Variable chamber round baler having a bale core formation chamber with a variable geometry, comprising at least a primary belt tensioner (15) and at least a secondary belt tensioner (16), whereby the primary belt tensioner (15) begins to act only after the bale core has been completely formed. Varying the initial geometry of the chamber and the compression program, it is possible to form bales having different properties, that is a hard or a soft core (with different diameters), a bale with constant density, etc.
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Variable chamber round baler having a bale core formation chamber with a variable geometry

Technical Field
The present invention relates to a round baler, that is an agricultural machine for picking-up and forming cylindrical bales of straw and silage, like maize plant, hay, grass or any other product which can be treated in this way. Particularly, the invention relates to a round baler which is generally known as variable chamber round baler for forming bales, having moreover the feature that the bale core formation chamber has a geometry which can be modified automatically by the operator.

Background Art
It is known that balers may be classified nowadays in two distinct groups: the variable chamber balers and the fixed-chamber balers. The variable chamber baler picks up the product which is arranged in windrows on the field, by means of a pickup and of supporting and feeding rollers or the like placed immediately after the pickup, and so the product is conveyed towards the inside of the round baler. One or more sets of belts or the like mounted on rollers which are partly fixed and partly movable through levers actuated by cylinder units, are brought into contact with the product and transform its linear motion into a rotary motion.
The feature which distinguishes the variable chamber baler from the fixed-chamber round baler results from the fact that the bale formation space bounded by the belts, at the time when the product is first introduced inside the baler, is only a fraction of the total volume enclosed within the machine body.

During the gradual formation of the cylindrical bale, the above mentioned levers or arms which support the movable belt tightening rollers, are rotated, thereby allowing the expansion of the bale which is continuously in contact with the belts, whose tension may be adjusted in order to vary the density of the cylindrical bale, by acting on belt tightening systems which may be mechanical (springs) or hydraulic (cylinder units and pressure changing valves).

Since the bale is continuously in touch with the tightened belts when it expands, starting from the formation of the core, a bale having a "hard" core is obtained. The "hard" core does not allow the passage of air and therefore more attention must be paid to the degree of humidity of the product.

The fixed-chamber baler has instead only stationary rollers; or fixed rollers for rotating belts, or chains provided with cross rods, and the bale compression starts only after the bale has reached a diameter such that it fills substantially the whole inner room of the machine, since previously the bale is in contact with the compression means only on its lower surface.

The drawbacks of the fixed-chamber baler are due to the
fact that the bales have a reduced weight/density, the bale diameter is previously set and may not be varied by the operator through the cab control means, the power absorption is greater.

5 Of course the core will be soft, allowing the passage of air inside it, thereby promoting the fermentation processes.
The patent EP-A-0 235 356 discloses a round baler which aims to solve the same problems of the present invention, that is the formation of a constant density bale having a hard core, or a bale with a soft core and a denser outer surface.

However, the means for attaining these aims are totally different since in EP-A-0 235 356, in order to change over from an arrangement suited to form a soft core to one suited to form a hard core and vice versa, it is necessary to manually displace the action (or linked connection) point of the cylinder unit which resists to the expansion of the bale. Moreover, in contrast with the arrangement of the present invention, the outer surface density is not controlled by the pressure of a hydraulic cylinder unit, rather by a spring associated to a switch which is triggered when the bale has reached a predetermined size.
The patent EP 0 125 719 discloses a system which prevents belts from breaking, by a circular arrangement of rollers defining the final shape and diameter of the bale. EP-0 102 530 proposes to solve other problems, and particularly it discloses a system which avoids clogging of
the aperture where the product is picked up, by means of a device (directly operated by the user from the cab), which lifts up a pair of arms defining the bale formation chamber, in the event of clogging.

US-4 273 036 discloses a round baler in which a primary belt tensioner and a secondary belt tensioner are provided with collars having rollers, whose displacement allows to obtain - with merely mechanical means - a compression of the bale at approximately constant pressure until the formation of the bale is completed. It is not possible to gradually increase the pressure in order to obtain a bale with a hard core and an uniform density.

EP 0 497 539 A1 discloses a manually operated adjustment system of the size to the bale formation chamber, including mechanical means. In this case it is not possible to speak of a primary belt tensioner and a secondary belt tensioner, rather of an arm which serves to adjust the size of the core formation chamber, and of only one belttightener which is located in the rear part of the round baler.

