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(54) Title: A ROLLER BALER, AND A METHOD FOR PRODUCING A ROUND BALE OF MATERIAL IN A ROLLER BALER

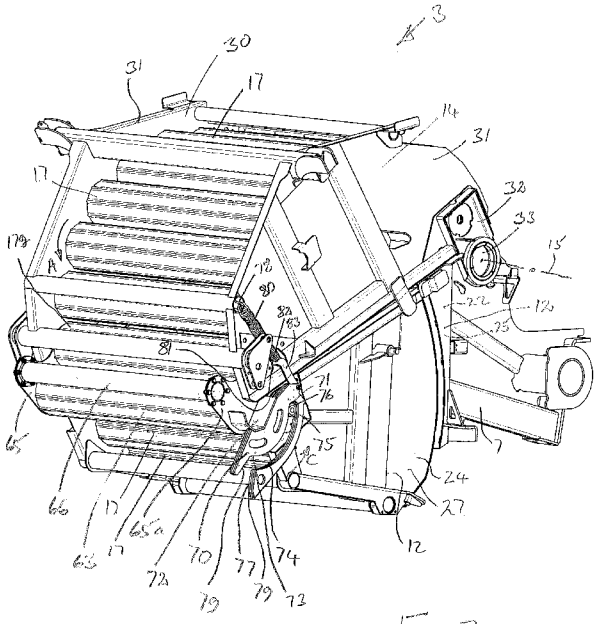

Fig 7

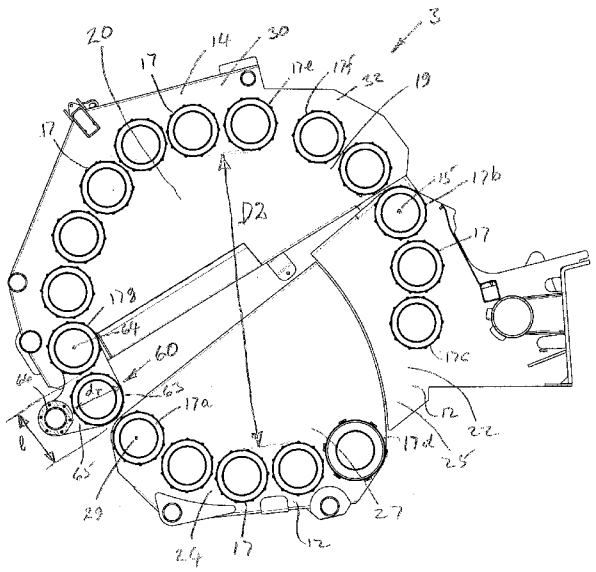

Fig 14

(57) Abstract: A roller baler (3) comprising a bale chamber (20) defined by a fixed segment (22), a discharge segment (24) and a closure segment (30) pivotally coupled to the fixed segment (22) about a main pivot axis (15) from a bale forming state to an open state comprises a plurality of bale rotating rollers (17) rotably carried on the fixed segment (22), the discharge segment (24) and the closure segment (30). A bridging roller (63) rotatably carried on carrier brackets (65) pivotally coupled to the closure segment (30) about a bridging element pivot axis (64) is coupled to the discharge segment (24) through a camming pole (70) and a cam follower (75) for controlling pivotal movement of the bridging roller (63) from an inoperative first state to a bridging second state located between rollers (17a and 17g) on the discharge segment (24) and the closure segment (30). The camming pole (70) rigidly secured to one of the carrier brackets (65) comprises a camming slot (74) along which the cam follower (75) is slideable between a first end (71) thereof

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and a second end (73) thereof urging the bridging roller (63) progressively from the inoperative first state as the closure segment (30) in the bale forming state is progressively pivoted about the main pivot axis (15) from a first state to a second state for forming bales of selectable diameter and of improved density.

A roller baler, and a method for producing a round bale of material in a roller baler

The present invention relates to a roller baler, and the invention also relates to a method for producing a round bale of material in a roller baler, and in particular, though not limited to a method for producing a round bale of selectable diameters from a roller baler.

Roller balers are well known for producing cylindrical bales of crop material, which typically, are referred to as round bales. Typically, such round bales are of diameter in the range of 500mm to 2,000mm, and of axial length ranging from 1,000mm to 1,300mm, and more typically, are of diameter in the range of 1,100mm to 1,400mm and of axial length in the range of 1,100mm to 1,300mm. In general, the crop material, which may be any type of crop material, such as grass silage, hay, straw and other such stalky crop materials, is rotated, pressed and formed into a round bale in a bale chamber of the baler. A plurality of bale rotating rollers are arranged in a circular formation, and define the circumferential periphery of the bale chamber. The bale rotating rollers are driven in rotation for rotating the crop material in the bale chamber. Some of the bale rotating rollers are carried on a fixed segment which is fixed to a chassis of the baler, and others of the bale rotating rollers are carried on a closure segment. The closure segment typically, is pivotal from a bale forming state cooperating with the fixed segment with the bale rotating rollers of the fixed and closure segments defining the bale chamber to rotate, press and form the crop material into a round bale, to an open state for accommodating discharge of the bale from the bale chamber.

In some roller balers, some of the bale rotating rollers are carried on a discharge segment, which is pivotal between a bale forming state defining with the fixed segment and the closure segment the bale chamber, and a discharge state for discharging a formed bale from the bale chamber.

A pair of hydraulic rams are provided on respective opposite sides of the baler for operating the closure segment between the bale forming state and the open state, and also for urging the closure segment into the bale forming state with a substantially constant pressure for producing a bale of bale density, which depends on the pressure with which the closure segment is urged into the bale forming state.

One problem with such roller balers is that due to the nature of the baler, the bale chamber defined by the bale rotating rollers is of a fixed size, and therefore, in general, the diameter of the bales produced in such

roller balers is fixed, in other words, the bales produced by such roller balers are all of substantially the same diameter. Another problem with conventional roller balers is that the density of the bale is not uniform throughout the bale. In general, a central portion of such bales produced by conventional roller balers tend to be of lower density than an outer peripheral portion of the bale, and in many cases, the more dense part of the bale adjacent the outer peripheral portion is of relatively small radial depth. This is undesirable, since firstly, it limits the quantity of material, which could otherwise be contained in a round bale, and secondly, it can effect the shape of the formed bale, in that over time the bale instead of being cylindrical, may become of ovoid transverse cross-section.

There is therefore a need for a roller baler which is configurable to produce a bale of selectable diameter, and with an outer peripheral portion of greater radial depth of the more densely packed material. There is also a need for a method for producing bales in a roller baler of selectable diameter and of improved bale density. There is also a need for a combined baler/bale wrapper which produces wrapped bales of selectable diameter and of improved bale density.

The present invention is directed towards addressing at least some of the problems of roller balers, and the invention is also directed towards addressing at least some of the problems of known methods for forming bales in a roller baler.

According to the invention there is provided a roller baler comprising a first part and a second part moveable relative to the first part, the first and second parts carrying respective pluralities of bale rotating rollers, the second part cooperating with the first part in a bale forming state with the bale rotating rollers defining a circumferential periphery of a bale chamber in which material is rotated, pressed and formed into a round bale by the bale rotating rollers, the second part being progressively moveable relative to the first part from a first state to a second state with the diameter of the bale chamber progressively increasing from a first diameter to a second diameter, and a circumferential gap defined between adjacent rollers of the respective first and second parts progressively increasing in circumferential length from a first value to a second value, an urging means applying an urging force to the second part for urging the second part from the second state to the first state thereof, a bridging element moveably coupled to the first part or the second part by a first connecting means, and moveably coupled to the other one of the first part and the second part by a camming means, the camming means controlling the bridging element to progressively move through progressive bridging states from a first state to a second state in response to the second part progressively moving from the first state to the second state to bridge the progressively increasing

circumferential gap as the second part is being urged from the first state to the second state against the urging force applied by the urging means.

In one embodiment of the invention the camming means is configured to constrain the bridging element to move synchronously with the second part.

Preferably, the camming means is configured to constrain the bridging element to move synchronously with the second part as the second part moves between the first and second states thereof.

Advantageously, the camming means retains the bridging element and the one of the first part and the second part to which the bridging element is coupled by the camming means captive relative to each other as the second part moves between the first state thereof and the second state thereof.

In one embodiment of the invention the camming means is configured to release the bridging element from the one of the first part and the second part to which the bridging element is coupled by the camming means in response to the second part being in the second state thereof.

In another embodiment of the invention a retaining means is provided for retaining the bridging element in an aligned state on release of the bridging element by the camming means from the one of the first part and the second part to which the bridging element is coupled by the camming means, so that the bridging element is re-engageable with the one of the first part and the second part through the camming means in response to return of the second part to the second state thereof.

Preferably, the first connecting means moveably coupling the bridging element to the one of the first part and the second part comprises a pivot coupling defining a bridging element pivot axis about which the bridging element is pivotal between the first state and the second state thereof.

In one embodiment of the invention the camming means comprises a camming element having a camming track extending therein, the camming element mounted on the bridging element or on the one of the first part and the second part to which the bridging element is coupled through the camming means, and a cam follower mounted on the other one of the bridging element and the one of the first part and the second part to which the bridging element is coupled through the camming means, the cam follower being engageable in and progressively urgeable along the camming track in response to the progressive

movement of the second part relative to the first part from the first state to the second state thereof for progressively urging the bridging element through the respective bridging states from the first state thereof to the second state thereof.

Preferably, the camming element is rigidly mounted on the one of the bridging element and the one of the first part and the second part on which the camming element is mounted, and the cam follower is rigidly mounted on the one of the bridging element and the one of the first part and the second part on which the cam follower is mounted.

Preferably, the camming track comprises an elongated camming track extending from a first end to a second end.

Advantageously, the cam follower is urgeable along the camming track from the first end thereof to the second end thereof as the second part is urged from the first state to the second state thereof.

Preferably, the camming track comprises an arcuate camming track having a centre of radius substantially coinciding with the bridging element pivot axis.

In one embodiment of the invention the camming element comprises an entry means communicating with the camming track for accommodating the cam follower into and out of the camming track in response to the second part being in the second state, for release and re-engagement of the bridging element relative to the one of the first part and the second part to which the bridging element is coupled.

Preferably, the entry means communicates with the camming track adjacent the second end thereof.

Preferably, the camming track terminates in the entry means adjacent the second end of the camming track.

In one embodiment of the invention a lead-in is provided in the entry means for accommodating the cam follower into the entry slot.

In one embodiment of the invention the camming track comprises an elongated camming slot formed in the camming element.

In another embodiment of the invention the entry means comprises an entry slot formed in the camming element communicating with the camming slot thereof.

Preferably, the entry slot diverges outwardly in a direction from the camming slot to define the lead-in to the entry means for accommodating the cam follower into the entry slot.

In another embodiment of the invention the retaining means for retaining the bridging element in the aligned state is configured for retaining the one of the camming element or the cam follower which is mounted on the bridging element in an aligned state with the entry means or the cam follower aligned with the other one of the entry means and the cam follower in response to the second part being in the second state.

In another embodiment of the invention the retaining means comprises one of a stop member or an abutment member associated with the bridging element, and the other one of the stop member and the abutment member being associated with the other one of the first part and the second part to which the bridging element is coupled through the camming means, the one of the stop member and the abutment member associated with the bridging element being engageable with the other one of the stop member and the abutment member when the bridging element is in the aligned state.

Preferably, engagement of the stop member and the abutment member defines the aligned state of the camming element or the cam follower.

In another embodiment of the invention the retaining means further comprises a resilient element resiliently urging the one of the stop member and the abutment member associated with the bridging element into engagement with the other one of the stop member and the abutment member.

Preferably, the resilient element acts between the bridging element and the one of the first part and the second part to which the bridging element is coupled by the first connecting means.

Advantageously, the resilient element comprises a spring, and preferably, a tension spring.

In one embodiment of the invention the camming element is mounted on the bridging element.

In another embodiment of the invention the cam follower is mounted on the one of the first part and the second part to which the bridging element is coupled through the camming means.

In one embodiment of the invention the bridging element is urgeable progressively from a first state thereof to a second state as the cam follower progressively traverses the camming slot from the first end to the second end for progressively urging the bridging element from the first state thereof through the respective bridging states to the second state thereof.

In another embodiment of the invention the bridging element is of length substantially equal to the length of one of the bale rotating rollers defining the circumferential gap with the other one of the bale rotating rollers.

In another embodiment of the invention the bridging element comprises a bridging roller extending substantially parallel to the bale rotating rollers.

Preferably, the bridging roller is freely rotatably mounted.

In another embodiment of the invention the first connecting means coupling the bridging element to the one of the first and second parts comprises a carrier bracket pivotally coupling the bridging element to the one of the first part and the second part.

Preferably, the bridging element is carried on a pair of the carrier brackets spaced apart from each other with the bridging element extending between and carried on the carrier brackets.

Advantageously, the bridging roller is freely rotatably mounted on and extends between the bridging element carrier brackets.

In one embodiment of the invention the bridging element pivot axis extends parallel to the bale rotating rollers.

In another embodiment of the invention the bridging element pivot axis coincides with a rotational axis of one of the bale rotating rollers of the one of the first and second parts to which the bridging element is

coupled by the first connecting means.

In another embodiment of the invention the bridging element pivot axis coincides with the rotational axis of the bale rotating roller carried on the one of the first and second parts to which the bridging element is coupled by the first connecting means and which defines the circumferential gap with the adjacent one of the bale rotating rollers in the other one of the first and second parts.

Preferably, the second part is pivotally coupled to the first part about a main pivot axis extending parallel to the bale rotating rollers, and is pivotal from the first state through the second state thereof to an open state for accommodating a bale from the bale chamber.

In one embodiment of the invention the urging means is adapted to urge the second part from the open state through the second state to the first state thereof.

In another embodiment of the invention the urging means is adapted to urge the second part from the second state to the first state thereof with the urging force of a substantially constant value.

Preferably, the value of the urging force with which the urging means urges the second part from the second state to the first state thereof is selectable for producing bales of selectable bale densities.

In another embodiment of the invention the urging means comprises at least one hydraulic ram operably connected between the first part and the second part for urging the second part relative to the first part from the second state to the first state.

In another embodiment of the invention the diameter of the bale is selectable by selecting the displacement of the second part from the first state thereof at which formation of the bale in the bale chamber is terminated.

In another embodiment of the invention a monitoring means is provided for monitoring the displacement of the second part from the first state thereof.

In a further embodiment of the invention the first value of the circumferential length of the circumferential gap between the adjacent bale rotating rollers of the respective first and second parts is substantially

similar to the spacing between an adjacent pair of the bale rotating rollers of the first part or the second part.

In another embodiment of the invention a discharge means is provided for discharging a bale from the bale chamber when the one of the first and second parts is in the open state.

In one embodiment of the invention one of the first and second parts comprises the discharge means.

Preferably, the second part is moveable from the bale forming state to the open state.

Preferably, the first part comprises the discharge means.

In one embodiment of the invention the first part comprises a fixed part and a discharge part forming the discharge means, the discharge part being moveable from a bale forming state cooperating with the fixed part of the first part and the second part when the second part is in the bale forming state to form the bale chamber, and a discharge state for discharging the bale when the second part is in the open state.

In one embodiment of the invention the second part is pivotally coupled to the first part, and is pivotal about a main pivot axis between the first state and the second state. Preferably, the main pivot axis extends parallel to the bale rotating rollers.

In another embodiment of the invention the second part is pivotal about the main pivot axis between the bale forming state and the open state.

In one embodiment of the invention the roller baler is mounted on a chassis, and preferably, the chassis is carried on a pair of ground engaging wheels, and advantageously, the roller baler is adapted for towing by a prime mover.

In one embodiment of the invention the urging means is adapted to urge the second part relative to the first part into the first state thereof with an urging force of a substantially constant value.

Additionally, the invention provides a combined baler/bale wrapper, the combined baler/bale wrapper comprising a chassis, a roller baler according to the invention mounted on the chassis, and a bale

wrapper mounted on the chassis and configured relative to the roller baler for receiving a bale from the roller baler. Preferably, the bale wrapper comprises a two axis bale wrapper for end-to-end wrapping of the bale.

In one embodiment of the invention the chassis is supported on a pair of ground engaging wheels, and preferably, the combined baler/bale wrapper is adapted for towing by a prime mover.

The invention also provides a method for producing a bale in a roller baler wherein the roller baler comprises a first part, and a second part moveable relative to the first part, the first and second parts carrying respective pluralities of bale rotating rollers, the second part cooperating with the first part in a bale forming state with the bale rotating rollers defining a circumferential periphery of a bale chamber in which material to be baled is rotated, pressed and formed into the round bale by the bale rotating rollers, the method comprising configuring the second part to be progressively moveable relative to the first part from a first state to a second state with the diameter of the bale chamber progressively increasing from a first diameter to a second diameter and a circumferential gap defined between adjacent rollers of the respective first and second parts progressively increasing in circumferential length from a first value to a second value, applying an urging force to the second part for urging the second part from the second state to the first state thereof, moveably coupling a bridging element to the first part or the second part by a first connecting means, and to the other one of the first part and the second part by a camming means, so that as the second part is progressively moved from the first state to the second state in response to the action of a radial outward force applied by the material being baled in the bale chamber against the urging force, the bridging element is progressively moved from a first state to a second state through respective bridging states bridging the circumferential gap as the circumferential gap progressively increases in circumferential length.

In one embodiment of the invention the bridging element is constrained by the camming means to move synchronously with the second part.

Preferably, the bridging element is constrained by the camming means to move synchronously with the second part as the second part moves between the first and second states thereof.

Advantageously, the bridging element and the one of the first part and the second part to which the bridging element is coupled by the camming means are retained captive relative to each other by the

camming means as the second part moves between the first state thereof and the second state thereof.

Preferably, the camming means releases the bridging element from the one of the first part and the second part to which the bridging element is coupled by the camming means in response to the second part being in the second state thereof.

Advantageously, the bridging element is retained in an aligned state by a retaining means on release of the bridging element by the camming means from the one of the first part and the second part to which the bridging element is coupled by the camming means, so that the bridging element is re-engageable with the one of the first part and the second part through the camming means in response to return of the second part to the second state thereof.

Preferably, the first connecting means defines a bridging element pivot axis, and the bridging element is pivotally coupled to the one of the first part and the second part by the first connecting means about the bridging element pivot axis between the first state and the second state thereof.

In one embodiment of the invention the urging force with which the second part is urged by the urging means comprises a substantially constant urging force.

In another embodiment of the invention the urging force with which the second part is urgeable into the bale forming state is selectable to produce the bale to a selectable bale density.

