stages for increasing toward the end of each stage the pressure on the material conveyed therethrough, drainage openings formed through said wall means in each of said stages of decreasing size along said stage in the same direction as the flow of the elastomeric material through said chamber of the press, said wall means being imperforate in said first stage immediately upstream of said expansion section, means forming an expansion section at said discharge end of said first stage and between said stages in which pressure on the material is effectively decreased, said expansion section also having drainage openings provided for escape of moisture and/or vapor released from the material, and means for injecting a compounding liquid into the region surrounded by the imperforate wall means for mixing of the liquid into the material.

2. Apparatus as defined in claim **1,** wherein said injecting means includes an injector nozzle opening into said chamber to release the liquid into the mass of material in the chamber.

3. Apparatus as defined in claim **2,** including a positive displacement pump means connected to deliver the liquid under pressure to said nozzle.

4. Apparatus as defined in claim **2,** wherein said injector nozzle includes valve means operable from the exterior of said press to control the flow through said nozzle.

5. Apparatus as defined in claim **2,** including an imperforate extruder section receiving the material from the discharge end of the second stage and having an end opposite said second stage toward which end the material is fed, and a die mounted at the end of said extruder section and having openings through which the liquid-extended material is discharged from the press.

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