Disclosure of Invention

An object of the present invention is to eliminate the disadvantages of one and the other kind of baler, by providing an adaptable machine which may be used to form bales having a hard or a soft core, wherein the soft core may have different diameter, and which may therefore be employed for any kind of product, regardless of its conditions (humidity degree).
Another object of the present invention is that of providing a baler which does not require manual work by the user, for defining the initial geometry of the chamber, like the assembling or disassembling or adjustment of mechanical parts, in order to adapt the baler to the desired kind of operation: formation of a bale with a great or small diameter, with a hard or soft core, with an outer surface which is made impervious by a greater compression thereof, etc.

Another object of the present invention is that of providing various compression programs:
- compression performed with a constant pressure during the whole process, starting from a hard or soft core;
- compression performed with a gradually increasing pressure, starting from a hard or soft core; in particular if the core is hard, it is possible to obtain a constant density of the bale;
- compression performed by setting an initial value and a final value of the pressure which acts starting from a predetermined adjustable diameter (the core being soft or hard).

According to the invention, it is indeed possible by acting on push-buttons or small levers or parts which are sensitive to the touch located on the electronic command monitor, to automatically modify the position of the cylinder units which determine the initial geometry of the core formation chamber, and to choose one of the three compression programs.
Brief Description of Drawings

The present invention will now be described for illustrative and non-limitative purposes, by means of two preferred embodiments thereof, which are illustrated in the drawings, wherein:

Fig. 1a is a schematic lateral and sectional view of the round baler of the present invention, in the condition allowing the formation of a bale with a hard core;

Fig. 1b is a view analogous to Fig. 1a, showing the bale starting in the case of a bale with a hard core;

Fig. 1c is a sectional view of a bale with a hard core;

Fig. 2a is a schematic lateral and sectional view of the round baler, in the condition allowing the formation of a bale having a soft core with a small diameter;

Fig. 2b is a view analogous to that of Fig. 2a, showing the formation of a bale having a soft core with a small diameter;

Fig. 2c is a sectional view of the bale having a soft core with a small diameter;

Fig. 3a is a sectional view of the round baler, in the arrangement allowing the formation of a bale having a soft core with an intermediate diameter;
Fig. 3b is a sectional view analogous to Fig. 3a, illustrating the process of bale formation, in the case of a soft core with an intermediate diameter;

Fig. 3c is a sectional view of a bale having a soft core with an intermediate diameter;

Fig. 4a is a sectional view of the round baler in which the machine initial arrangement allows the formation of a bale having a soft core with a large diameter;

Fig. 4b is a sectional view of the round baler of Fig. 4a, showing the process of bale formation, in the case of a bale with a large-diameter soft core;

Fig. 4c is a sectional view of a bale with a large diameter soft core;

Fig. 5a is a second embodiment of the round baler of the invention, in which both belt tensioners are hinged on a common axis, and wherein the machine's initial arrangement allows the formation of a bale having a hard core;

Fig. 5b shows the round baler of Fig. 5a, wherein the machine's arrangement is that corresponding to the formation of a bale having a soft core;

Fig. 6 the sectional view of the round baler and a
schematic illustration of the potentiometer, the electronic control unit, and the electrically controlled hydraulic valve;

5 Fig. 7 is a diagram of the hydraulic circuit, the hydraulic cylinder units for displacing the primary belt tensioners, and the oil ports or oil intakes of the tractor, according to a first operative phase of the round baler;

10 Fig. 8 is a diagram of the hydraulic circuit of Fig. 7, according to a second operative phase;

Fig. 9 is a diagram of the hydraulic circuit of Fig. 7, according to a third operative phase corresponding to the bale compression process.

Best Mode of Carrying out the Invention

In the figures, numeral 1 denotes the baler body or frame, which is closed on its rear portion by a tailgate 2 hinged on a horizontal axis 3. The opening of the tailgate 2 is performed by hydraulic cylinder units or equivalent devices;

the cab command monitor of the drawing vehicle indicates the locking condition of the tailgate after its closing, once the bale has been discharged by the bale ejector (not shown).