In another embodiment of the invention the formation of the bale in the bale chamber is terminated in response to the displacement of the second part relative to the first part through a predefined displacement from the first state of the bale forming state to produce the bale of a selectable diameter.

In one embodiment of the invention the urging force applied to the second part to urge the second part into the first state is maintained at a substantially constant value in order to produce the bale of a predefined bale density.

In one embodiment of the invention the substantially constant value of the urging force is selectable to produce bales of selectable bale densities.

In another embodiment of the invention the completion diameter of the bale chamber is selectable to produce bales of selectable bale diameters.

In one embodiment of the invention the completion diameter of the bale chamber is selectable between the first diameter of the bale chamber and at least the second diameter of the bale chamber, and preferably, the completion diameter of the bale chamber is selectable between the first diameter of the bale chamber and a diameter greater than the second diameter of the bale chamber.

In another embodiment of the invention on determining completion of the formation of the bale in the bale chamber, the bale is circumferentially secured.

In one embodiment of the invention the bale is circumferentially secured by circumferentially wrapping the bale with net wrapping material, and in an alternative embodiment of the invention the bale is circumferentially secured by circumferentially wrapping the bale with a film wrapping material.

In one embodiment of the invention one of the first and second parts is urged relative to the other one of the first and second parts to an open state for discharging a bale from the bale chamber.

In another embodiment of the invention the bale is discharged from the bale chamber by a discharge means when the one of the first and second parts is urged relative to the other one of the first and second parts to the open state.

In one embodiment of the invention the method for producing the bale is carried out on the roller baler according to the invention.

In one embodiment of the invention the second part is urgeable by at least one ram into the first state, and preferably, the at least one ram comprises a hydraulic ram. Preferably, the hydraulic pressure of hydraulic fluid applied to the at least one ram for operating the at least one ram to urge the second part into the first state with the urging force of the substantially constant value is selectable, for in turn selecting the substantially constant value of the urging force produced by the at least one ram for urging the second part into the first state.

In one embodiment of the invention the operation of the at least one ram is controlled by a signal

processor, and preferably, an interface means is provided for interfacing with the signal processor in order to permit inputting of a selected diameter to which a bale is to be formed or a selected completion diameter of the bale chamber to be inputted to a memory in or accessible to the signal processor.

In another embodiment of the invention the interface means is configured for entry of a selected value of the pressure of the hydraulic fluid to be applied to the at least one ram or the selected bale density to which the bale is to be formed into a memory in or accessible to the signal processor.

In another embodiment of the invention the signal processor is configured to operate the at least one hydraulic ram and to control the pressure of the hydraulic fluid applied to the at least one hydraulic ram for forming the bale to the selected bale diameter and the selected bale density.

In one embodiment of the invention a monitoring means is provided for monitoring a dimension indicative of the diameter of the bale chamber, and to produce a signal indicative of the diameter of the bale chamber, and preferably, the signal processor is configured to read the signal from the monitoring means to determine when the diameter of the bale chamber has reached the completion diameter. Preferably, the signal processor is configured to operate the baler to circumferentially wrap the bale in the bale chamber in response to the diameter of the bale chamber reaching the completion diameter.

The advantages of the roller baler according to the invention are many. Firstly, the diameter of the bales produced by the roller baler according to the invention is selectable, and the roller baler according to the invention is capable of producing bales of selectable diameters within a range of selectable diameters. Secondly, the density to which the bales are produced by the roller baler according to the invention is also selectable. A further, and a particularly important advantage of the invention is that the density of the bales is improved. In particular, the ratio of the diameter of the central core of the bales produced by the baler according to the invention, which is less dense than the more dense outer peripheral portion of the bale, to the radial depth of the more dense outer peripheral portion, is smaller than the corresponding ratio of the diameter of the less dense central core to the radial depth of the more dense outer peripheral portion of bales produced by a conventional roller baler known heretofore. In other words, the bales produced by the roller baler according to the invention are produced with a radially deeper outer peripheral portion more dense than the less dense central portion resulting in the bales retaining their cylindrical shape and being more suitable for storage, stacking and transportation.

The invention will be more clearly understood from the following description of a preferred embodiment thereof which is given by way of example only with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a combined baler/bale wrapper according to the invention comprising a roller baler also according to the invention and a bale wrapper,

Fig. 2 is a perspective view of the combined baler/bale wrapper of Fig. 1 illustrating parts of the combined baler/bale wrapper in different states to those of Fig. 1,

Fig. 3 is a schematic side elevational view of a portion of the combined baler/bale wrapper of Fig. 1 in one state thereof,

Fig. 4 is a view similar to that of Fig. 3 of the portion of Fig. 3 of the combined baler/bale wrapper of Fig. 1 illustrating parts of the combined baler/bale wrapper in different states to those of Fig. 3,

Fig. 5 is a view similar to that of Fig. 3 of the portion of Fig. 3 of the combined baler/bale wrapper of Fig. 1 illustrating parts of the combined baler/bale wrapper in different states to those of Figs. 3 and 4,

Fig. 6 is a view similar to that of Fig. 3 of the portion of Fig. 3 of the combined baler/bale wrapper of Fig. 1 illustrating parts of the combined baler/bale wrapper in further different states to those of Figs. 3 to 5,

Fig. 7 is a perspective view of the roller baler of the combined baler/bale wrapper of Fig. 1,

Fig. 8 is another perspective view of the roller baler of Fig. 7 illustrating a portion of the roller baler of Fig. 7 in a different state to that of Fig. 7,

Fig. 9 is a side elevational view of the roller baler of Fig. 7 illustrating a portion of the roller baler of Fig. 7 in a different state to those of Figs. 7 and 8,

Fig. 10 is a side elevational view of the roller baler of Fig. 7 illustrating a portion of the roller baler in the state of Fig. 8,

Fig. 11 is a side elevational view of the roller baler of Fig. 7 in a different state to those of Figs. 7 to 10,

Fig. 12 is a cross-sectional side elevational view of the roller baler of Fig. 7 with the roller baler in the state of Fig. 7,

Fig. 13 is a cross-sectional side elevational view similar to that of Fig. 12 of the roller baler of Fig. 7 with a portion of the roller baler in a state substantially similar to that of Fig. 9,

Fig. 14 is a cross-sectional side elevational view similar to that of Fig. 12 of the roller baler of Fig. 7 with a portion of the roller baler in the state of Figs. 8 and 10, and

Fig. 15 is a circuit diagram of a part of the control system for controlling the operation of the combined baler/bale wrapper.

Referring to the drawings there is illustrated a combined baler/bale wrapper according to the invention indicated generally by the reference numeral 1 for producing round bales 2 of crop material wrapped end-to-end, typically, in plastics film wrapping material. The crop material may comprise any type of crop material, such as grass silage, hay, straw and the like, and any other such stalky crop material. Such wrapped bales will be well known to those skilled in the art, and further description should not be required. Each bale 2 defines a longitudinally extending central axis 4.

The combined baler/bale wrapper 1 comprises a roller baler also according to the invention indicated generally by the reference numeral 3 for forming the bales 2 of crop material and a bale wrapper 5 for wrapping each bale 2 produced by the roller baler 3 end-to-end in plastics film wrapping material. The baler 3 and the bale wrapper 5 are mounted on a chassis 7 carried on a pair of rotatably mounted main ground engaging wheels 9. A towing arm 10 extends forwardly from the chassis 7 for coupling to a prime mover, for example, and in this case a tractor 11 for towing and powering the combined baler/bale wrapper 1. The tractor 11 is illustrated in Fig. 15 only in block representation. The bale wrapper 5 is mounted on the chassis 7 for receiving formed bales from the roller baler 3 sequentially for wrapping thereof. The combined baler/bale wrapper 1 is substantially similar to a combined baler/bale wrapper disclosed in PCT Published Specification No. WO 02/076183, and only the parts of the combined

baler/bale wrapper which are of relevance to the invention will be described in detail. The remaining parts will be described only briefly.

Turning initially to the baler 3, the baler 3 comprises a first part 12 which is partly fixed to the chassis 7, and a second part 14 which is pivotally coupled to the first part 12 about a main pivot axis 15. The first and second parts 12 and 14 carry respective pluralities of parallel bale rotating rollers 17 of similar diameter extending parallel to the main pivot axis 15. The second part 14 is cooperable with the first part 12 in a bale forming state, as will be described in more detail below, with the bale rotating rollers 17 configured in a substantially circular configuration to define a circumferential periphery 19 of a bale chamber 20 within which crop material is rotated, pressed and formed into the bales 2.

The first part 12 comprises a fixed segment 22 and a discharge segment 24, which acts as a discharge means for discharging each one of the formed bales 2 from the bale chamber 20 onto the bale wrapper 5 as will be described below. The fixed segment 22 comprises a pair of spaced apart side walls 25 which are fixedly secured to the chassis 7, and carry three of the bale rotating rollers 17 extending between and rotatably mounted in the side walls 25. The discharge segment 24 comprises a pair of spaced apart side walls 27 carrying five of the bale rotating rollers 17 extending between the side walls 27 and rotatably carried in the side walls 27. The discharge segment 24 is pivotally coupled to the chassis 7 about a discharge pivot axis 29, and is pivotal about the discharge pivot axis 29 from a bale forming state illustrated in Figs. 1 and 6 cooperating with the fixed segment 22 and the second part 14 to define the bale chamber 20, to a discharge state illustrated in Figs. 2, 3 and 4 for discharging each bale 2 from the bale chamber 20 to the bale wrapper 5. The discharge pivot axis 29 coincides with the rotational axis of the bale rotating roller 17a of the discharge segment 24 and is parallel to the main pivot axis 15.

The second part 14 comprises a closure segment 30 comprising a pair of spaced apart side walls 31 which carry nine of the bale rotating rollers 17 with the bale rotating rollers 17 extending between and rotatably carried in the side walls 31. Pivot brackets 32 extend from the respective side walls 31 of the closure segment 30 and are pivotally engageable with a shaft 33 of the bale rotating roller 17b of the fixed segment 22 which defines the main pivot axis 15. The closure segment 30 is pivotal relative to the fixed segment 22 about the main pivot axis 15 from a bale forming state illustrated in Figs. 1 and 6 cooperating with the fixed segment 22 and the discharge segment 24 with the bale rotating rollers 17 defining the bale chamber 20, to an open state illustrated in Figs. 2, 3 and 4 for discharge of a bale 2 from the bale chamber 20 by the discharge segment 24.

The side walls 25, 27 and 31 of the fixed segment 22, the discharge segment 24 and the closure segment 30, respectively, define respective opposite ends of the bale chamber when the discharge segment 24 and the closure segment 30 are in the respective bale forming states.

The bale rotating rollers 17 of the fixed segment 22, the discharge segment 24 and the closure segment 30 are driven in rotation in the direction of the arrow A by respective chain drives (not shown) as will be understood by those skilled in the art, for in turn rotating the crop material and the bale 2 thereof in the bale chamber 20 in the direction of the arrow B, see Fig. 6. The drive chains (not shown) are driven through a gearbox (not shown) by drive from the power take-off shaft of the tractor 11.

An urging means comprising a pair of double-acting main hydraulic rams 34 acting between the chassis 7 and the closure segment 30 operate the closure segment 30 from the bale forming state to the open state. Each main ram 34 comprises a cylinder 35 pivotally coupled to the chassis 7 by a corresponding pivot mounting 36. A piston rod 37 extending from the cylinder 35 of each main ram 34 is pivotally coupled to the closure segment 30 by a corresponding pivot mounting 38. As well as the main rams 34 pivoting the closure segment 30 between the bale forming state and the open state, the main rams 34 also apply a selectable substantially constant urging force to the closure segment 30 for urging the closure segment 30 into the bale forming state during formation of a bale in the bale chamber 20 to produce the bale 2 of a selectable bale density as will be described in more detail below.

A pair of link members 39 pivotally coupled to the closure segment 30 at 40 and slideably and pivotally coupled to the discharge segment 24 cooperate with the main rams 34 to pivot the discharge segment 24 about the discharge pivot axis 29 from the bale forming state to the discharge state as the closure segment 30 is being urged from the bale forming state to the open state by the main rams 34. A delay slot 42 in each link member 39 slideably and pivotally engages a corresponding pivot pin 44 on the corresponding side wall 27 of the discharge segment 24 to provide a delay whereby commencement of operation of the discharge segment 24 from the bale forming state to the discharge state is delayed until after the closure segment 30 has been pivoted from the bale forming state a sufficient angular distance about the main pivot axis 15 to accommodate discharge of a bale from the bale chamber 20. Before operation of the discharge segment 24 from the bale forming state to the discharge state, the pivot pins 44 must traverse the length of the delay slot 42 from a distal end 41 thereof to a proximal end 43 thereof, thereby delaying commencement of pivoting of the discharge segment 24 from the bale forming state to

the discharge state. The link members 32 and the main rams 34 cooperate to return the discharge segment 24 from the discharge state to the bale forming state as the main rams 34 are returning the closure segment 30 from the open state to the bale forming state.

A pick-up mechanism 45 extending forwardly and downwardly from the chassis 7 picks up crop material from an elongated windrow of the crop material lying in a field as the combined baler/bale wrapper 1 is being towed along the windrow by a tractor. The pick-up mechanism 45 urges the picked-up crop material into the bale chamber 20 between one of the bale rotating rollers 17 of the fixed segment 22, namely, the bale rotating roller 17c, and one of the bale rotating rollers 17 of the discharge segment 24, namely, the bale rotating roller 17d. Such pick-up mechanisms and their operation as the pick-up mechanism 45 will be well known and understood by those skilled in the art.

A circumferential wrapping material dispensing mechanism (not shown) which will be well known to those skilled in the art is mounted on the closure segment 30 for feeding either net wrapping or plastics film wrapping material from a roll (also not shown) thereof mounted on the forward end of the chassis 7 for circumferentially wrapping each formed bale 2 in the bale chamber 20 for circumferentially securing the bale 2 prior to discharge of the bale from the bale chamber 20. The wrapping material is fed into the bale chamber 20 between two of the bale rotating rollers 17 of the closure segment 30, namely, between the bale rotating rollers 17e and 17f, see Fig. 6.

Turning now to the bale wrapper 5, and referring in particular to Figs. 1 to 6, the bale wrapper 5 comprises a two axis wrapper and comprises a pair of spaced apart bale support rollers 50 and 51, which extend parallel to the bale rotating rollers 17, and which are rotatably carried on the chassis 7 for supporting and rotating each bale 2 in the bale wrapper 5 during wrapping thereof. The bale support roller 50 is driven through a chain drive (not shown) by a hydraulic motor 52 for rotating the bale 2 supported on the bale support rollers 50 and 51 about a horizontal rotational axis coinciding with the longitudinally extending central axis 4 of the bale 2. A carrier ring 53 carries a pair of spaced apart wrapping material dispensers 54, which are carried on respective carrier brackets 55 mounted on the carrier ring 53. The carrier brackets 55, and in turn the wrapping material dispensers 54 are disposed at approximately 180° around the carrier ring 53. The carrier ring 53 is carried on a pair of lower driven rollers 56 which rotate the carrier ring 53 about a substantially horizontal axis defined by the carrier ring 53 and extending perpendicular to the central axis 4 of the bale 2 and substantially intersecting the central axis 4 of the bale 2 for revolving the wrapping material dispensers 54 around the bale 2 as the bale is being rotated on the bale support

rollers 50 and 51 for end-to-end wrapping of a bale.

The bale support roller 50 is carried on a U-shaped roller carrier 57 which is pivotally connected to the chassis 7 by pivot mountings 58. A hydraulic actuator ram (not shown) acting between the chassis 7 and the roller carrier 57 pivots the roller carrier 57 downwardly about the pivot mountings 58 from a bale wrapping state illustrated in Figs. 1 and 2 to a discharge state (not shown) for discharging the wrapped bale from the bale wrapper 5 to the ground. Such a bale wrapper as the bale wrapper 5 is disclosed in PCT Specification No. WO 02/076183, and further description of the bale wrapper 5 should not be required.

An intermediate roller 59 rotatably carried on the chassis 7 extends parallel to the bale rotating rollers 17 and is located between the baler 3 and the bale wrapper 5 for assisting in the transfer of a bale 2 from the baler 3 to the bale wrapper 5.

Returning now to the roller baler 3, and referring in particular to Figs. 6 to 14, in this embodiment of the invention in the bale forming state, the closure segment 30 is moveable, in this case, is pivotal about the main pivot axis 15, between a first state illustrated in Figs. 6, 7 and 12 with the bale chamber 20 defined by the bale rotating rollers 17 of a first diameter D1, and a second state illustrated in Figs. 8, 10 and 14 with the bale rotating rollers 17 defining the bale chamber 20 of a second diameter D2, which is greater than the first diameter D1, in order to allow bales of different selectable diameters, selectable bale densities and improved densities to be produced by the baler 3. As the closure segment 30 pivots about the main pivot axis 15 from the first state to the second state in the bale forming state thereof, a gap 60 of progressively increasing circumferential length ℓ opens between an adjacent pair of bale rotating rollers 17 of the discharge segment 24 and the closure segment 30, respectively, namely, between the bale rotating roller 17a of the discharge segment 24 and the bale rotating roller 17g of the closure segment 30.

A bridging element, in this embodiment of the invention a bridging roller 63 is provided for bridging the circumferential gap 60 as the closure segment 30 progressively pivots about the main pivot axis 15 from the first state to the second state. The bridging roller 63 extends between and is carried on a pair of first connecting means comprising a pair of spaced apart carrier brackets 65 which are pivotally coupled to the closure segment about a bridging element pivot axis 64. The bridging roller 63 with the carrier brackets 65 are pivotal about the bridging element pivot axis 64 from a first state, namely, an inoperative first state,

illustrated in Figs. 6, 7 and 12, through a plurality of intermediate bridging states, to a second state, namely a bridging second state, illustrated in Figs. 8, 10 and 14.

In the bridging second state, the bridging roller 63 is located between the bale rotating roller 17a of the discharge segment 24 and the bale rotating roller 17g of the closure segment 30, bridging the circumferential gap 60 between the bale rotating rollers 17a and 17g when the closure segment 30 is in the second state and the bale chamber 20 is of the second diameter D2. In the inoperative first state, the bridging roller 63 is located spaced apart outwardly from the bale rotating rollers 17a and 17g. The bridging roller 63 is freely rotatably carried in the carrier brackets 65, and is of length similar to the length of each of the bale rotating rollers 17 for bridging the circumferential gap 60. The carrier brackets 65 are rigidly connected together by a strut 66 extending between and rigidly secured to the carrier brackets 65. The carrier brackets 65 pivotally engage a pivot shaft 67 of the bale rotating roller 17g of the closure segment 30, which defines the bridging element pivot axis 64, about which the carrier brackets 65 and the bridging roller 63 are pivotally coupled to the closure segment 30.

One of the carrier brackets 65, namely, the carrier bracket 65a, is coupled to the discharge segment 24 through a camming means comprising a camming element, namely, a camming plate 70 and a cam follower 75 for controlling the pivotal movement of the bridging roller 63 about the bridging roller pivot axis 64 from the inoperative first state to the bridging second state in response to pivoting of the closure segment 30 from the first state to the second state thereof. The camming plate 70 is rigidly secured to the carrier bracket 65a by a plate bracket 72 which is welded to the carrier bracket 65a and to the camming plate 70. The cam follower 75 is rigidly secured to and extends sidewardly outwardly from a corresponding one of side walls 27 of the discharge segment 24. The cam follower 75 defines a central axis which coincides with the pivot axis 29 of the discharge segment 24.

The camming plate 70 comprises a camming track formed in this case by a camming slot 74 of arcuate shape extending in the camming plate 70 from a first end 71 to a second end 73, within which the cam follower 75 is slideably engageable. The camming slot 74 defines a centre of radius coinciding with the bridging element pivot axis 64, so that as the cam follower 75 traverses through the camming slot 74, the camming plate 70 along with the carrier brackets 65, and in turn the bridging roller 63 are pivoted about the bridging element pivot axis 64. An entry means, in this embodiment of the invention an entry slot 77 extends from the camming slot 74 adjacent the second end 73 for accommodating the cam follower 75 into and out of the camming slot 74, as will be described in more detail below.

The cam follower 75 is configured to cooperate with the camming slot 74 to progressively urge the bridging roller 63 in the direction of the arrow C from the inoperative first state, illustrated in Fig. 7, to the bridging second state, illustrated in Figs. 8 and 10, through the plurality of bridging states as the cam follower 75 is urged progressively along the camming slot 74 from the first end 71 thereof to the second end 73 thereof in response to the closure segment 30 progressively pivoting about the main pivot axis 15 from the first state thereof to the second state thereof. Thus, as the closure segment 30 progressively pivots about the main pivot axis 15 from the first state thereof to the second state thereof, the cam follower 75 is progressively urged along the camming slot 74 from the first end 71 thereof to the second end 73 thereof, and is retained captive in the camming slot 74 between the first and second ends 71 and 73 thereof, so that the bridging roller 63 is urged progressively about the bridging element pivot axis 64 from the inoperative first state to the bridging second state through the plurality of the bridging states bridging the circumferential gap 60, in synchronisation with the pivotal movement of the closure segment 30 about the main pivot axis 15 from the first state to the second state thereof. The cam follower 75 rotatably carries a bearing 76 for rollably engaging the camming slot 74 as the cam follower 75 traverses along the camming slot 74 between the first end 71 thereof and the second end 73.

The camming slot 74 terminates adjacent the second end 73 thereof in the entry slot 77 for accommodating the cam follower 75 therethrough on the closure segment 30 reaching the second state thereof and the cam follower 75 reaching the second end 73 of the camming slot 74, when the closure segment 30 is being urged by the main rams 34 from the bale forming state through the second state thereof to the open state for accommodating discharge of a bale from the bale chamber 20. Opposite side edges 79 of the entry slot 77 diverge in a radial outward direction relative to the bridging element pivot axis 64 for accommodating re-entry of the cam follower 75 into the camming slot 74 as the closure segment 30 returns to the second state of the bale forming state from the open state thereof.

A stop member formed by an end edge 81 of the plate bracket 72 which secures the camming plate 70 to the carrier bracket 65a, is engageable with an abutment member, which is defined by an abutment edge 82 of the corresponding side wall 31 of the closure segment 30 for defining an aligned state of the camming plate 70 and, in turn the carrier brackets 65 and the bridging roller 63. The aligned state of the camming plate and in turn the carrier brackets 65 and the bridging roller 63 corresponds to the second states thereof. In the aligned state the entry slot 77 of the camming plate 70 is aligned with the cam follower 75 as the closure segment 30 is approaching the second state from the open state. Thus, when

the closure segment 30 is approaching the second state thereof from the open state, the entry slot 77 is aligned with the cam follower 75, and enters the camming slot 74 adjacent the second end 73 thereof through the entry slot 77 with the bridging roller 63 in the bridging second state. Further pivoting of the closure segment 30 from the second state to the first state thereof results in the cam follower 75 being urged along the camming slot 74 from the second end 73 to the first end 71, which in turn results in the camming plate 70 and in turn the bridging roller 63 being pivoted about the bridging roller pivot axis 64 in the direction of the arrow D from the bridging second state through the intermediate bridging states to the inoperative first state. Since the central axis of the cam follower 75 coincides with the pivot axis 29 of the discharge segment 24, the cam follower 75 remains in a fixed position relative to the chassis 7, and in turn relative to the main pivot axis 15.

A retaining means for retaining the camming plate 70 in the aligned state when the cam follower 75 has disengaged the camming slot 74 and the entry slot 77, in this embodiment of the invention comprises a retaining spring 80, in this case, a tension spring acting between the closure segment 30 and the camming plate 70. The retaining spring 80 urges the camming plate 70 into the aligned state with the end edge 81 of the plate bracket 72 in abutting engagement with the abutment edge 82 of the corresponding side wall 31 of the closure segment 30. One end of the retaining spring 80 is hooked onto a bracket 78 extending from the corresponding one of the side walls 31 of the closure segment 30, and the other end of the tension spring 80 is secured to a link member 83, which in turn is pivotally coupled to the camming plate 70.

Referring now to Fig. 15, a hydraulic control circuit 85 operated under the control of a signal processor controls the operation of the main rams 34 for operating the closure segment 30 and the discharge segment 24. The signal processor, in this embodiment of the invention comprises a microcontroller 90 which also controls the operation of the combined baler/bale wrapper 1. The signal processor 90 through the hydraulic control circuit 85 operates the main rams 34 for operating the closure segment 30 between the bale forming state and the open state, and in turn for operating the discharge segment 24 between the bale forming state and the discharge state, and also for controlling the closure segment 30 in the bale forming state thereof to produce the bales 2 of selectable diameters and of selectable bale densities.

An interface means, namely, an electronic interface is provided for inputting data to the microcontroller 90, as well as the selected diameter to which the bales 2 are to be formed and the selected bale density to which the bales 2 are to be formed. The electronic interface may comprise any suitable interface, for

example, a keypad, a touch screen or the like. In this embodiment of the invention the electronic interface comprises a touch screen 91, which may be located on the baler 3, or in the cab of the tractor 11 towing the combined baler/bale wrapper 1. When located in the cab of the tractor 11, the touch screen 91 typically is hardwired to the microcontroller 90, and is configured to display status messages regarding the formation of the bale in the bale chamber 20, and to provide alert signals alerting the tractor driver to actions to be taken, for example, advising the tractor driver that the formation of the bale in the bale chamber is complete, and that the combined baler/bale wrapper 1 should be brought to a halt in order to allow circumferential wrapping of the bale in the bale chamber 20. Typically, the electronic interface, as well as comprising the touch screen 91, comprises a sounder 92 for producing audible alert signals to the tractor driver.

The hydraulic circuit 85 is supplied with pressurised hydraulic fluid from a pressurised hydraulic fluid source, which in this case, is provided from a pressurised hydraulic fluid source 94 of the hydraulic system 95 of the tractor 11. A pair of hydraulic couplers 96 and 97 couple the hydraulic control circuit 85 to the high pressure side 98 of the pressurised hydraulic fluid source 94 and to the low pressure side of the pressurised hydraulic fluid source 94, namely, a low pressure tank 100. The hydraulic coupler 96 couples the hydraulic control circuit 85 to the high pressure side 98 of the pressurised hydraulic fluid source 94, and the hydraulic coupler 97 couples the hydraulic control circuit 85 to the low pressure tank 100. The pressurised hydraulic fluid is supplied to the hydraulic control circuit 85 at the pressure of the hydraulic system 95 of the tractor 11, which may be as high as 240 bar.

A primary pressure regulator 102 located in the hydraulic control circuit 85 is controlled by the microcontroller 90 to regulate the pressure of the pressurised hydraulic fluid from the pressurised hydraulic fluid source 94 of the tractor 11 to a suitable system pressure for the combined baler/bale wrapper 1, which typically, is approximately 210 bar. A secondary pressure regulator 104 also operated under the control of the microcontroller 90 controls the pressure of the hydraulic fluid received from the primary pressure regulator 102 at a selectable hydraulic pressure. The selectable hydraulic pressure is commonly referred to as the hydraulic density pressure, and is the pressure at which the hydraulic fluid is to be applied to the main rams 34, so that the main rams 34 apply a substantially constant urging force to the closure segment 30 to urge the closure segment 30 into the bale forming state during formation of the bale in the bale chamber in order to produce the bale of the selected bale density.

Hydraulic fluid at the selected hydraulic density pressure from the secondary pressure regulator 104 is

applied to the main rams 34, and low pressure hydraulic fluid is returned from the main rams 34 to the low pressure tank 100 of the pressurised hydraulic fluid source 94 of the tractor 11 through a solenoid operated spool valve 105. The solenoid operated spool valve 105 is operated under the control of the microcontroller 90 for operating the main rams 34 between an extended state, illustrated in Fig. 2 and a retracted state, illustrated in Fig. 1 for operating the closure segment 30 between the open state and the bale forming state and for applying the constant urging force to the closure segment 30 in the bale forming state during formation of the bale in the bale chamber 20. The operation of the spool valve 105 by the microcontroller 90 for operating the main rams 34 between the extended and retracted states will be well known to those skilled in the art, and further description should not be required. A hydraulic accumulator 107 accumulates pressurised hydraulic fluid from the main rams 34 during formation of each bale in the bale chamber 20 as the formation of the bale is nearing completion, as will be described below.

A monitoring means for monitoring the displacement of the closure segment 30 from the first state thereof comprises a pair of proximity sensors 108 mounted on the cylinders 35 of the respective main rams 34 adjacent distal ends 109 of the cylinders 35. The proximity sensors 108 monitor the spacing between the distal ends 109 of the cylinders 35 from the corresponding pivot mountings 38 which pivotally mount the piston rods 37 of the main ram 34 to the corresponding side wall 31 of the closure segment 30. Each proximity sensor 108 produces an electronic signal indicative of the spacing between the distal end 109 of the cylinder 35 of the corresponding main ram 34 from the pivot mounting 38 of the corresponding piston rod 37. The spacing between the distal ends 109 of the main rams 34 from the pivot mountings 38 of the corresponding piston rods 37 is proportional to the angular displacement of the closure segment 30 from the fixed segment 22 about the main pivot axis 15. In other words, the spacing between the distal ends 109 of the main rams 34 from the pivot mountings 38 of the corresponding piston rods 37 is proportional to the angular displacement of the closure segment 30 from the first state thereof about the main pivot axis 15. The microcontroller 90 reads the signals from the proximity sensors 108 and is programmed to compute the angular displacement of the closure segment 30 about the main pivot axis 15 from the first state thereof from the signals read from the proximity sensors 108 for determining when the formation of the bale in the bale chamber 20 has been formed to the selected diameter and its formation is complete.

In order to assist in a full understanding of the invention, the operation of the baler 3 to produce bales 2 of selectable diameters and selectable bale densities will now be described. Initially, the diameter to which the bales are to be formed, and the bale density to which the bales are to be formed, are selected and entered into the microcontroller 90 through the touch screen 91. The diameter to which the bales may be

formed range from the first diameter D1 of the bale chamber 20 or slightly less than the first diameter D1 to the second diameter D2 of the bale chamber 20, and in some cases, bales of diameter greater than the second diameter D2 of the bale chamber may be formed as will be described below. Typically, the diameter to which the bales are to be formed is entered in millimetres or selectable from a table of predefined selectable diameters.

The bale density may be selected as one of a range of bale densities, generally, presented in a range of one to ten on the touch screen 91, one being the lowest bale density and ten being the highest bale density. Alternatively, the bale density to which the bales are to be formed may be entered by selecting the pressure of the hydraulic fluid, namely, the hydraulic density pressure to be applied to the main rams 34 during the formation of the bales, so that the urging force applied by the main rams 34 to the closure segment 30 to urge the closure segment 30 into the first state of the bale forming state is of the appropriate substantially constant value. The higher the hydraulic density pressure, the greater will be the bale density of the formed bales.

Once the diameter and the bale density to which the bales are to be formed have been entered into the microcontroller 90 through the touch screen 91, the microcontroller 90 operates the secondary pressure regulator 104 to apply the hydraulic fluid at the appropriate or selected hydraulic density pressure, so that the urging force applied to the closure segment 30 by the main rams 34 during the formation of each bale 2 in the bale chamber 20 is of the appropriate substantially constant value.

If the closure segment 30 is not already in the bale forming state, the microcontroller 90 operates the spool valve 105 to apply the hydraulic fluid to the main rams 34 in order to urge the closure segment 30 into the first state of the bale forming state with the urging force of the appropriate substantially constant value.

The combined baler/bale wrapper 1 is then towed by the tractor 11 along an elongated windrow of crop material, and the crop material is picked-up from the windrow by the pick-up mechanism 45, and delivered into the bale chamber 20. As the crop material is being progressively urged into the bale chamber 20, the crop material is rotated in the bale chamber 20 in the direction of the arrow B by the bale rotating rollers 17. As the volume of crop material in the bale chamber 20 continues to progressively increase, the rotating crop material is formed into the round bale 2, the diameter of which progressively increases. On the diameter of the bale 2 reaching the first diameter D1 of the bale chamber 20 and with crop material

continuing to be urged into the bale chamber 20, the rotating bale acts on the bale rotating rollers 17 with a progressively increasing radial outward pressure.

On the radial outward pressure of the rotating bale acting on the bale rotating rollers 17 beginning to exceed the substantially constant pressure applied by the bale rotating rollers 17 to the crop material resulting from the urging force of the constant value applied to the closure segment 30 by the main rams 34, the closure segment 30 begins to be progressively displaced angularly about the main pivot axis 15 from the first state of the bale forming state of the closure segment 30 towards the second state thereof. The accumulator 107 accumulates the pressurised hydraulic fluid from the main rams 34 as the closure segment 30 is being displaced angularly about the main pivot axis 15 from the first state thereof in order to substantially maintain the pressure of the hydraulic fluid in the main rams 34 substantially at the selected density pressure, to in turn maintain the urging force applied by the main rams 34 to the closure segment 30 substantially constant at the appropriate value.

As the closure segment 30 is being progressively angularly displaced about the main pivot axis 15 from the first state thereof by the radial outward pressure being applied to the bale rotating rollers 17 by the rotating bale 2 in the bale chamber 20, the cam follower 75 is progressively urged along the camming slot 74 from the first end 71 towards the second end 73, thereby progressively urging the bridging roller 63 from the inoperative first state through a plurality of bridging states to continuously bridge the progressively increasing circumferential gap 60 between the bale rotating rollers 17a and 17g.

The microcontroller 90 reads the signals from the proximity sensors 108 as the closure segment 30 is being progressively displaced angularly about the main pivot axis 15 from the first state thereof by the radial outward pressure of the bale 2 on the bale rotating rollers 17, and determines the diameter of the bale chamber 20 from the signals read from the proximity sensors 108. On the diameter of the bale chamber 20 reaching the completion diameter, namely, the diameter to produce the bale of the selected bale diameter, the microcontroller 90 outputs a signal to the touch screen 91 and to the sounder 92 alerting the driver of the tractor 11 to the completion of the formation of the bale in the bale chamber 20, and that the combined baler/bale wrapper 1 should be brought to a halt, in order to allow circumferential wrapping of the bale in the bale chamber 20 to commence.

On completion of circumferential wrapping of the bale 2 in the bale chamber 20, the microcontroller 90 operates the spool valve 105 to in turn operate the main rams 34 to urge the closure segment 30 from the

bale forming state to the open state. As the closure segment 30 is being pivoted from the bale forming state to the open state, after an initial delay determined by the length of the slots 42 in the link members 39, the discharge segment 24 is pivoted about the discharge pivot axis 29 from the bale forming state to the discharge state to in turn discharge the circumferentially wrapped bale from the baler 3 onto the bale support rollers 50 and 51 of the bale wrapper 5 for end-to-end wrapping of the bale thereon.

If the diameter of the bale chamber 20 corresponding to the completion diameter of the bale is less than the second diameter D2 of the bale chamber 20, as the closure segment 30 is being urged from the bale forming state to the open state, the cam follower 75 is urged along the remaining portion of the camming slot 74 to the second end 73 thereof, with the camming plate 70 and the bridging roller 63 in the second states thereof, which is also the aligned state of the camming plate 70. Further urging of the closure segment 30 towards the open state results in the cam follower 75 disengaging the camming slot 74 through the entry slot 77. As the cam follower 75 exits the entry slot 77, the retaining spring 80 retains the camming plate 70 in the aligned state with the end edge 81 of the plate bracket 72 engaging the abutment edge 82 of the corresponding side wall 31 of the closure segment 30, so that on return of the closure segment 30 from the open state to the second state of the bale forming state, the entry slot 77 to the camming slot 74 is aligned with the cam follower 75 for reengaging of the cam follower 75 with the entry slot 77, and in turn with the camming slot 74.

On discharge of the bale 2 from the baler 3 onto the bale wrapper 5, the spool valve 105 is operated by the microcontroller 90 for operating the main rams 34 to urge the closure segment 30 from the open state to the bale forming state. As the closure segment 30 is being returned to the bale forming state, the discharge segment 24 is returned about the discharge pivot axis 29 from the discharge state to the bale forming state.

As the closure segment 30 is approaching the second state thereof, further movement of the closure segment 30 into the second state thereof results in the cam follower 75 entering the second end 73 of the camming slot 74 through the entry slot 77. As the closure segment 30 is being urged in the bale forming state into the first state thereof, the cam follower 75 is urged along the camming slot 74 from the second end 73 thereof to the first end 71 thereof, to in turn urge the camming plate 70 in the direction of the arrow D to in turn urge the bridging roller 63 into the inoperative first state. On the closure segment 30 being in the first state thereof, the microcontroller 90 outputs a signal to the touch screen 91 and to the sounder 92 alerting the tractor driver that the baler 3 is ready to commence forming of the next bale. The tractor

driver then commences to tow the combined baler/bale wrapper 1 along the windrow of crop material, thereby commencing the forming of the next bale in the bale chamber 2.