The baler comprises drawing means 4, and power transmission means transmitting power from the tractor to the baler,
which are of any known kind (not shown).
Moreover, in the lower front part there is provided a
pickup 5. The numeral 6 indicates a conveyor for feeding
the silage or straw towards the inside of the frame 1. The
conveyor 6 cooperates with a floor roll 7 in order to feed
the product, said roll starting the curling of the product
inside the chamber 9 by cooperating with the belts 8. The
components 6, 7 may be replaced by any other group of
mechanical feed parts known to the skilled person. For
instance, some balers make use of rollers which transmit
the motion to belts acting like belt conveyors.
The bale core formation chamber 9 is bounded by the set of
belts 8 which is wound around a plurality of stationary
rollers 10a, b, c, d, e, f, g, h, some of which are mounted inside
the tailgate 2 and others on the front stationary part of
the frame 1.
The belts 8 are moreover wound around belt tightening
rollers 11, 12, 13, 14, the first three of them being mounted
on two belt tightening arms 15, one on each side of the
baler, while the fourth one is mounted on two arms of a
second belt tensioner or subordinate belt tensioner 16.
The main arm or belt tensioner 15 is rotatable around the
axis 17, whereas the subordinate arm or belt tensioner 16
is mounted on the axis 18.
The two belt sections between the stationary transmission
roller 10d and the movable belt tightening rollers 11, 12,
moves in opposite directions and they substantially separate
the set of belts 8 in two sections 8a, 8b, inside the frame 1.
The bale core formation chamber 9 is also bounded by two other stationary rollers 19, 20, which are also driven in order to form the bale core. The rollers driven by the PTO (power take-off) are the rollers 10a, 10b, 7, 19 and 20. The others are idle rollers.

According to the invention, the belt tightening arm 15 is actuated by two double-acting hydraulic units 21, which are located on two opposite sides of the machine, and which move the belt tightening arm 15 to a definite position, defining a certain geometry and dimension of the bale core formation chamber 9. Moreover, said hydraulic units 21, oppose a resistance to the upward rotation of the arm 15, thereby exerting a traction on the belts which surround the bale 22, due to the expansion of the bale 22 itself.

The traction on the belts 8 is transmitted in the first place through the belt tightening roller 13, which must however lift itself in order to provide the necessary amount of belt length to allow the formation of the bale.

The pressure exerted by the hydraulic units 21 is adjusted by a valve which is actuated by the electronic control unit, so that at any instant of time during the bale formation, its compression is adjustable, according to three compression programs described hereinafter.

In Fig. 1a, the primary or first belt tensioner 15 is arranged in its lowest position so that the bale core formation chamber 9 has a minimum size and the two belts sections A and B have a minimum length. In this
arrangement, a "hard" core will be formed, since the belts 8 are noticeably stretched, the sections A and B are very short, and these two conditions obviously cause a large compression of the product from the very beginning of the bale starting process, and moreover a further tension on the belts 8 will be caused by the secondary belt tensioner 16, whose spring 31 fixed to the tailgate 2 at the point 30 exerts a maximum tensile stress, since in this condition the second belt tensioner 16 is completely in its lifted position (position in which the roller 14 is tangent to the belts) and the length of the spring is greatest.

Furthermore the moment of the force of the spring 31 about the axis 18 is greatest (length D).

Therefore, the second baler of the invention may be used to form a "hard" core.

On the contrary, with reference to Fig. 2a, it may be noticed that the sections A and B are longer than those of Fig.1a, since the arm 15 is lifted in this arrangement and the size of the bale core formation chamber is greater. In this case the product will exert a pressure on the two belt sections A and B which have a larger length, thus causing first only the lifting of the second belt tensioner or arm 16, as shown in Fig. 2b, and only afterwards the lifting of the first belt tensioner or arm 15.