While the next bale is being formed in the bale chamber 20, the bale wrapper 5 is operated to wrap the bale 2 thereon. The bale support roller 50 is rotated by the hydraulic motor 52 to rotate the bale 2 thereon about the longitudinally extending central axis 4 of the bale 2, and simultaneously, the carrier ring 53 is rotated about the longitudinally extending horizontal axis for in turn revolving the wrapping material dispensers 54 about the rotating bale 2 on the bale support rollers 50 and 51 for end-to-end wrapping of the bale. On completion of wrapping of the bale on the bale wrapper 5, the wrapped bale is lowered onto the field by pivoting the U-shaped roller carrier 57 downwardly about the pivot mountings 58 from the bale wrapping state to the discharge state by the hydraulic actuator ram (not shown) under the control of the microcontroller 90.

The completion diameter of the bale chamber 20 at which the formation of the bale in the bale chamber 20 to the selected bale diameter is deemed to be complete by the microcontroller 90, may be equal to or greater than the selected bale diameter of the bale, and will be dependent on the type of crop material and the density to which the bale is to be formed. During circumferential wrapping of a bale 2 in the bale chamber 20, the diameter of the bale 2 is reduced due to tightening of the wrapping material circumferentially around the bale 2. The reduction in the diameter of the bale 2 is dependent on the type of crop material and the density to which the bale is to be formed. If the crop material is a dense type crop material, for example, silage, and the bale density to which the bale is to be formed is high, then the reduction in the diameter of the bale during circumferential wrapping thereof in the bale chamber 20 is minimal. However, on the other hand, when the crop material is of a less dense nature, for example, hay or the like, and the bale is to be formed to a relatively low bale density, then the reduction in the diameter of the bale during circumferential wrapping thereof in the bale chamber may be relatively large.

Accordingly, in the case of a bale of a relatively dense crop material, and the bale being formed to a relatively high bale density, since the reduction of the diameter of the bale during circumferential wrapping thereof in the bale chamber 20 is minimal, the completion diameter to which the bale chamber 20 should increase during formation of the bale therein will be substantially similar to the selected bale diameter. While on the other hand, in the case of a bale of a less dense crop material and the bale being formed to a relatively low bale density, the completion diameter to which the bale chamber 20 should increase during formation of the bale therein will be greater than the selected bale diameter.

A look-up table is stored in memory of the microcontroller 90 with the appropriate completion diameters of the bale chamber 20 for bales cross-referenced with corresponding selectable bale diameters for different crop materials and for bales of different selectable bale densities. Thus, when the selected bale diameter and the selected bale density and the type of crop material being baled is entered into the microcontroller 90 through the touch screen 91, the microcontroller 90 selects the appropriate completion diameter of the bale chamber 20 from the look-up table to produce the bale of the selected diameter.

Should it be desired to produce a bale of diameter greater than the second diameter D2 of the bale chamber 20, this is possible by entering the desired diameter of the bale through the touch screen 91 to the microcontroller 90. In this case, during formation of the bale, the microcontroller 90 monitors the signals from the proximity sensors 108, and on the signals from the proximity sensors 108 being indicative of the diameter of the bale chamber 20 having reached the completion diameter corresponding to the selected bale diameter, the microcontroller 90 determines that the formation of the bale 2 is complete, and feeding of crop material into the bale chamber 20 is terminated and the bale is circumferentially wrapped in the bale chamber.

In cases where the selected bale diameter requires the diameter of the bale chamber 20 to exceed the second diameter D2 in order to form the bale to the selected bale diameter, the closure segment 30 is displaced angularly about the main pivot axis 15 until the diameter of the bale chamber 20 reaches the appropriate completion diameter. This results in the cam follower 75 exiting the camming slot 74 into the entry slot 77. However, in general, it is envisaged that it is not practical to form bales of diameter of approximately 250mm greater than the second diameter D2 of the bale chamber 20, otherwise, the spacing between the bridging roller 63 and the bale rotating roller 17a of the discharge segment 24 in the circumferential gap 60 would be of such a width as to allow loss of crop material from the bale chamber 20 between the bridging roller 63 and the bale rotating roller 17a of the discharge segment 24.

In this embodiment of the invention the first diameter D1 of the bale chamber 20 defined by the bale rotating rollers 17 is approximately 1120mm, and the second diameter of the bale chamber 20 defined by the bale rotating rollers 17 and the bridging roller 63 is approximately 1250mm. However, it will be readily apparent to those skilled in the art that the first diameter D1 of the bale chamber 20 may be of any suitable diameter, and typically, will be determined by the number of bale rotating rollers 17 forming the bale chamber 20, and the diameter of the bale rotating rollers 17. Typically, the first diameter D1 of a bale

chamber 20 of a roller baler according to the invention, may range from 1050mm to 1200mm.

The bridging roller 63 is of diameter similar to the diameter of the bale rotating rollers 17, and when the closure segment is in the second state, the bridging roller 63 is located fully between the bale rotating rollers 17a and 17g to define with the bale rotating rollers 17 the circumferential periphery 19 of the bale chamber 20 of the second diameter D2. Accordingly, if the diameter of the bridging roller 63 is of diameter d_r, the second diameter D2 may be derived from the following equation:

$$D2 = D1 + 2\left(\frac{d_r}{\pi}\right)$$

In this embodiment of the invention the diameter d_r of the bridging roller 63 and each rollers 17 is 210mm. Accordingly, as mentioned above, the second diameter D2 of the bale chamber 20 is 1250mm. However, it will be readily apparent to those skill in the art that the bridging roller 63, as well as the bale rotating rollers 17 may be of any suitable diameter, and the bridging roller 63 may be of the same diameter as that of the bale rotating roller 17 or of a different diameter, either of a greater diameter or a lesser diameter of the bale rotating rollers 17. However, typically, it is envisaged that the diameter d_r of the bridging roller 63 would lie in the range of 200mm to 225mm. However, it is envisaged in some embodiments of the invention that two or more bridging rollers may be provided in order to allow a greater difference between the first diameter D1 and the second diameter D2. However, in general, it is envisaged that the second diameter D2 would lie in the range of 1200mm to 1400mm.

The advantages of the roller baler 3 according to the invention are many. A particularly important advantage of the roller baler 3 is that bales of selectable diameters in the range substantially between and including the first and second diameters D1 and D2 of the bale chamber 20 and slightly less than the first diameter D1 and slightly greater than the second diameter D2 may be produced. Another particularly important advantage of the invention is that the density of the bales of each selectable diameter is also selectable, and thus, bales of the minimum diameter, namely, the first diameter D1 of the bale chamber or less, depending on the density of the bale and the density of the crop material, may be produced of a range of densities from a high density or low density, depending on the setting of the hydraulic density pressure of the hydraulic pressure at which the pressurised hydraulic fluid is applied to the main rams 34 during the formation of the bale. Similarly, bales of the maximum diameter corresponding to the second diameter D2 of the bale chamber or greater than the second diameter D2, may be produced of selectable bale densities over a range of bale densities from a relatively low bale density to a relatively high bale

density. Similarly, bales of selectable intermediate diameters between the minimum and maximum bale diameters, may be produced of a range of bale densities from a low bale density to a high bale density depending on the hydraulic density pressure at which the hydraulic fluid is applied to the main rams during formation of the bale.

A particularly important advantage of the roller baler 3 according to the invention is that the ratio of the diameter of a central core of the bales produced by the roller baler according to the invention, which is of density less than the density of an outer peripheral portion of the bales, to the radial depth of that more dense outer peripheral portion, is less than the corresponding ratio of bales produced by a conventional roller baler. This is due to the fact that irrespective of the diameter to which the bales are to be formed, once the bales are to be formed to a diameter, which requires the diameter of the bale chamber 20 to exceed the first diameter D1, compacting of the crop material commences once the diameter of the bale in the bale chamber reaches the first diameter D1 of the bale chamber 20, and continues until the diameter of the bale chamber 20 reaches the diameter to which the bale chamber 20 must increase to produce the bale of the selected bale diameter. Therefore, the radial depth of the compacted outer peripheral portion of a bale formed by the roller baler according to the invention is greater than the radial depth of a compacted outer peripheral portion of a bale formed in a conventional roller baler. Accordingly, the ratio of the diameter of the central core of a bale produced by the roller baler according to the invention to the radial depth of the compacted outer peripheral portion thereof, is less than the corresponding ratio of a bale produced by a conventional baler.

Additionally, from the time the diameter of the bale in the bale chamber 20 reaches the first diameter D1 thereof, and the radial outward pressure exerted by the rotating bale in the bale chamber 10 on the bale rotating rollers 17 reaches the pressure exerted by the bale rotating rollers 17 on the rotating bale resulting from the urging force applied by the main rams 34 to the closure segment 30, the rotating bale in the bale chamber 20 continues to be subjected to the pressure exerted thereon by the bale rotating rollers 17 resulting from the urging force applied by the main rams 34 to the closure segment 30 until the bale has been formed to the selected diameter. This further increases the radial depth of the more dense outer peripheral portion of the bale, thereby further reducing the ratio of the diameter of the less dense central core to the radial depth of the more dense outer peripheral portion of the bale. This advantage is particularly gained in bales of larger diameter, and in particular, bales of diameter the completion of the formation of which requires the completion diameter of the bale chamber 20 to be greater than the first diameter D1 thereof. In fact, the larger the diameter to which the bale is to be formed, the greater is the

benefit gained from this advantage.

By producing the bales to comprise a radially deeper dense outer peripheral portion than bales produced by conventional roller balers know heretofore, the bales produced by the roller baler according to the invention have a much greater ability to retaining their cylindrical shape, and are therefore more suitable to transportation, storage and stacking than bales produced by conventional roller baler known heretofore.

A further advantage of the invention is achieved when the combined baler/bale wrapper, or indeed, when the roller baler 3 without a bale wrapper 5 is being operated on forwardly downwardly inclining land. In cases where the land is downwardly inclining in a forward direction relative to the normal forward direction of travel of the baler, it may be difficult in conventional roller balers to fully discharge the formed bale from the bale chamber. For example, if the bale has only been partly discharged from the bale chamber when the closure segment of a conventional roller baler is being returned from the open state to the bale forming state, the bale may be caught between the bale rotating rollers of the conventional baler corresponding to the bale rotating rollers 17a and 17g of the discharge segment and the closure segment, respectively, of the roller baler 3. Since both the bale rotating rollers of a conventional roller baler corresponding to the bale rotating rollers 17a and 17g are driven rollers, when the bale is caught between the rotating rollers 17a and 17g, the circumferential wrapping material of the bale may be damaged thereby resulting in a discharged bale unravelling on being discharged from the bale chamber. In the baler according to the invention, since in the open state of the closure segment the camming plate 70 and the bridging roller 63 are retained in the second state, namely, the aligned state, by the retaining spring 80 once the closure segment 30 has passed through the second state thereof from the bale forming state, and since the bridging roller 63 is freely rotatable in the carrier brackets 65, if the bale is caught between the bale rotating roller 17a of the discharge segment 29 and the closure segment 30, or between the intermediate roller 59, which is also freely rotatable, and the closure segment 30, the bridging roller 63 being freely rotatable, rotates with the bale as the bale is urged from the bale chamber 20 by the action of the closure segment 30 on the bale as the closure segment 30 is returning from the open state to the bale forming state, thereby allowing the bale to be discharged without damaging the circumferential wrapping material of the bale.

While the bridging element has been described as comprising a bridging roller, any other suitable bridging element may be provided, for example, a bridging plate which would extend substantially the width of the circumferential gap 60 between the bale rotating rollers 17a and 17g, or the bridging element may

comprise one or more bars which would not be rotatable and which would bridge the circumferential gap 60 between the bale rotating rollers 17a and 17g. It is also envisaged that in some embodiments of the invention two or even three bridging rollers may be provided, which would typically be carried on the carrier brackets 65. Alternatively, it is envisaged that two bridging rollers may be provided one of which may be coupled to the closure segment and the other which would be coupled to the discharge segment, and in which case the bridging rollers would be sequentially urged from the inoperative first states to the bridging states, such that movement of the second one of the two bridging rollers from its inoperative first state would not commence until the first bridging roller had reached its bridging second state. Although in some embodiments of the invention in cases where two bridging rollers are provided, one being provided on the closure segment and the other being provided on the discharge segment of the roller baler, it is envisaged that the two bridging rollers may move simultaneously from their respective inoperative first states to their bridging second states.

It is also envisaged that while the roller baler 3 according to the invention has been described as being provided in a combined baler/bale wrapper, the roller baler may be provided on its own without a bale wrapper.

Needless to say, any other suitable mechanism for operating the discharge segment from the bale forming state to the discharge state may be provided besides the link members connected between the closure segment and the discharge segment. In some embodiments of the invention it is envisaged that a single hydraulic ram or a pair of hydraulic rams may be provided for operating the discharge segment between the bale forming state and the discharge state, and such hydraulic ram or rams typically would operate between the chassis and the discharge segment.

It is also envisaged that in some embodiments of the invention the roller baler may comprise only two segments, namely, the closure segment and a fixed segment. In which case, the fixed segment would include the bale rotating rollers of both the fixed segment and the discharge segment, and the fixed and the discharge segments would be formed as a single integral fixed segment. In which case, it is envisaged that the closure segment would be pivotal to the fixed segment about an upper horizontal main pivot axis, and would depend downwardly from the upper horizontal main pivot axis, and would be pivotal substantially rearwardly and upwardly about the upper main pivot axis from the bale forming state to the open state for permitting a formed and wrapped bale to drop under gravity from the bale chamber onto the ground.

It will be appreciated that any appropriate numbers of bale rotating rollers of any suitable diameter and length may be provided on the fixed segment, the discharge segment and the closure segment other than the numbers and diameters of bale rotating rollers described.

While the bridging element has been described as being moveably coupled to the second part of the roller baler by a first connecting means and has been described as being moveably coupled to the first part of the roller baler by a camming means, it is envisaged that in some embodiments of the invention the bridging element may be moveably coupled to the first part by the first connecting means, and may be moveably coupled to the second part of the roller baler by the camming means. It is also envisaged that in the embodiment described with reference to the drawings, while the cam follower has been described as being located on the transfer segment and the camming plate has been described as being secured to the bridging element, in some embodiments of the invention the cam follower may be provided on the bridging element, while the camming plate may be located on the transfer segment and fixed relative to the fixed segment, or the camming plate may be mounted fixed relative to the chassis. In embodiments where the roller baler is provided with only a fixed segment and a closure segment, and the bale rotating rollers carried by the fixed segment define approximately 180° of the periphery of the bale chamber, it is envisaged that if the camming plate is located on the fixed segment, the camming plate would be rigidly secured to the fixed segment.

It is also envisaged that in embodiments of the invention where the bridging element is coupled to either the first part or the second part of the roller baler by the camming means, the cam follower of the camming means may be located on either the bridging element or the relevant one of the first part or the second part, and the camming plate of the camming means would be located on the other one of the bridging element and the relevant one of the first part or the second part of the roller baler. In cases where the cam follower is located on the bridging element, the cam follower would be fixed relative to the bridging element, and the camming plate would be mounted on the relevant one of the first part or the second part of the roller baler and fixedly secured to that relevant one of the first part or the second part of the roller baler.

While the cam follower has been described as comprising a bearing rollably engageable with the camming slot, while this is advantageous, the cam follower may be provided without the bearing.

Claims

1. A roller baler comprising a first part and a second part moveable relative to the first part, the first and second parts carrying respective pluralities of bale rotating rollers, the second part cooperating with the first part in a bale forming state with the bale rotating rollers defining a circumferential periphery of a bale chamber in which material is rotated, pressed and formed into a round bale by the bale rotating rollers, the second part being progressively moveable relative to the first part from a first state to a second state with the diameter of the bale chamber progressively increasing from a first diameter to a second diameter, and a circumferential gap defined between adjacent rollers of the respective first and second parts progressively increasing in circumferential length from a first value to a second value, an urging means applying an urging force to the second part for urging the second part from the second state to the first state thereof, a bridging element moveably coupled to the first part or the second part by a first connecting means, and moveably coupled to the other one of the first part and the second part by a camming means, the camming means controlling the bridging element to progressively move through progressive bridging states from a first state to a second state in response to the second part progressively moving from the first state to the second state to bridge the progressively increasing circumferential gap as the second part is being urged from the first state to the second state against the urging force applied by the urging means.

2. A roller baler as claimed in Claim 1 in which the camming means is configured to constrain the bridging element to move synchronously with the second part.

3. A roller baler as claimed in Claim 1 or 2 in which the camming means is configured to constrain the bridging element to move synchronously with the second part as the second part moves between the first and second states thereof.

4. A roller baler as claimed in any preceding claim in which the camming means retains the bridging element and the one of the first part and the second part to which the bridging element is coupled by the camming means captive relative to each other as the second part moves between the first state thereof and the second state thereof.

5. A roller baler as claimed in any preceding claim in which the camming means is configured to release the bridging element from the one of the first part and the second part to which the bridging element is coupled by the camming means in response to the second part being in the second state

thereof.

6. A roller baler as claimed in any preceding claim in which a retaining means is provided for retaining the bridging element in an aligned state on release of the bridging element by the camming means from the one of the first part and the second part to which the bridging element is coupled by the camming means, so that the bridging element is re-engageable with the one of the first part and the second part through the camming means in response to return of the second part to the second state thereof.

7. A roller baler as claimed in any preceding claim in which the first connecting means moveably coupling the bridging element to the one of the first part and the second part comprises a pivot coupling defining a bridging element pivot axis about which the bridging element is pivotal between the first state and the second state thereof.

8. A roller baler as claimed in any preceding claim in which the camming means comprises a camming element having a camming track extending therein, the camming element mounted on the bridging element or on the one of the first part and the second part to which the bridging element is coupled through the camming means, and a cam follower mounted on the other one of the bridging element and the one of the first part and the second part to which the bridging element is coupled through the camming means, the cam follower being engageable in and progressively urgeable along the camming track in response to the progressive movement of the second part relative to the first part from the first state to the second state thereof for progressively urging the bridging element through the respective bridging states from the first state thereof to the second state thereof.

9. A roller baler as claimed in Claim 8 in which the camming element is rigidly mounted on the one of the bridging element and the one of the first part and the second part on which the camming element is mounted, and the cam follower is rigidly mounted on the one of the bridging element and the one of the first part and the second part on which the cam follower is mounted.

10. A roller baler as claimed in Claim 8 or 9 in which the camming track comprises an elongated camming track extending from a first end to a second end.

11. A roller baler as claimed in Claim 10 in which the cam follower is urgeable along the camming

track from the first end thereof to the second end thereof as the second part is urged from the first state to the second state thereof.

12. A roller baler as claimed in any of Claims 8 to 11 in which the camming track comprises an arcuate camming track having a centre of radius substantially coinciding with the bridging element pivot axis.