In said first phase, the effect to the first belt tensioner 15 is totally cancelled, that is the compressive action on the bale is exerted by the second belt tensioner 16, whose tensile stress on the belts 8 must be only large enough to
avoid their slipping on the rolls.
The product which comes into contact with the belts immediately after entering, is compressed with a smaller force, until the secondary tensioner or arm 16 is lifted (Fig. 2b), since the action of the primary belt tensioner (which causes a greater compression of the bale) is temporary cancelled, and moreover since the sections A and B are longer and the tensile stress of the spring 31 lower than in the case of Fig. 1a (in Fig. 2a the spring is less stretched), and lastly since the torque around the axis 18 (given also by the length D of Fig. 2a) is lower.
Then, the round baler will allow to obtain a bale 22 having a "soft" core.
This is schematically shown in Fig. 2c, which illustrates the characteristic "star" of a bale with a "soft" and small diameter core.
The above statements may be repeated for the case of Figs. 3a, 3b and 3c or 4a, 4b and 4c.
In Fig. 4a, A and B are longer than in the case of Fig. 3a so that the preset size and geometry (from the cab) of the chamber 9, will be used - in each case - to form a "soft" core with an intermediate diameter (Fig. 3a), or a "soft" core of large diameter (Fig. 4a), or even a "soft" core of small diameter (Fig. 2a).
Obviously, it may be conceived to provide a number of possible presettings of the volume of the chamber for forming a "soft" core, which exceeds three.
The greater the bale core formation chamber, the smaller
will be the pressure exerted on the product, since the sections A and B will be longer and the length D, smaller. Therefore, to form a bale with a soft core, it is necessary to adjust the position of the first belt tensioner 15, using electric, electronic, mechanical systems and so on, possibly the hydraulic circuit of Fig. 6 described hereinafter, but in order to stretch the belts 8 it is necessary to provide the second belt tensioner 16, since the roller 13 is no more in its position shown in Fig. 1a (presetting corresponding to the formation of a hard core), in which it applies a tensile stress on the belts 8. When the chamber 9 is full, the bale starts to push both belt sections A, B, overcoming only the force of the spring 31 of the secondary belt tensioner 16. Only after the secondary belt tensioner 16 has reached the maximum level (Figs. 2b, 3b, 4b), the hydraulic pressure of the two hydraulic units 21 of the primary belt tensioner 15 begins to act, and this pressure may be adjusted according to three programs which can be preset by the operator; for instance to form a dense and impervious layer as will be described in the following.

Setting each time the initial and final angular positions of the arm 15, and varying the temporary hydraulic pressure of the hydraulic cylinder units 21, it will be possible to obtain bales with different properties and sizes.

A plurality of stops (like pins or axes inserted into appropriate holes) may replace the automatic positioning of the hydraulic units 21 performed by means of the hydraulic
circuit.
In Figs 5a and 5b, another embodiment of the round baler is illustrated.
The first belt tensioner 15 is rotatably mounted on the same axis 17 as the second belt tensioners 16'.
The second belt tensioner 16' is provided with a projection 40 on its opposite end with respect to where the spring acts. Until this projection 40 does not come into contact with the first arms 15, thereby acting as a stop, the bale may expand more easily overcoming only the force of the second belt tensioner 16', so that in the initial arrangement shown in Fig. 5b it will be possible to form a soft core. On the contrary, since the projection 40 already abuts the primary belt tensioner 15 in Fig. 5a, this arrangement or presetting is that which corresponds to Fig. 1a (first embodiment) for the formation of a hard core. This second embodiment shows that the position of the secondary belt tensioner 16' may be chosen in the present invention according to the application. The round baler of the present invention seeks to solve the problem of providing a versatile machine, allowing the formation of bales of hay, maize plants, straw, silage, etc, with different properties with respect to density (hard core, or soft core with variable diameter).
According to the invention there are provided three programs for bale compression, which are performed automatically by the electronic control unit. The hydraulic circuit (Figs. 7, 8, 9) controlled by the
electronic control unit 50 (Fig. 6) will be described afterwards. The presetting of the geometry of the bale core formation chamber, is performed by closing at a predetermined instant of time, an electrically controlled two-way valve 57 of the hydraulic circuit, which stops the oil flow towards the hydraulic cylinders 21 which serve to compress the bale, when the hydraulic cylinder units 21 have reached the desired position. This position is detected by the signal sent by a potentiometer.

The compression program with a constant pressure (acting through the hydraulic units 21) provides that the pressure of the hydraulic cylinder units 21 exerted on the bale by the belt 8 (starting from the condition shown in Figs. 1b, 2b, 3b or 4b, when the second belt tensioner is lifted and the roll 14 is tangent to the belts 8) is constant until the bale has reached its maximum diameter (the diameter of the bale when the latter is discharged out of the round baler). This pressure may be preset in an interval comprised for instance between 80 and 220 bar.