13. A roller baler as claimed in any of Claims 8 to 12 in which the camming element comprises an entry means communicating with the camming track for accommodating the cam follower into and out of the camming track in response to the second part being in the second state, for release and re-engagement of the bridging element relative to the one of the first part and the second part to which the bridging element is coupled.

14. A roller baler as claimed in Claim 13 in which the entry means communicates with the camming track adjacent the second end thereof.

15. A roller baler as claimed in Claim 13 or 14 in which the camming track terminates in the entry means adjacent the second end of the camming track.

16. A roller baler as claimed in any of Claims 13 to 15 in which a lead-in is provided in the entry means for accommodating the cam follower into the entry slot.

17. A roller baler as claimed in any of Claims 8 to 16 in which the camming track comprises an elongated camming slot formed in the camming element.

18. A roller baler as claimed in Claim 16 in which the entry means comprises an entry slot formed in the camming element communicating with the camming slot thereof.

19. A roller baler as claimed in Claim 18 in which the entry slot diverges outwardly in a direction from the camming slot to define the lead-in to the entry means for accommodating the cam follower into the entry slot.

20. A roller baler as claimed in any of Claims 8 to 19 in which the retaining means for retaining the

bridging element in the aligned state is configured for retaining the one of the camming element or the cam follower which is mounted on the bridging element in an aligned state with the entry means or the cam follower aligned with the other one of the entry means and the cam follower in response to the second part being in the second state.

21. A roller baler as claimed in Claim 20 in which the retaining means comprises one of a stop member or an abutment member associated with the bridging element, and the other one of the stop member and the abutment member being associated with the other one of the first part and the second part to which the bridging element is coupled through the camming means, the one of the stop member and the abutment member associated with the bridging element being engageable with the other one of the stop member and the abutment member when the bridging element is in the aligned state.

22. A roller baler as claimed in Claim 21 in which engagement of the stop member and the abutment member defines the aligned state of the camming element or the cam follower.

23. A roller baler as claimed in Claim 21 or 22 in which the retaining means further comprises a resilient element resiliently urging the one of the stop member and the abutment member associated with the bridging element into engagement with the other one of the stop member and the abutment member.

24. A roller baler as claimed in Claim 23 in which the resilient element acts between the bridging element and the one of the first part and the second part to which the bridging element is coupled by the first connecting means.

25. A roller baler as claimed in Claim 23 or 24 in which the resilient element comprises a spring, and preferably, a tension spring.

26. A roller baler as claimed in any of Claims 8 to 25 in which the camming element is mounted on the bridging element.

27. A roller baler as claimed in any of Claims 8 to 26 in which the cam follower is mounted on the one of the first part and the second part to which the bridging element is coupled through the camming means.

28. A roller baler as claimed in any of Claims 17 to 27 in which the bridging element is urgeable progressively from a first state thereof to a second state as the cam follower progressively traverses the camming slot from the first end to the second end for progressively urging the bridging element from the first state thereof through the respective bridging states to the second state thereof.

29. A roller baler as claimed in any preceding claim in which the bridging element is of length substantially equal to the length of one of the bale rotating rollers defining the circumferential gap with the other one of the bale rotating rollers.

30. A roller baler as claimed in any preceding claim in which the bridging element comprises a bridging roller extending substantially parallel to the bale rotating rollers.

31. A roller baler as claimed in Claim 30 in which the bridging roller is freely rotatably mounted.

32. A roller baler as claimed in any preceding claim in which the first connecting means coupling the bridging element to the one of the first and second parts comprises a carrier bracket pivotally coupling the bridging element to the one of the first part and the second part.

33. A roller baler as claimed in Claim 32 in which the bridging element is carried on a pair of the carrier brackets spaced apart from each other with the bridging element extending between and carried on the carrier brackets.

34. A roller baler as claimed in Claim 33 in which the bridging roller is freely rotatably mounted on and extends between the bridging element carrier brackets.

35. A roller baler as claimed in any of Claims 7 to 34 in which the bridging element pivot axis extends parallel to the bale rotating rollers.

36. A roller baler as claimed in any of Claims 7 to 35 in which the bridging element pivot axis coincides with a rotational axis of one of the bale rotating rollers of the one of the first and second parts to which the bridging element is coupled by the first connecting means.

37. A roller baler as claimed in any of Claims 7 to 36 in which the bridging element pivot axis

coincides with the rotational axis of the bale rotating roller carried on the one of the first and second parts to which the bridging element is coupled by the first connecting means and which defines the circumferential gap with the adjacent one of the bale rotating rollers in the other one of the first and second parts.

38. A roller baler as claimed in any preceding claim in which the second part is pivotally coupled to the first part about a main pivot axis extending parallel to the bale rotating rollers, and is pivotal from the first state through the second state thereof to an open state for accommodating a bale from the bale chamber.

39. A roller baler as claimed in Claim 38 in which the urging means is adapted to urge the second part from the open state through the second state to the first state thereof.

40. A roller baler as claimed in any preceding claim in which the urging means is adapted to urge the second part from the second state to the first state thereof with the urging force of a substantially constant value.

41. A roller baler as claimed in any preceding claim in which the value of the urging force with which the urging means urges the second part from the second state to the first state thereof is selectable for producing bales of selectable bale densities.

42. A roller baler as claimed in any preceding claim in which the urging means comprises at least one hydraulic ram operably connected between the first part and the second part for urging the second part relative to the first part from the second state to the first state.

43. A roller baler as claimed in any preceding claim in which the diameter of the bale is selectable by selecting the displacement of the second part from the first state thereof at which formation of the bale in the bale chamber is terminated.

44. A roller baler as claimed in any preceding claim in which a monitoring means is provided for monitoring the displacement of the second part from the first state thereof.

45. A roller baler as claimed in any preceding claim in which the first value of the circumferential

length of the circumferential gap between the adjacent bale rotating rollers of the respective first and second parts is substantially similar to the spacing between an adjacent pair of the bale rotating rollers of the first part or the second part.

46. A combined baler/bale wrapper comprising the roller baler as claimed in any preceding claim and a bale wrapper for receiving a formed bale from the roller baler and for wrapping thereof.

47. A combined baler/bale wrapper as claimed in Claim 46 in which the bale wrapper is located rearwardly of the roller baler.

48. A method for producing a bale in a roller baler wherein the roller baler comprises a first part, and a second part moveable relative to the first part, the first and second parts carrying respective pluralities of bale rotating rollers, the second part cooperating with the first part in a bale forming state with the bale rotating rollers defining a circumferential periphery of a bale chamber in which material to be baled is rotated, pressed and formed into the round bale by the bale rotating rollers, the method comprising configuring the second part to be progressively moveable relative to the first part from a first state to a second state with the diameter of the bale chamber progressively increasing from a first diameter to a second diameter and a circumferential gap defined between adjacent rollers of the respective first and second parts progressively increasing in circumferential length from a first value to a second value, applying an urging force to the second part for urging the second part from the second state to the first state thereof, moveably coupling a bridging element to the first part or the second part by a first connecting means, and to the other one of the first part and the second part by a camming means, so that as the second part is progressively moved from the first state to the second state in response to the action of a radial outward force applied by the material being baled in the bale chamber against the urging force, the bridging element is progressively moved from a first state to a second state through respective bridging states bridging the circumferential gap as the circumferential gap progressively increases in circumferential length.

49. A method as claimed in Claim 48 in which the bridging element is constrained by the camming means to move synchronously with the second part.

50. A method as claimed in Claim 48 or 49 in which the bridging element is constrained by the camming means to move synchronously with the second part as the second part moves between the first

and second states thereof.

51. A method as claimed in any of Claims 48 to 50 in which the bridging element and the one of the first part and the second part to which the bridging element is coupled by the camming means are retained captive relative to each other by the camming means as the second part moves between the first state thereof and the second state thereof.

52. A method as claimed in any of Claims 48 to 51 in which the camming means releases the bridging element from the one of the first part and the second part to which the bridging element is coupled by the camming means in response to the second part being in the second state thereof.

53. A method as claimed in any of Claims 48 to 52 in which the bridging element is retained in an aligned state by a retaining means on release of the bridging element by the camming means from the one of the first part and the second part to which the bridging element is coupled by the camming means, so that the bridging element is re-engageable with the one of the first part and the second part through the camming means in response to return of the second part to the second state thereof.

54. A method as claimed in any of Claims 48 to 53 in which the first connecting means defines a bridging element pivot axis, and the bridging element is pivotally coupled to the one of the first part and the second part by the first connecting means about the bridging element pivot axis between the first state and the second state thereof.

55. A method as claimed in any of Claims 48 to 54 in which the camming means comprises a camming element having a camming track extending therein, the camming element mounted on the bridging element or on the one of the first part and the second part to which the bridging element is coupled through the camming means, and a cam follower mounted on the other one of the bridging element and the one of the first part and the second part to which the bridging element is coupled through the camming means, the cam follower being engageable in and progressively urgeable along the camming track in response to the progressive movement of the second part relative to the first part from the first state to the second state thereof for progressively urging the bridging element through the respective bridging states from the first state thereof to the second state thereof.

56. A method as claimed in Claim 55 in which the camming element is rigidly mounted on the one of

the bridging element and the one of the first part and the second part on which the camming element is mounted, and the cam follower is rigidly mounted on the one of the bridging element and the one of the first part and the second part on which the cam follower is mounted.

57. A method as claimed in Claim 55 or 56 in which the camming track comprises an elongated camming track extending from a first end to a second end.

58. A method as claimed in any of Claims 55 to 57 in which the cam follower is urgeable along the camming track from the first end thereof to the second end thereof as the second part is urged from the first state to the second state thereof.

59. A method as claimed in any of Claims 55 to 58 in which the camming track comprises an arcuate camming track having a centre of radius substantially coinciding with the bridging element pivot axis.

60. A method as claimed in any of Claims 55 to 59 in which the camming element comprises an entry means communicating with the camming track for accommodating the cam follower into and out of the camming track in response to the second part being in the second state, for release and re-engagement of the bridging element relative to the one of the first part and the second part to which the bridging element is coupled.

61. A method as claimed in Claim 60 in which the entry means communicates with the camming track adjacent the second end thereof.

62. A method as claimed in Claim 60 or 61 in which the camming track terminates in the entry means adjacent the second end of the camming track.

63. A method as claimed in any of Claims 60 to 62 in which a lead-in is provided in the entry means for accommodating the cam follower into the entry slot.

64. A method as claimed in any of Claims 55 to 63 in which the camming track comprises an elongated camming slot formed in the camming element.

65. A method as claimed in Claim 64 in which the entry means comprises an entry slot formed in the

camming element communicating with the camming slot thereof.

66. A method as claimed in Claim 64 or 65 in which the entry slot diverges outwardly in a direction from the camming slot to define the lead-in to the entry means for accommodating the cam follower into the entry slot.

67. A method as claimed in any of Claims 48 to 66 in which the retaining means for retaining the bridging element in the aligned state is configured for retaining the one of the camming element or the cam follower which is mounted on the bridging element in an aligned state with the entry means or the cam follower aligned with the other one of the entry means and the cam follower in response to the second part being in the second state.

68. A method as claimed in Claim 67 in which the retaining means comprises one of a stop member or an abutment member associated with the bridging element, and the other one of the stop member and the abutment member being associated with the other one of the first part and the second part to which the bridging element is coupled through the camming means, the one of the stop member and the abutment member associated with the bridging element being engageable with the other one of the stop member and the abutment member when the bridging element is in the aligned state.

69. A method as claimed in Claim 68 in which engagement of the stop member and the abutment member defines the aligned state of the camming element or the cam follower.

70. A method as claimed in any of Claims 67 to 69 in which the retaining means further comprises a resilient element resiliently urging the one of the stop member and the abutment member associated with the bridging element into engagement with the other one of the stop member and the abutment member.

71. A method as claimed in Claim 70 in which the resilient element acts between the bridging element and the one of the first part and the second part to which the bridging element is coupled by the first connecting means.

72. A method as claimed in Claim 70 or 71 in which the resilient element comprises a spring, and preferably, a tension spring.

73. A method as claimed in any of Claims 55 to 72 in which the camming element is mounted on the bridging element.

74. A method as claimed in any of Claims 55 to 73 in which the cam follower is mounted on the one of the first part and the second part to which the bridging element is coupled through the camming means.

75. A method as claimed in any of Claims 55 to 74 in which the bridging element is urgeable progressively from a first state thereof to a second state as the cam follower progressively traverses the camming slot from the first end to the second end for progressively urging the bridging element from the first state thereof through the respective bridging states to the second state thereof.

76. A method as claimed in any of Claims 48 to 75 in which the bridging element is of length substantially equal to the length of one of the bale rotating rollers defining the circumferential gap with the other one of the bale rotating rollers.

77. A method as claimed in any of Claims 48 to 76 in which the bridging element comprises a bridging roller extending substantially parallel to the bale rotating rollers.

78. A method as claimed in Claim 77 in which the bridging roller is freely rotatably mounted.

79. A method as claimed in any of Claims 48 to 78 in which the first connecting means coupling the bridging element to the one of the first and second parts comprises a carrier bracket pivotally coupling the bridging element to the one of the first part and the second part.

80. A method as claimed in Claim 79 in which the bridging element is carried on a pair of the carrier brackets spaced apart from each other with the bridging element extending between and carried on the carrier brackets.

81. A method as claimed in Claim 80 in which the bridging roller is freely rotatably mounted on and extends between the bridging element carrier brackets.

82. A method as claimed in any of Claims 48 to 81 in which the bridging element pivot axis extends parallel to the bale rotating rollers.

83. A method as claimed in any of Claims 48 to 82 in which the bridging element pivot axis coincides with a rotational axis of one of the bale rotating rollers of the one of the first and second parts to which the bridging element is coupled by the first connecting means.

84. A method as claimed in any of Claims 48 to 83 in which the bridging element pivot axis coincides with the rotational axis of the bale rotating roller carried on the one of the first and second parts to which the bridging element is coupled by the first connecting means and which defines the circumferential gap with the adjacent one of the bale rotating rollers in the other one of the first and second parts.

85. A method as claimed in any of Claims 48 to 84 in which the second part is pivotally coupled to the first part about a main pivot axis extending parallel to the bale rotating rollers, and is pivotal from the first state through the second state thereof to an open state for accommodating a bale from the bale chamber.

86. A method as claimed in Claim 85 in which the urging means is adapted to urge the second part from the open state through the second state to the first state thereof.

87. A method as claimed in any of Claims 48 to 86 in which the urging force with which the second part is urged by the urging means comprises a substantially constant urging force.

88. A method as claimed in any of Claims 48 to 87 in which the urging means is adapted to urge the second part from the second state to the first state thereof with the urging force of a substantially constant value.

89. A method as claimed in any of Claims 48 to 88 in which the urging force with which the second part is urgeable into the bale forming state is selectable to produce the bale to a selectable bale density.

90. A method as claimed in any of Claims 48 to 89 in which the value of the urging force with which the urging means urges the second part from the second state to the first state thereof is selectable for producing bales of selectable bale densities.

91. A method as claimed in any of Claims 48 to 90 in which the formation of the bale in the bale chamber is terminated in response to the displacement of the second part relative to the first part through

a predefined displacement from the first state of the bale forming state to produce the bale of a selectable diameter.

92. A method as claimed in any of Claims 48 to 91 in which the urging means comprises at least one hydraulic ram operably connected between the first part and the second part for urging the second part relative to the first part from the second state to the first state.

93. A method as claimed in any of Claims 48 to 92 in which the diameter of the bale is selectable by selecting the displacement of the second part from the first state thereof at which formation of the bale in the bale chamber is terminated.

94. A method as claimed in any of Claims 48 to 93 in which a monitoring means is provided for monitoring the displacement of the second part from the first state thereof.

95. A method as claimed in any of Claims 48 to 94 in which the first value of the circumferential length of the circumferential gap between the adjacent bale rotating rollers of the respective first and second parts is substantially similar to the spacing between an adjacent pair of the bale rotating rollers of the first part or the second part.

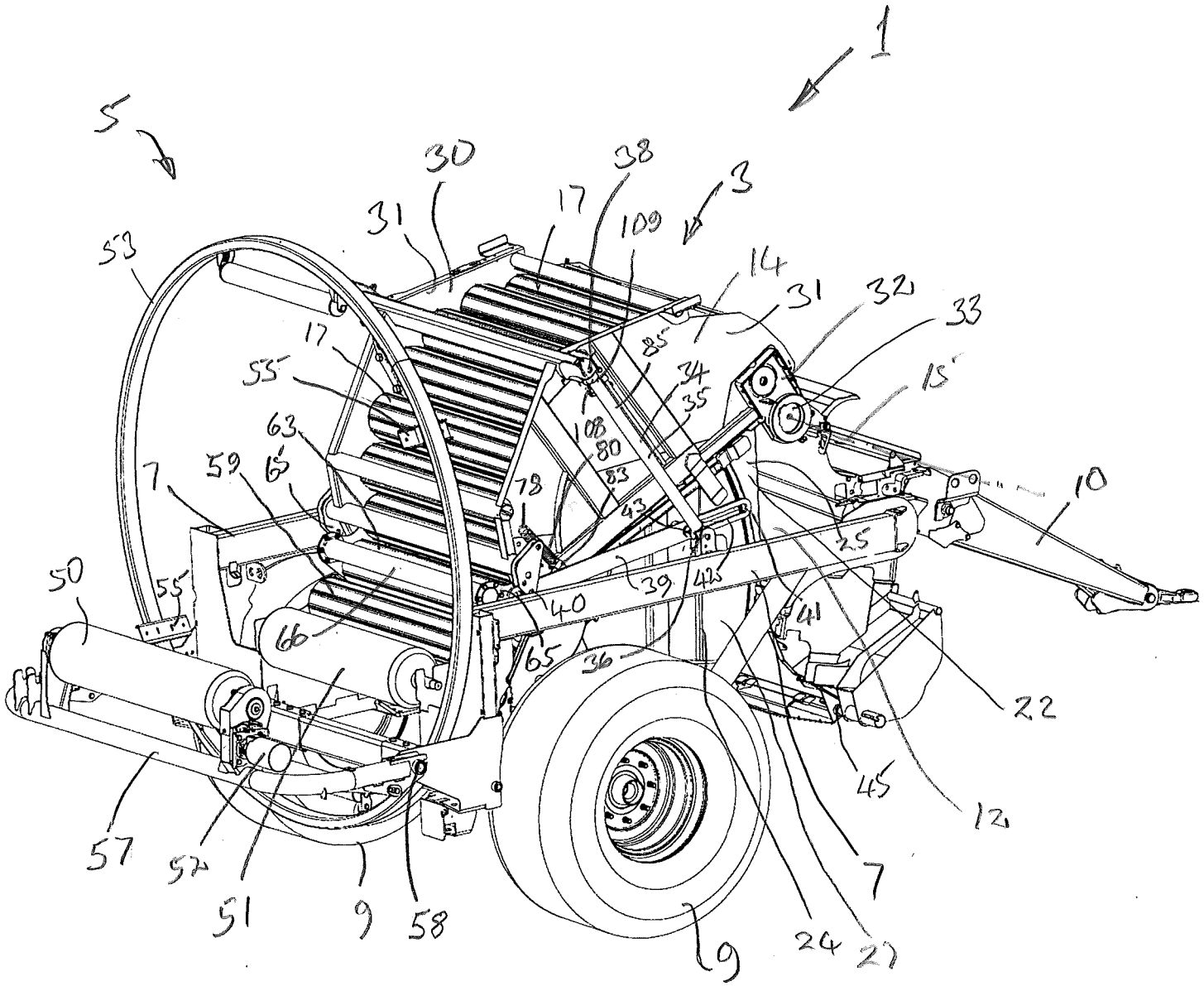
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FIG 1