The compression program with a constant pressure increase is characterized by the presetting of the initial value and final value of the pressure and of the final value of the bale diameter (diameter of the bale when the latter is discharged out of the round baler).

The pressure increases in a constant way from the initial to the final value, once the product has filled the chamber Figs. 1b, 2b, 3b, 4b).
The compression program with variable pressure provides that two pressure values V1 and V2 are chosen. The value V1 acts after the bale core formation chamber has been completely filled and is maintained constant until the bale has reached a predetermined diameter (for example 2/3 of the maximum angular rotation amplitude of the primary belt tensioner).

Thereafter, the pressure V2 starts acting and this pressure remains constant until the bale is completed.

The compression method makes use of various components, as shown in Fig. 6, that is an electronic control unit 50, a potentiometer 51, hydraulic cylinder units 21, and an electrically controlled hydraulic valve 52 included in the circuit 53 shown in Figs. 7, 8, 9.

The electrically controlled hydraulic valve 52 is realized in a single-block of metal and comprises a pilot-operated check valve 54, a proportional solenoid valve 55 for pressure control, a maximum pressure safety valve 56, and a two-position two-way electrically controlled valve 57.

The electronic control unit 50 is usually located in the cab of the tractor and in a position such as to be easily seen and operated by the user, who can choose and set different compression programs performed by the round baler.

Said control unit 50 is supplied with 12V and is managed by a microprocessor.

The potentiometer 51 is located on the round baler (Fig. 6), it is connected to the primary belt tensioner 15, and it is
suited to detect the position thereof during the rotation, from a minimum to a maximum allowed position.

In the following, the operation of the hydraulic circuit (Figs. 7, 8, 9) will be described in the case of an intentional upward displacement of the primary belt tensioner 15 (Fig. 7), an intentional downward displacement (Fig. 8), and an induced displacement of the hydraulic cylinder units 21 caused by the bale expansion (compression method, Fig. 9).

With reference to Fig. 7, oil is drawn by an oil distributor or dispenser (not shown) of the tractor and is supplied to the circuit 53 of Fig. 6 through the oil intakes 58, 59, by moving a lever (not shown).

In the particular case of Fig. 7, oil enters through the oil intake 59, in the circuit 53 of Fig. 6 and supplies the hydraulic cylinder units 21, thereby extending the latter. Oil is discharged in the distributor through the two-position two-way electrically controlled valve 57 and through the pilot-operated check valve 54 which will be open since it is controlled by the delivery flow of oil through the conduit 60.

With reference to Fig. 8, which relates to the positioning of the primary belt tensioner 15 during its lowering to the predetermined position, the operator sets (chooses) by means of the electronic control unit 50 of Fig. 6, the initial position to be occupied by the primary belt tensioner 15 of Fig. 6.

Using the distributor of the tractor, operating a lever,
oil is supplied through the oil port or intake 58. This oil passes through the check valve 54, the valve 57 and acts on the cylinder units causing their retraction. The cylinder units 21, when retracting, displace the primary belt tensioner 15 which is connected to the potentiometer 51 of Fig. 6. When the preset position is reached, according to a well defined voltage signal from the potentiometer 51, the electronic control unit controls the closing of the two-position two-way solenoid valve 57. Then, the oil cannot be supplied to the cylinder units 21 any more, and is discharged through the maximum pressure safety valve 56. The oil flow inside the circuit 53 operates then the hydraulic cylinder units (not shown) for closing the tailgate of the round baler.

Fig. 9 shows the compression process, that is the pressure control process inside the hydraulic circuit, said pressure acting against the extension of the hydraulic cylinder units 21 which control the displacement of the primary belt tensioner 15.

As has been said before, three compression programs may be chosen:
- constant pressure;
- constant density;
- variable pressure (V1 --> V2).

The pressure inside the circuit is defined by the pressure control proportional solenoid valve 55.

Generally, a pressure control valve maintains the pressure
inside a hydraulic circuit below a predetermined value. Usually it comprises a spring-loaded valve body which under normal conditions closes an oil passage hole. When reaching the calibration pressure defined by the force exerted by the spring on the valve body and by the useful cross-section of the passage, the hole is opened and oil passes through, said oil being usually directed towards the distributor of the hydraulic control unit.

Varying the preloading of the spring, for instance with a screw, the calibration pressure changes from a minimum to a maximum value.