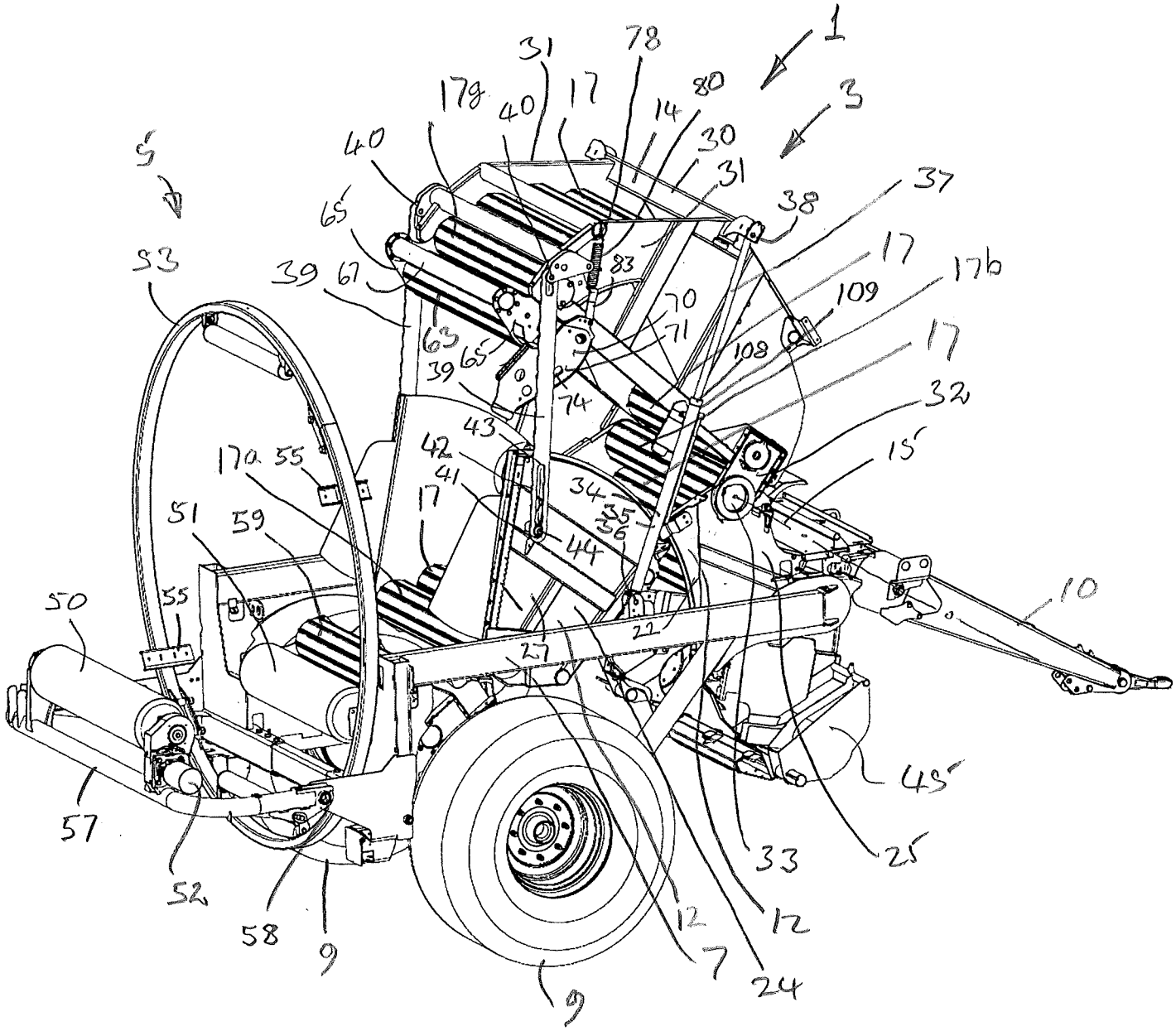
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FIG 2

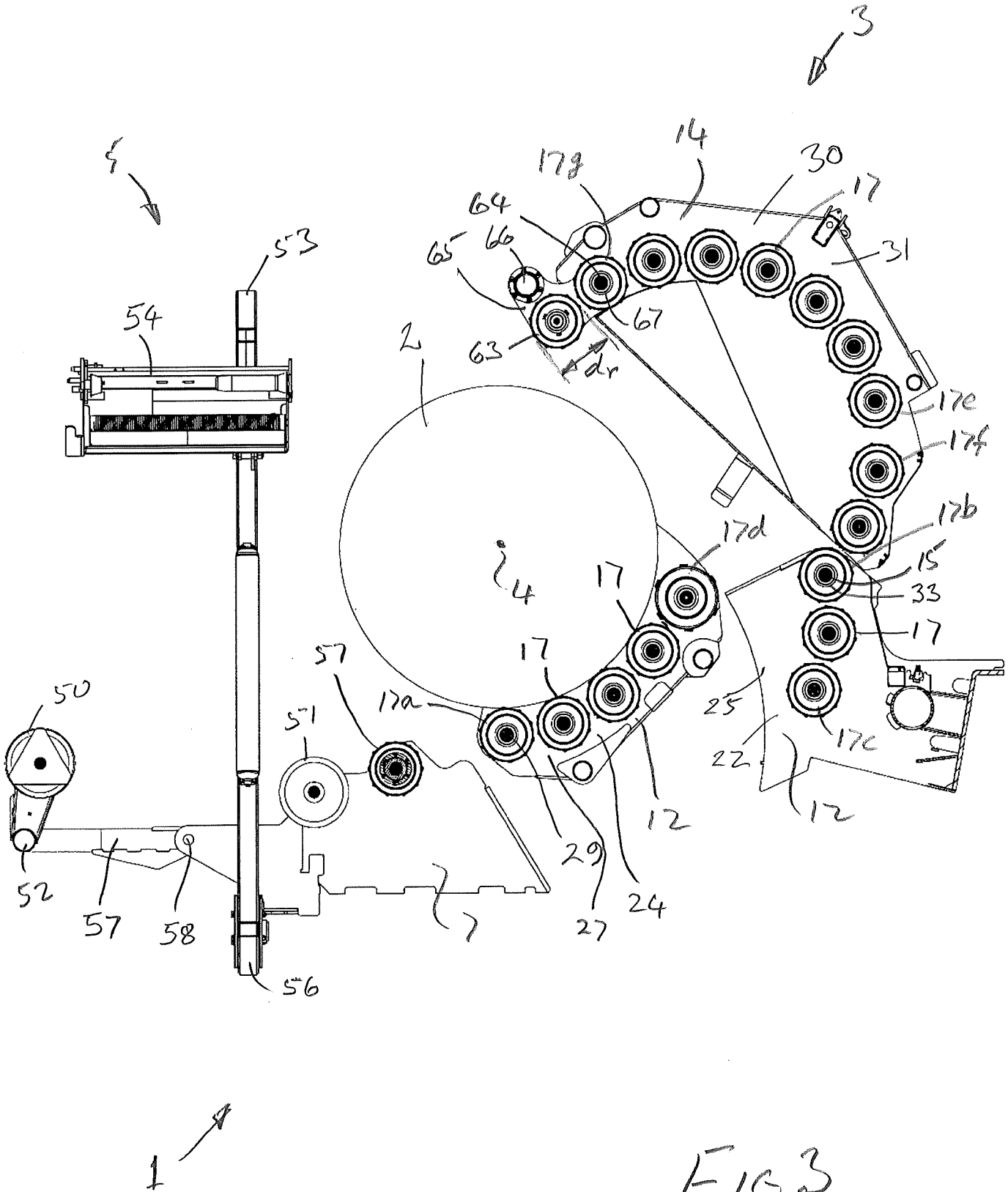
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FIG 3

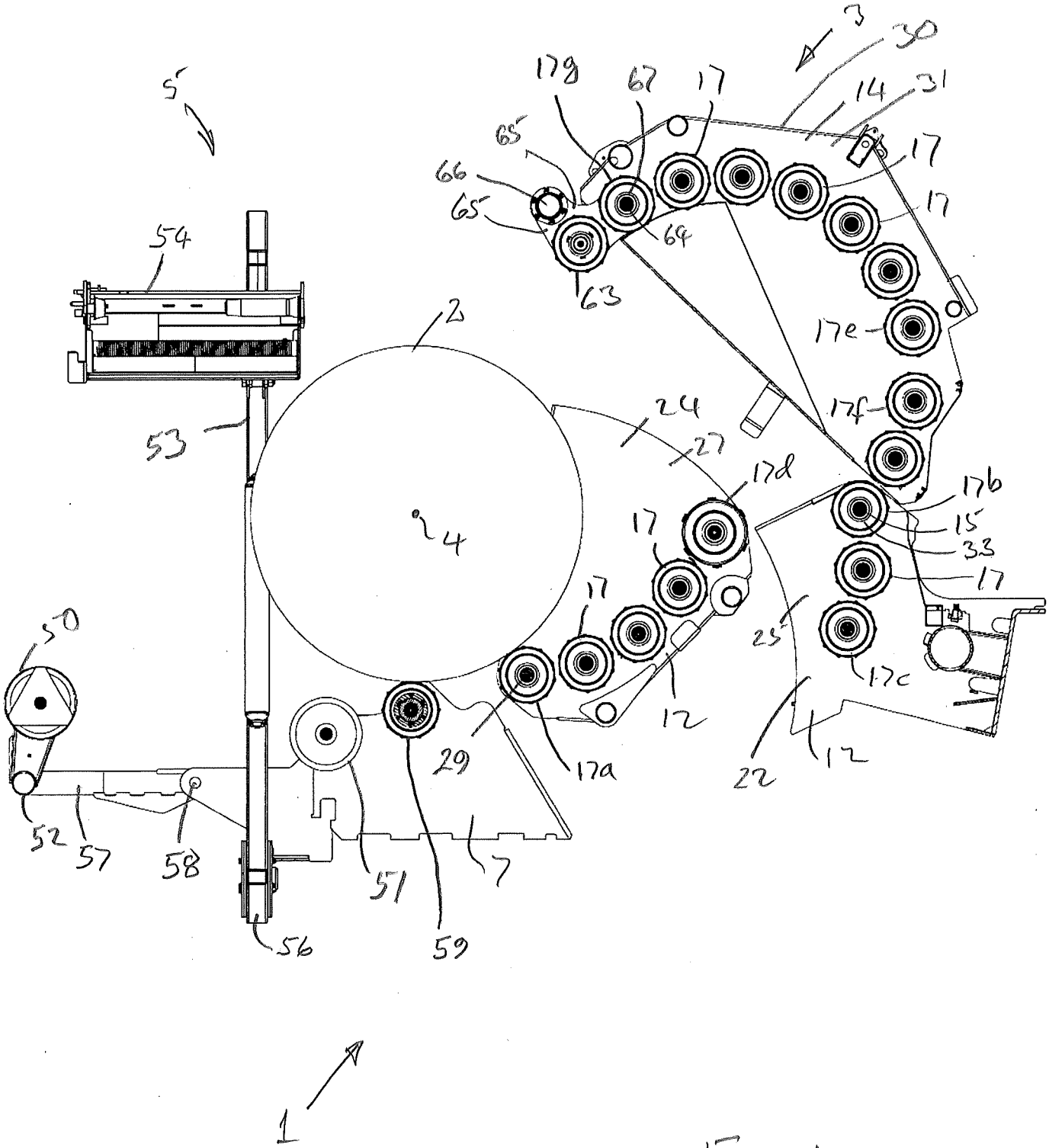
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FIG 4

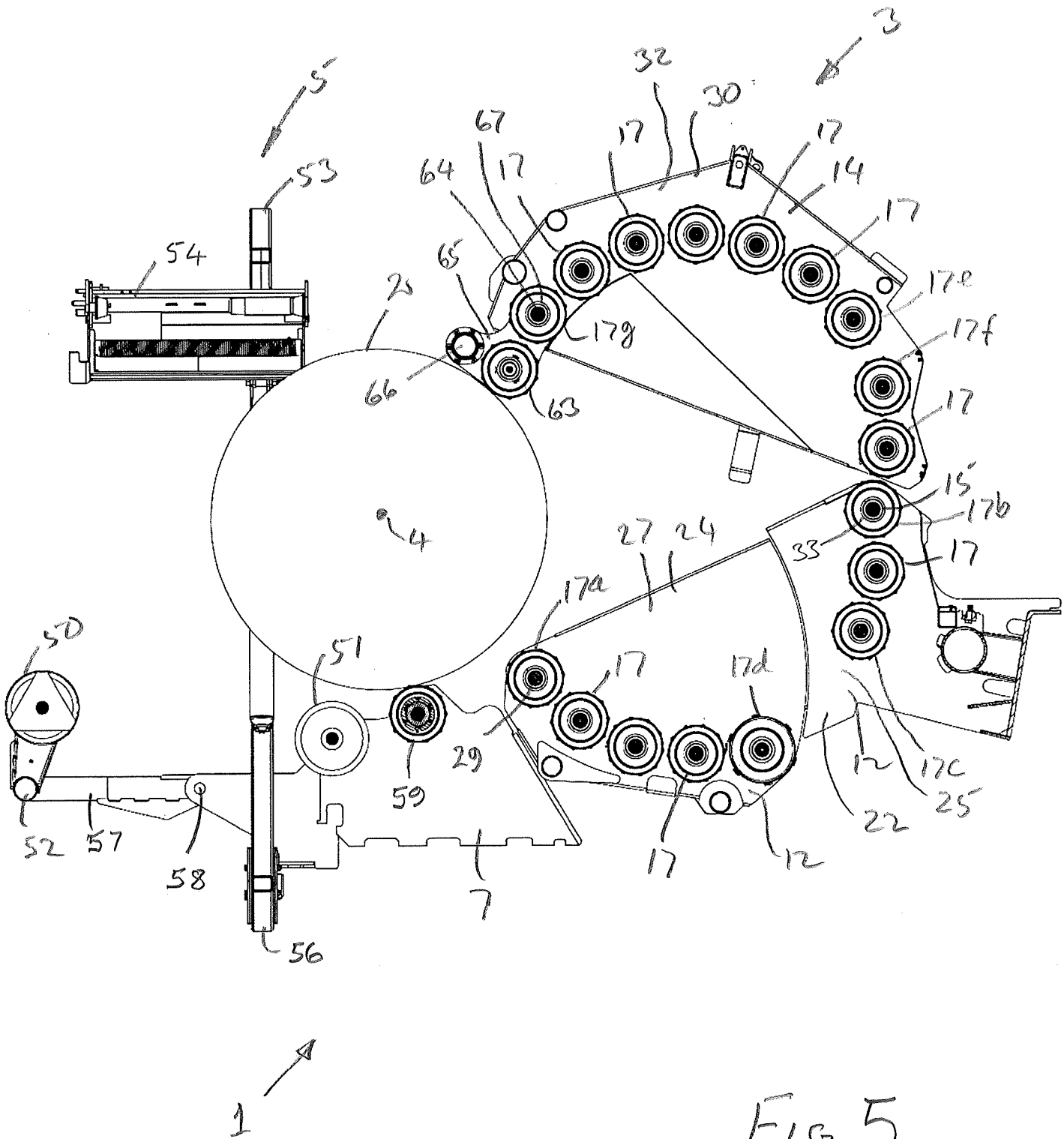
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FIG 5

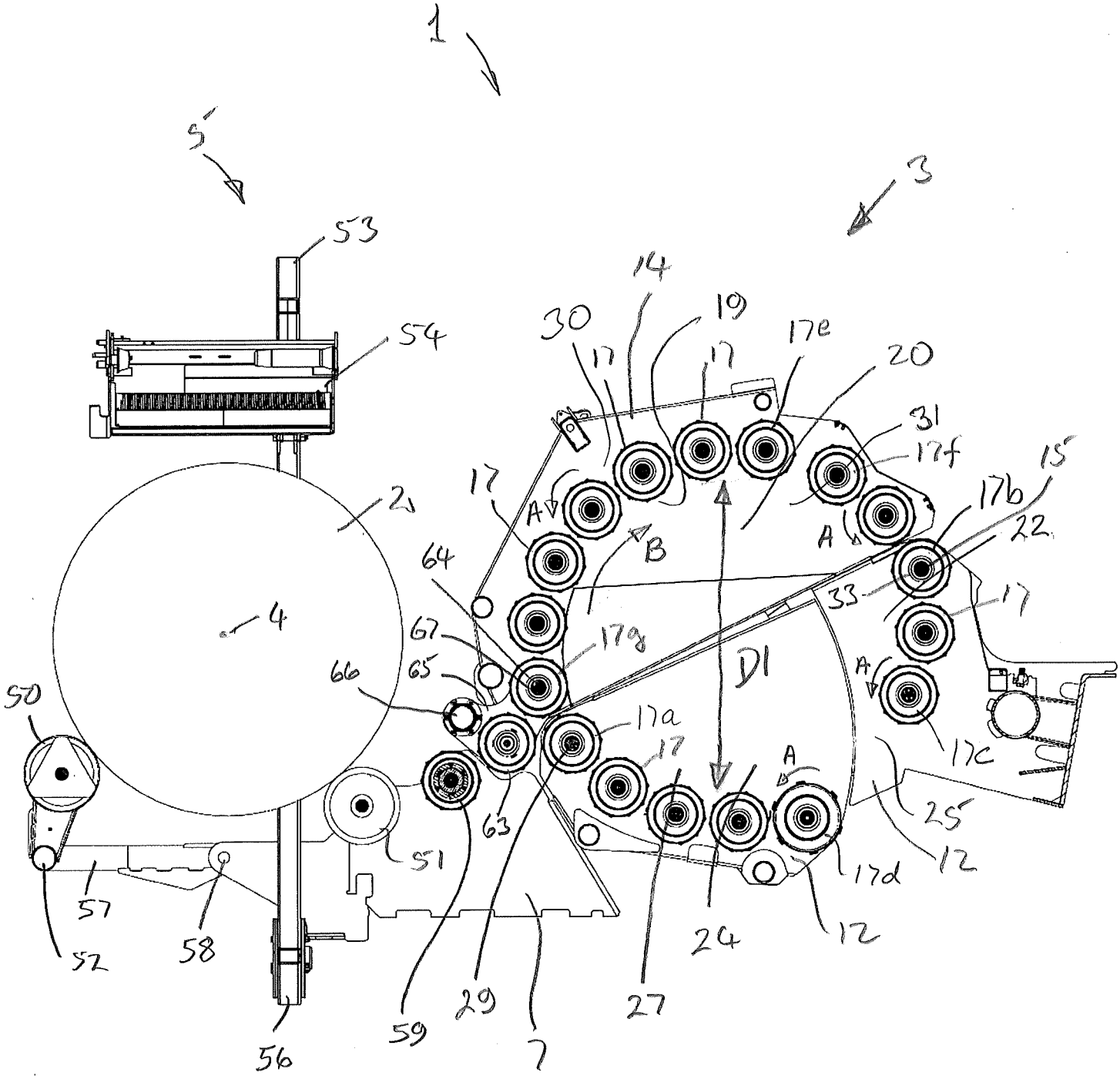
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FIG 6