In the proportional solenoid valve 55, corresponding to our specific situation, the preloading of spring is effected by an electromagnet. Varying the supply current, the induced magnetic field is modified, therefore the force, pushing on an electromagnet which presses on the spring, varies accordingly.

The control of said proportional solenoid valve is effected by means of a printed circuit board mounted on the block of the electrically controlled valve 52, said printed circuit board transforming a variable voltage signal, usually from 0 (zero) to 10 Volt, into a signal having a constant voltage and a variable current depending on the input voltage value.

The calibration pressure is thereby changed between a minimum and a maximum value, according to the structural shape of the valve body.

Therefore, when a constant pressure compression process is
chosen, a presetting of the operation pressure is performed on the electronic control unit 50.
The potentiometer sends voltage signals to the electronic control unit during the rotation of the primary belt tensioner 15, and this unit converts them into the voltage value (which is always the same in this case), corresponding to the required pressure value.
This signal is input in the printed circuit board (not shown) mounted on the electrically controlled valve 52, which maintains constant the pressure value in the hydraulic circuit.
In the situation shown in Fig. 9, oil does not pass through the oil ports or intakes 58, 59, and the pilot-operated check valve 54 stops the flow of oil displaced by the hydraulic cylinder units 21 under the action of the expanding bale, so that oil may pass in a "controlled way" through the pressure control proportional solenoid valve 55 (once the calibration value has been reached).
When the constant density compression process is chosen, a presetting of the initial and final pressure values and of the bale diameter is performed on the electronic control unit 50.
The potentiometer 51, or generally on analogue, digital or capacitive detector of linear or angular variations, sends voltage signals to the electronic control unit 50 during rotation of the primary belt tensioner 15, and this control unit processes these signals by means of the microprocessor and sends them to the printed circuit board of the
electrically controlled hydraulic valve 52, which through the electromagnet modifies the preload of the spring on the valve body. In this way it is possible to increase the pressure in a constant way, from the initial value to the final value associated to the preset diameter. In the operation mode involving a variable pressure, two pressure values V1 and V2 are set on the electronic control unit 50, the desired value of the bale diameter and the initial geometry of the chamber.

The control unit will control the valve 55 according to the pressure V1, until the potentiometer 51 transmits a signal corresponding to the position of the primary belt tensioner 15 between the minimum one (initial geometry of the chamber) and a second position calculated according to a desired ratio (for instance 2/3 of the rotation amplitude angle of the belt tensioner, referring to the preset diameter of the bale).

Once this position of the primary belt tensioner is reached, the voltage signal of the potentiometer 51 is processed to obtain the pressure V2 which will remain constant until the bale is completed.

Obviously, in the case of a compression with a constant pressure, the pressure control solenoid valve could be replaced by an usual mechanical pressure control valve with a spring which is loaded with a screw, since the preloading in this case does not change with time.
Claims

1. Round baler of the kind with a variable chamber and with a bale core formation chamber having a variable geometry, comprising at least one set of belts, chains with cross-rods or the like (8), stationary rollers (10a,b,c,d,e,f,g,h) and movable belt tightening rollers (11, 12, 13, 14), characterized in that said movable rollers are mounted on at least one primary belt tensioner (15) which is displaced by means of hydraulic cylinder units (21) and on at least one secondary belt tensioner (16), whereby the primary belt tensioner (15) defines the initial geometry of the bale core formation chamber, which is obtained by controlling the position of the primary belt tensioner (15) with an electrical and hydraulic system and an electronic control unit stopping the oil flow to the hydraulic cylinder units (21); the tensile stress or the slackening of the belts or the like is balanced by the secondary belt tensioners for any position of the primary belt tensioner, whereby the secondary belt tensioners (16) cancel the action of hydraulic compression of the primary belt tensioner (15) in a first bale compression phase and exert on the belts a pressure by means of their springs (31) which is just sufficient to ensure the adherence of the belts on the stationary and driven rollers (10a, 10b).

2. Round baler according to claim 1, characterized in that in the position in which the primary belt tensioner (15) is
the lowest possible and the secondary belt tensioner (16) has its roller (14) tangent to the belts, so that the tensile stress of springs (31) is the largest possible, the belt sections [A,B] are in a condition of maximum tensile stress determined by the pressure of the hydraulic circuit, and the machine has an arrangement suited to form a hard core.