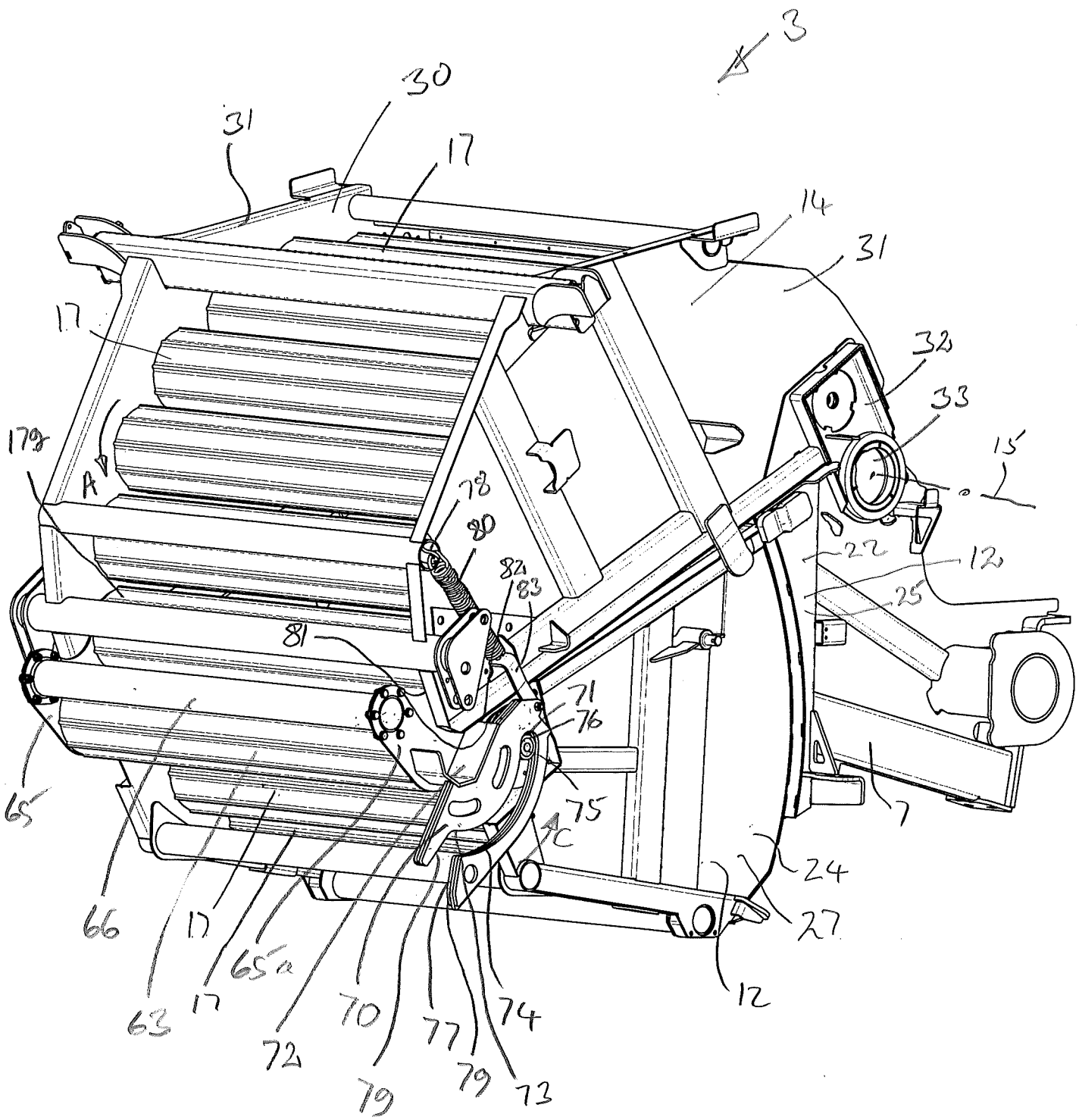
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FIG 7

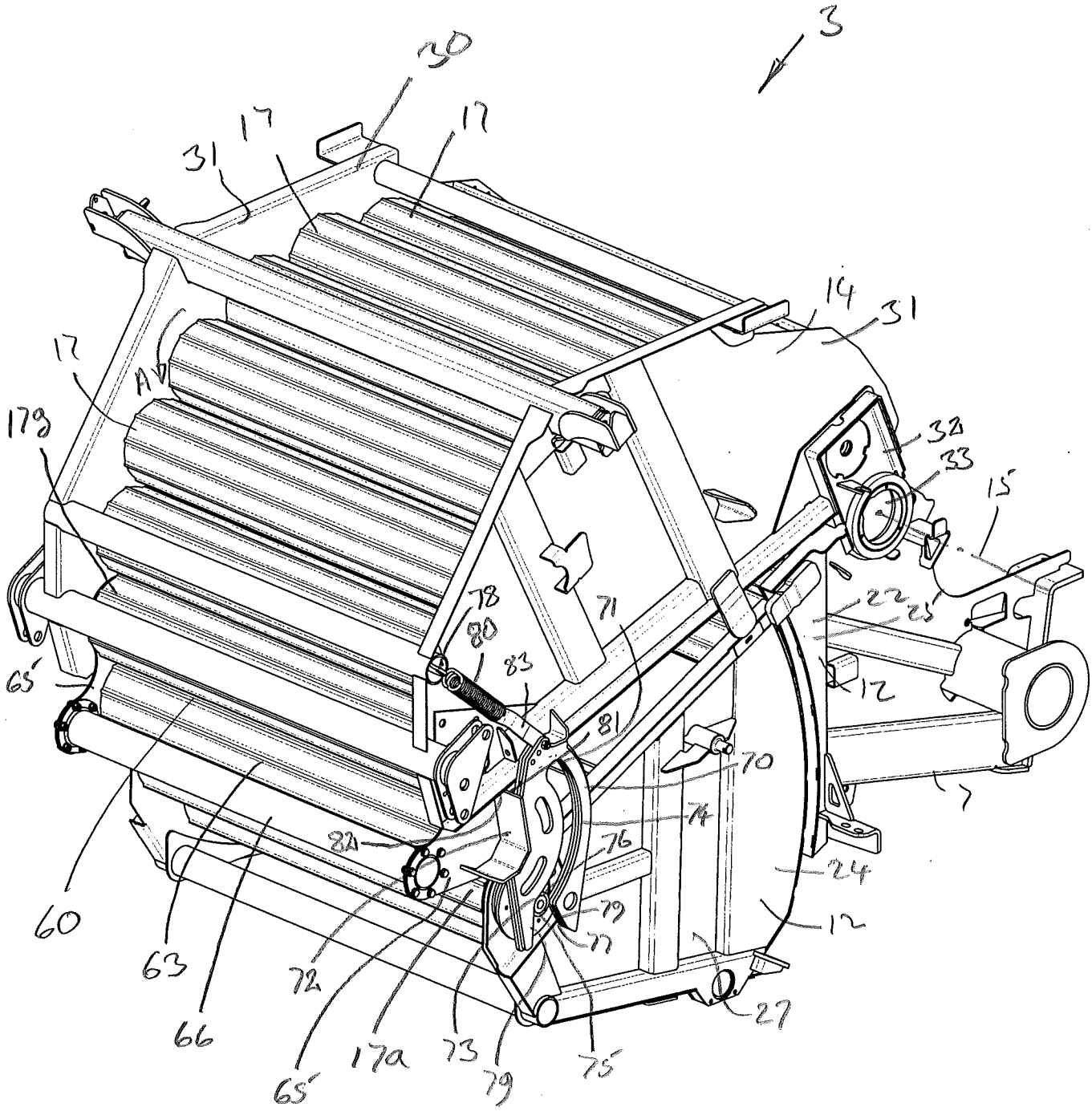
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FIG 8

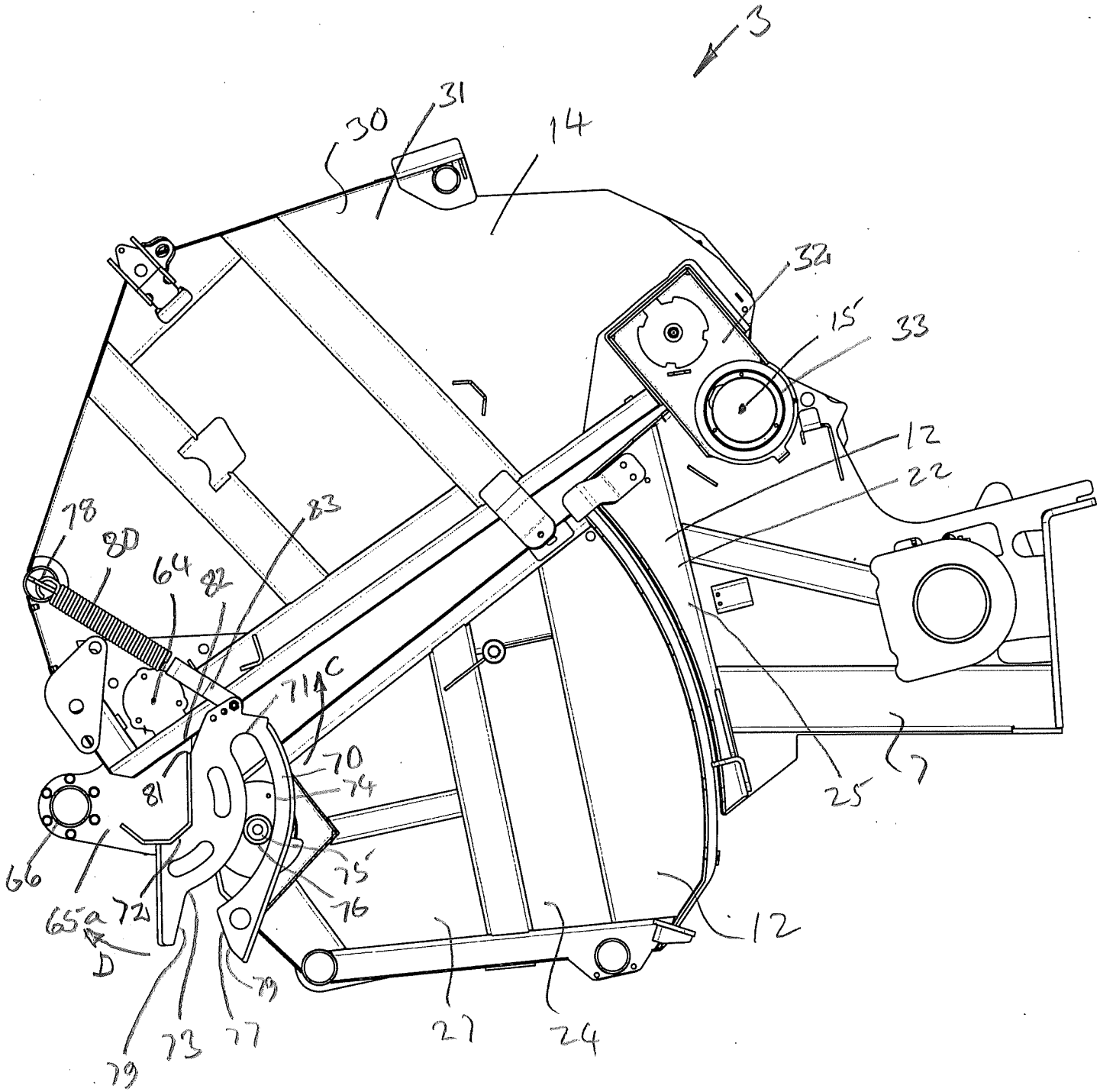
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Fig 9

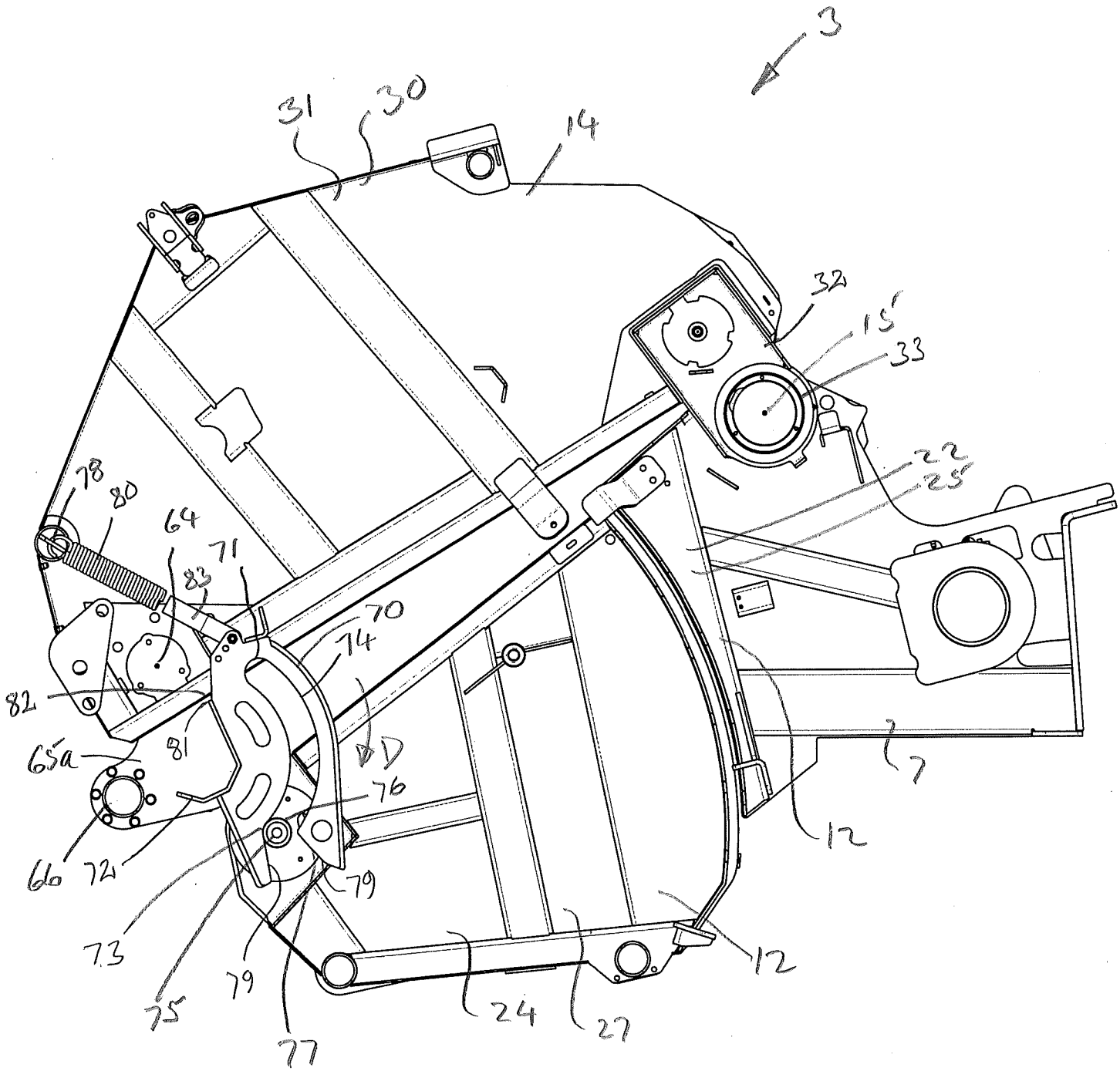
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FIG 10

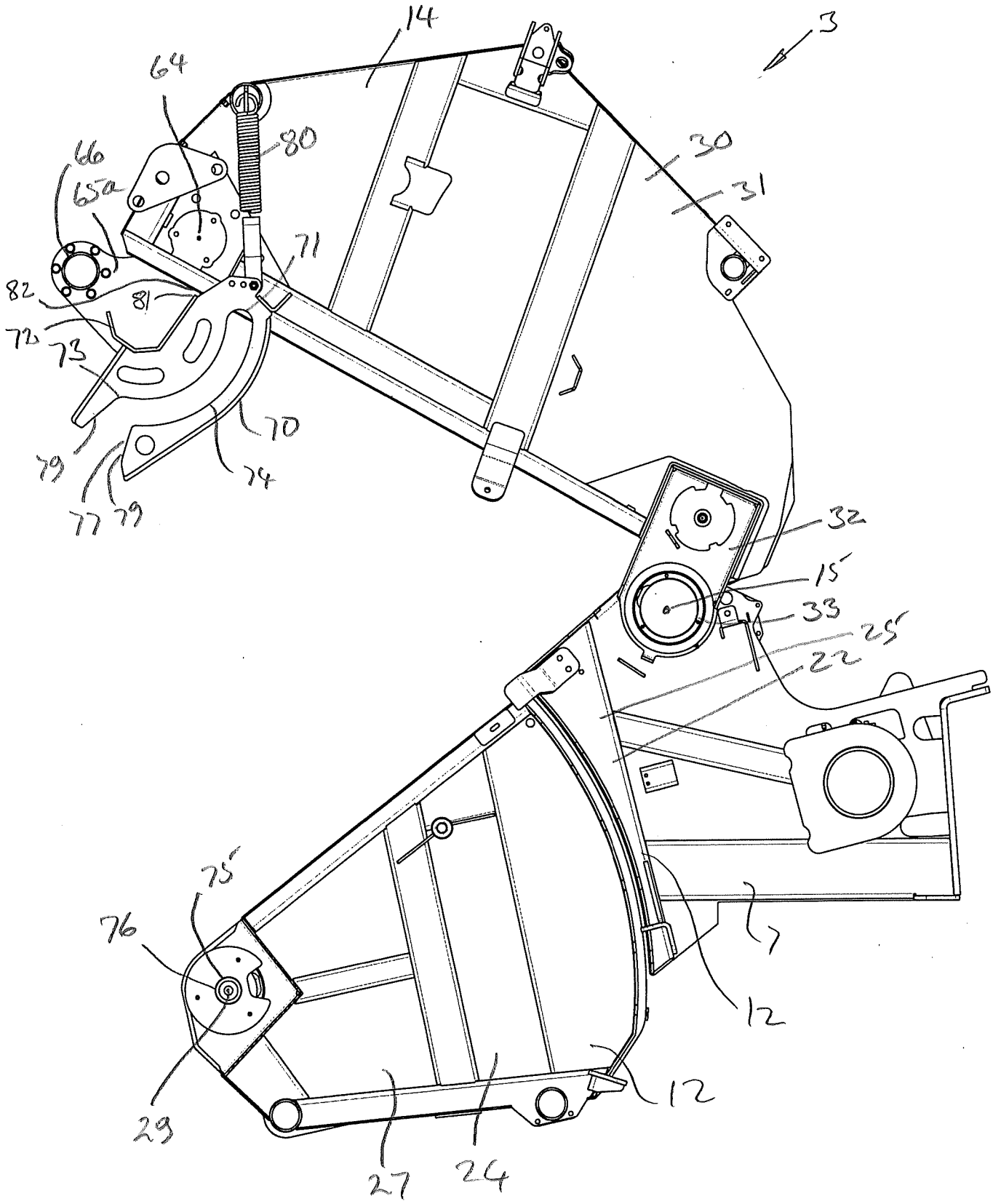
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FIG 11