3. Round baler according to claim 1 or 2, characterized in that the positioning of the primary belt tensioners (15) is automatic and is effected by means of an electric signal which is sent by the electronic control unit, or requires manual work and is effected by stops for the positioning of the primary belt tensioners (15).

4. Round baler according to claims 1, 2 or 3 characterized in that the secondary belt tensioners are controlled by springs (31) or mixed mechanical/hydraulic devices in order to prevent slackening of the belts (8) and their slipping, thereby contributing to increase the bale compression.

5. Round baler according to claim 1, characterized in that the secondary belt tensioners (16) are mounted on the tailgate (2).

6. Round baler according to claim 1, characterized in that the secondary belt tensioners (16') are mounted on the front stationary part of the machine body (1).
7. Round baler according to any of the preceding claims, characterized in that the rotation angle of the belt or chain tensioners (15) is adjustable according to the desired diameter of the bales, and in that the bales may be tied up by means of a wire, a net or a plastic film, for any present diameter.

8. Round baler according to claim 6, characterized in that the secondary belt tensioners (16’) are mounted on the same axis (17) as the primary belt tensioners (15).

9. Round baler according to claim 8, characterized in that the secondary belt tensioners (16’) have projections (40) which define the beginning of the compression phase by the hydraulic control units (21), when they abut the primary belt tensioners (15).

10. Round baler according to claim 9, characterized in that in the lowest position of the primary belt tensioners (15), in which the projections (40) already abut the primary belt tensioners (15), the product introduced inside the round baler will have a hard core at the end of the bale formation.

11. Round baler according to any of the preceding claims, characterized in that according to the initial position of the hydraulic cylinder units (21), determined by the the hydraulic circuit and the control unit, or by mechanical
stops disposed on the lateral internal walls of the round baler, and according to the compression program selected by the operator - constant pressure, variable (V1, V2) pressure or gradually increasing pressure -, a bale will be formed with different density distributions, with a hard core, or with a soft core with a variable diameter.

12. Round baler according to any of the preceding claims characterized in that it comprises an electronic control unit (50) which according to voltage signals produced by a position sensor of the primary belt tensioner (15), changes by means of an electromagnet the force acting on the spring of the valve body of a pressure control proportional solenoid valve (55).

13. Round baler according to claim 12, characterized in that said position sensor is an analogue, digital or capacitive detector of angular or linear displacements (51), mounted on the round baler and connected to the primary belt tensioner (15).

14. Round baler according to claim 12, characterized in that it comprises a valve which stops the flow of oil to the hydraulic cylinder units (21) at a predetermined time during the lowering of the primary belt tensioners (15), when the position sensor indicates that the primary belt tensioner (15) has reached a preset position corresponding to a selected geometry of the baler core formation chamber.
15. Round baler according to claim 14, characterized in that said valve is an electrically controlled two-position two-way valve (57).

16. Round baler according to claims 12 to 15, characterized in that a pilot-operated check valve (54) allows oil flow to the hydraulic cylinder units (21), both during their intentional lowering and lifting, whereas it stops the flow of oil in case the oil ports (58,59) of the hydraulic circuit do not supply oil and the hydraulic cylinder units are displaced by the expansion of the bale itself, in which case the oil flows through the pressure control proportional solenoid valve (55).

17. Round baler according to claim 16, comprising a maximum pressure valve (56), which allows the flow of oil to further hydraulic cylinder units used for closing the tailgate, at the time when the two-position two-way electrically controlled valve (57) is closed.

18. A method for compressing a bale in a round baler according to claims 1-17, characterized in that the voltage signals from the position sensor are processed by the electronic control unit which converts them into a voltage value, the latter being transformed into a signal with a constant tension and a variable current by means of a printed circuit board, whereby the last signal activates the electromagnet which modifies the preloading of the
spring associated to the valve body of the pressure control valve (57), according to the pressure to be instantaneously exerted on the bale.
**INTERNATIONAL SEARCH REPORT**

**International Application No**

PCT/IT 96/00114

### A. CLASSIFICATION OF SUBJECT MATTER

**IPC** A01F15/07

According to International Patent Classification (IPC) or to both national classification and IPC.

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPC** A01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search

26 August 1996

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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx 31 651 epo nl,
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