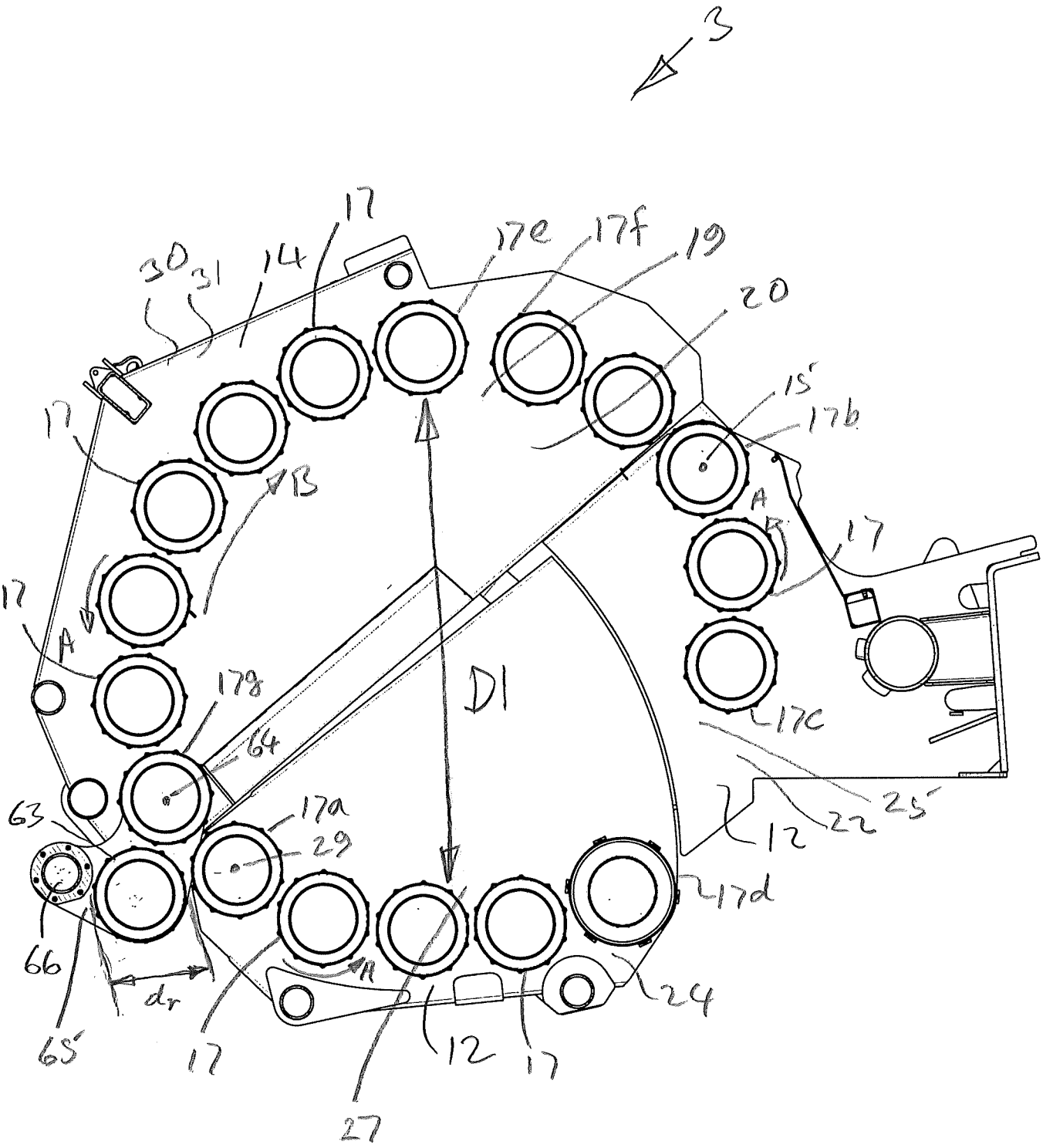
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FIG 12

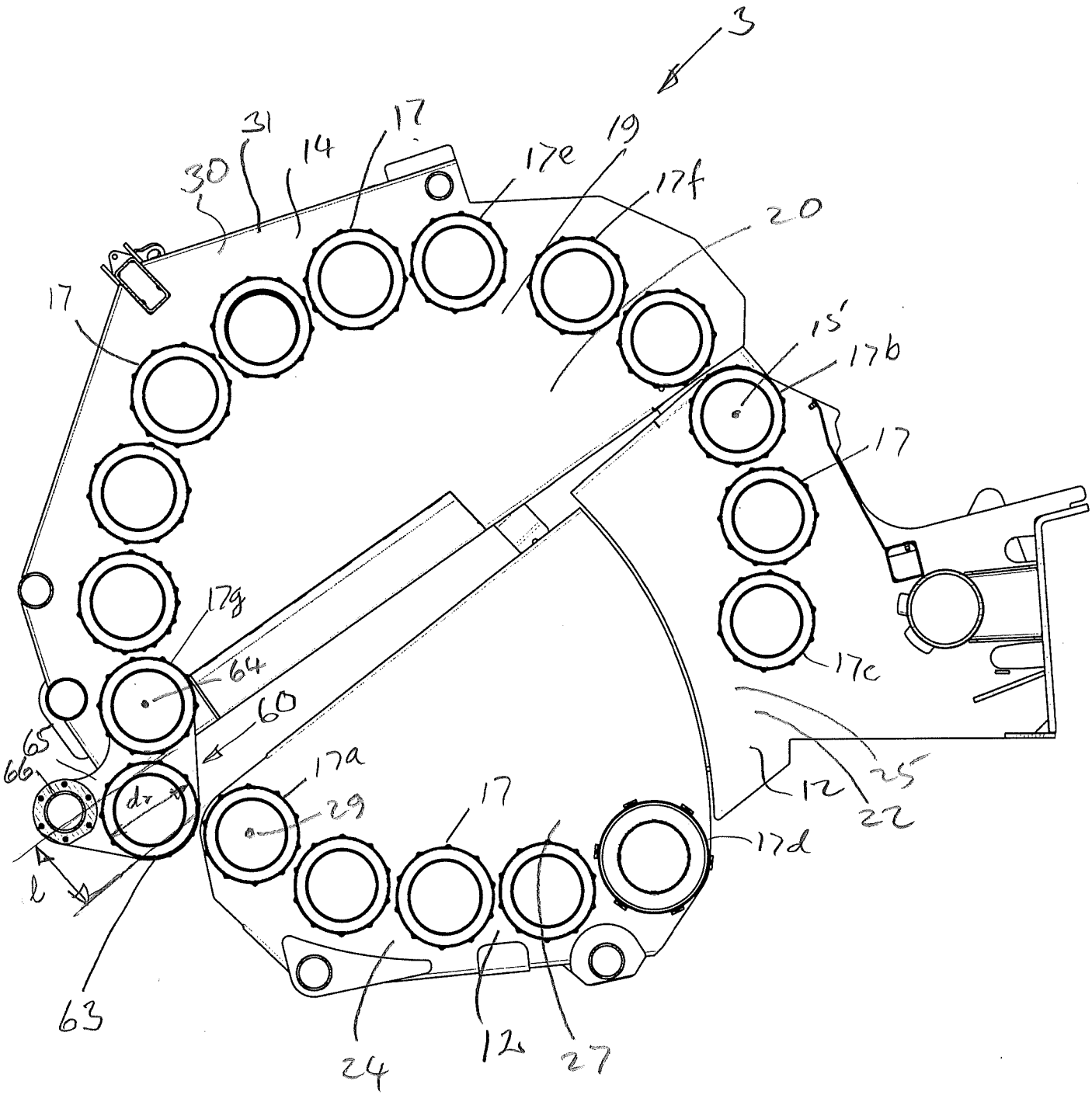
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FIG 13

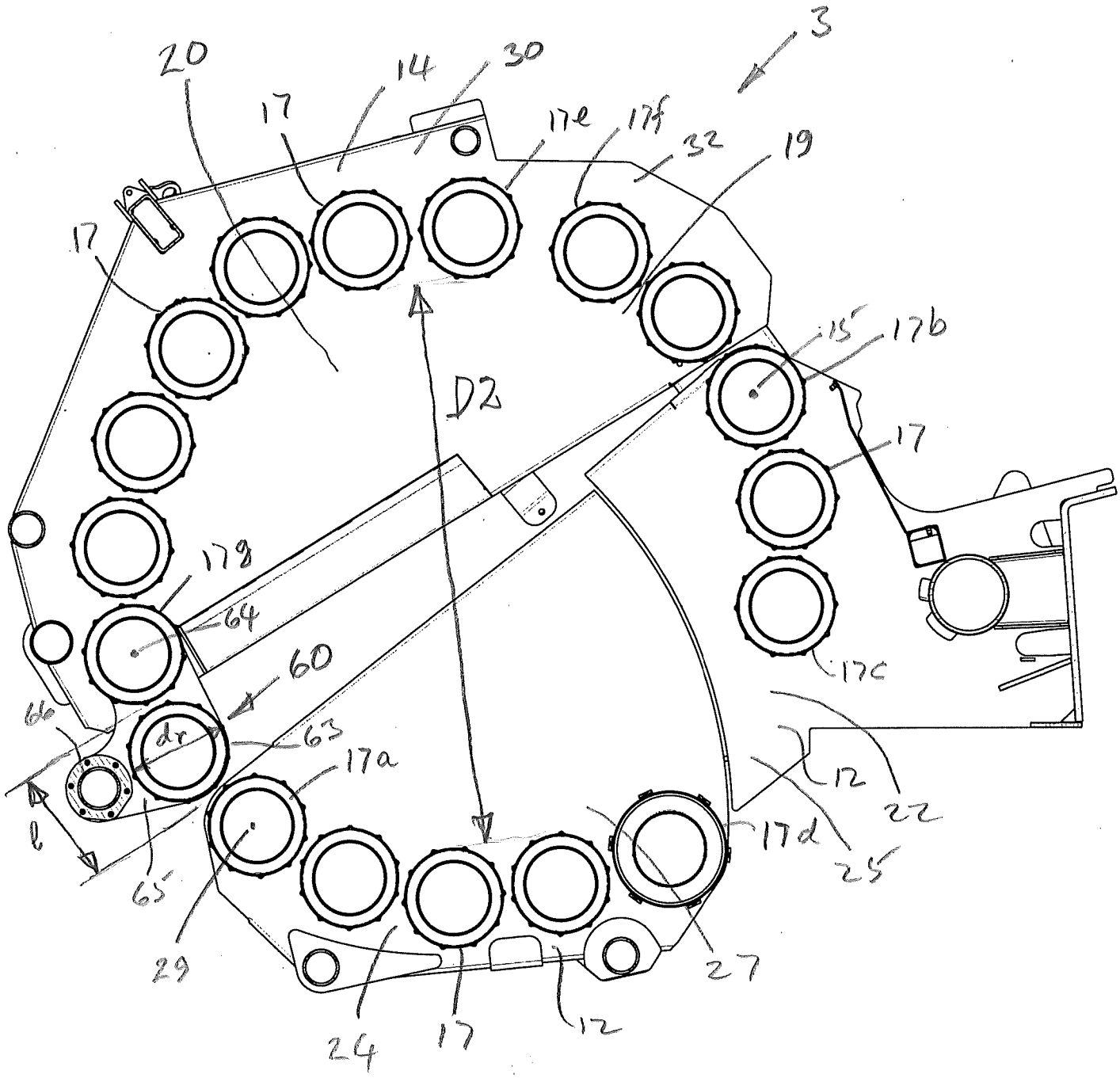
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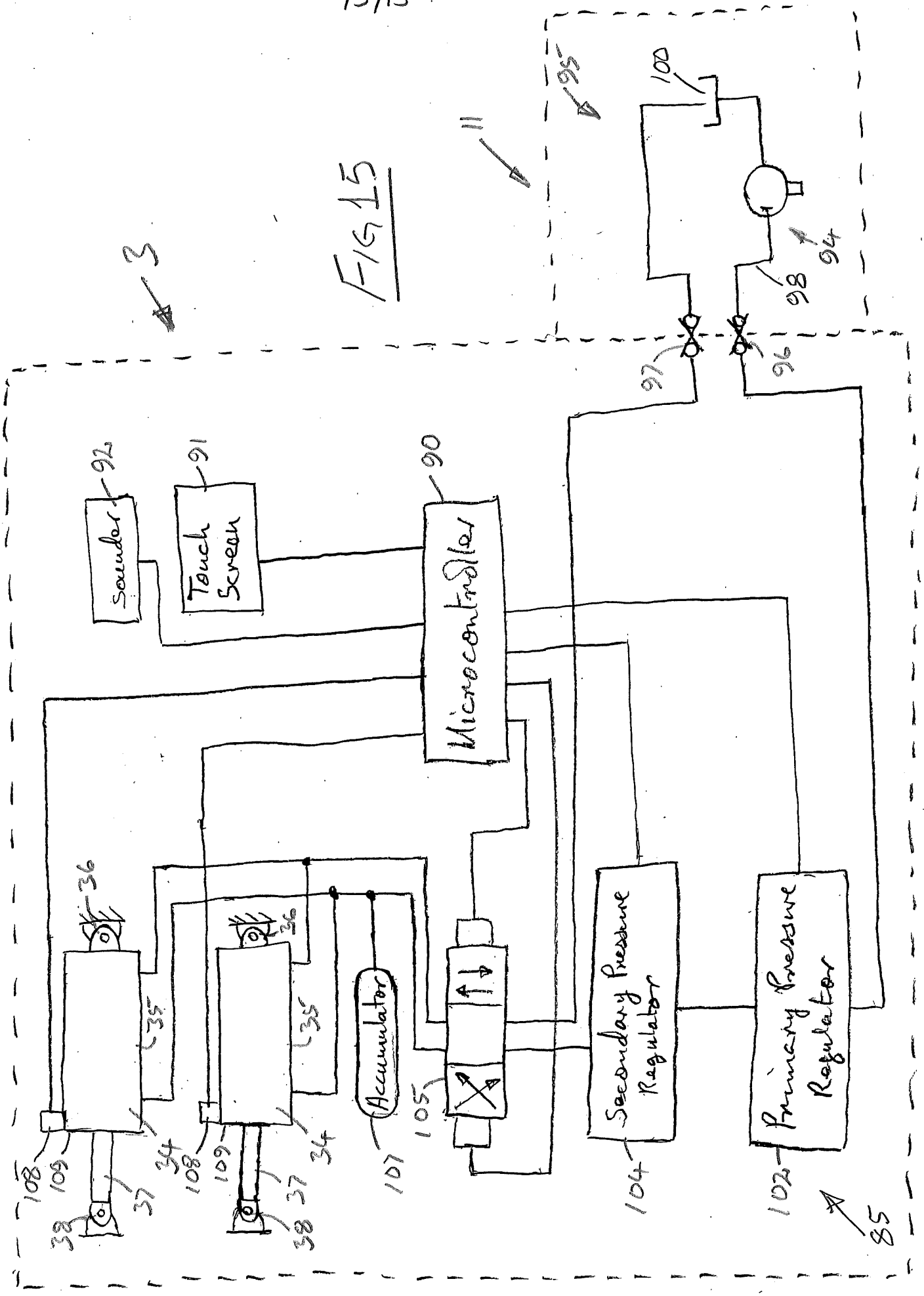
FIG 14

FIG 15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Accumulator
101
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Secondary Pressure Regulator
104
Primary Pressure Regulator
102
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INTERNATIONAL SEARCH REPORT

International application No
PCT/IE2024/000007

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01F15/07 A01F15/08
ADD.

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)
A01F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 2 570 022 A1 (MCHALE PADRAIC CHRISTOPHER [IE]; MCHALE MARTIN WILLIAM [IE]) 20 March 2013 (2013-03-20) figures 1-3, 6-12 paragraphs [0030], [0033], [0036] - [0043], [0051], [0054]	1-7, 29-54, 76-95 8-28, 55-75
A	EP 0 954 958 B1 (KVERNELAND GOTTMADINGEN GMBH & [DE]) 11 December 2002 (2002-12-11) figures 1-5	1-95
A	EP 0 264 493 B1 (NEW HOLLAND NV [BE]) 20 December 1989 (1989-12-20) figures 1-3	1-95
A	WO 2015/105417 A1 (FORAGE INNOVATIONS BV [NL]) 16 July 2015 (2015-07-16) figures 1-4	1-95

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 September 2024	16/10/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Holtermann, Timm

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IE2024/000007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2570022 A1	20-03-2013	NONE	
EP 0954958 B1	11-12-2002	DE 29808383 U1	06-08-1998
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		US 4765238 A	23-08-1988
WO 2015105417 A1	16-07-2015	EP 3091829 A1	16-11-2016
		NL 2012073 C2	13-07-2015
		WO 2015105417 A1	16-07-2015