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(54) **SEEDING MACHINE WITH SEED DELIVERY SYSTEM**

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A01C 7/20	(2006.01)
A01C 21/00	(2006.01)

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USPC 111/170–172, 177–185, 14, 11, 200, 900
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,141,044 A	12/1938	Rassman
3,122,283 A	2/1964	Walters
3,176,636 A	4/1965	Wilcox et al.

(Continued)

FOREIGN PATENT DOCUMENTS

FR	858062 A	11/1940
FR	1026090 A	4/1953

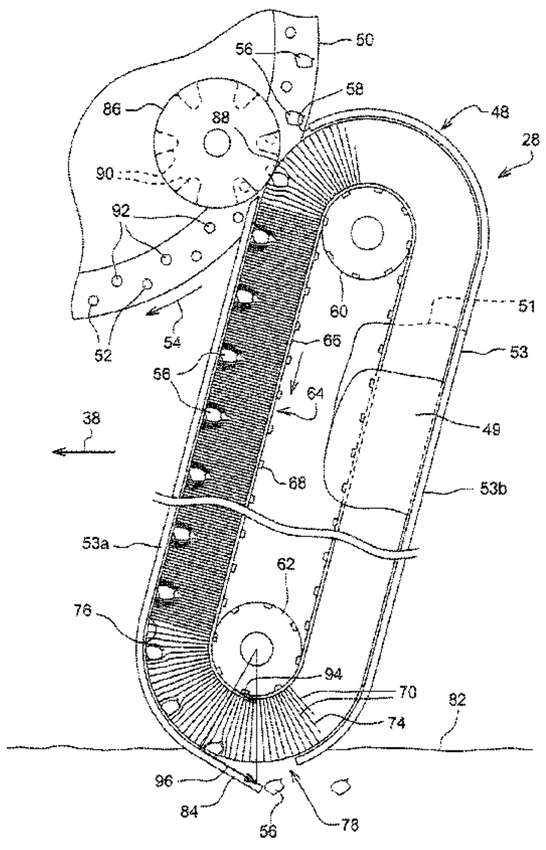
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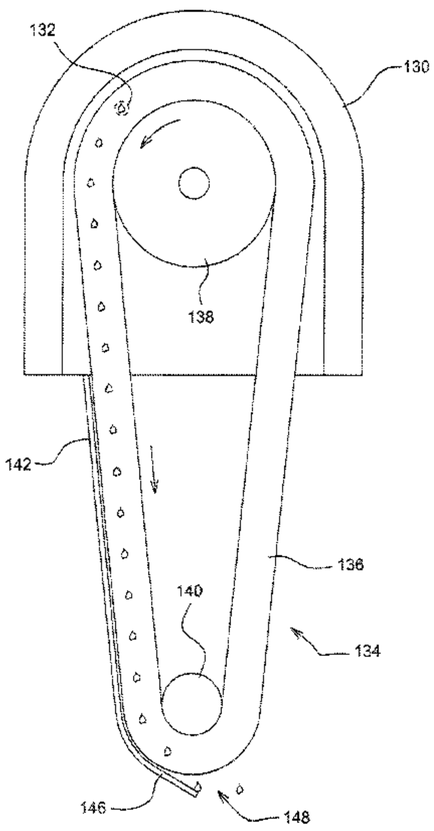
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(57) **ABSTRACT**

A seeding machine with a seed meter and a seed delivery system for moving seed from a seed meter to a furrow formed in the soil. The delivery system has an endless member moving in a housing about pulleys to move seed from an upper opening in the housing to a lower discharge opening. In one embodiment, a loading wheel at the upper opening to the housing engages seed on a metering disk to move seed into the housing. The metering disk and housing can be arranged in planes parallel to one another.

20 Claims, 10 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

3,343,507	A	9/1967	Smith	
3,552,601	A	1/1971	Hansen et al.	
3,913,503	A	10/1975	Becker	
4,193,523	A	3/1980	Koning	
4,600,122	A	7/1986	Lundie et al.	
4,646,941	A	3/1987	Grosse-Scharmann et al.	
5,533,458	A	7/1996	Bergland et al.	
5,936,234	A	8/1999	Thomas et al.	
6,237,514	B1	5/2001	Romans	
6,651,570	B1	11/2003	Thiemke	
6,681,706	B2	1/2004	Sauder et al.	
7,185,596	B2	3/2007	Thiemke et al.	
7,343,868	B2	3/2008	Stephens et al.	
7,448,334	B2	11/2008	Mariman et al.	
7,631,606	B2	12/2009	Sauder et al.	
7,918,168	B2	4/2011	Garner et al.	
8,074,586	B2 *	12/2011	Garner	A01C 7/105 111/171
8,468,960	B2 *	6/2013	Garner	A01C 7/20 111/171
8,671,856	B2	3/2014	Garner et al.	
8,789,482	B2 *	7/2014	Garner	A01C 7/20 111/171
8,800,457	B2	8/2014	Garner et al.	
8,813,663	B2 *	8/2014	Garner	A01C 7/20 111/11
8,850,995	B2 *	10/2014	Garner	A01C 7/20 111/11
2003/0159631	A1 *	8/2003	Sauder	A01C 7/04 111/171
2010/0300341	A1	12/2010	Peterson et al.	

FOREIGN PATENT DOCUMENTS

FR	2210887	A5	7/1974
FR	2414288	A1	8/1979
FR	2635432	A1	2/1990
GB	926217	A	5/1963

* cited by examiner

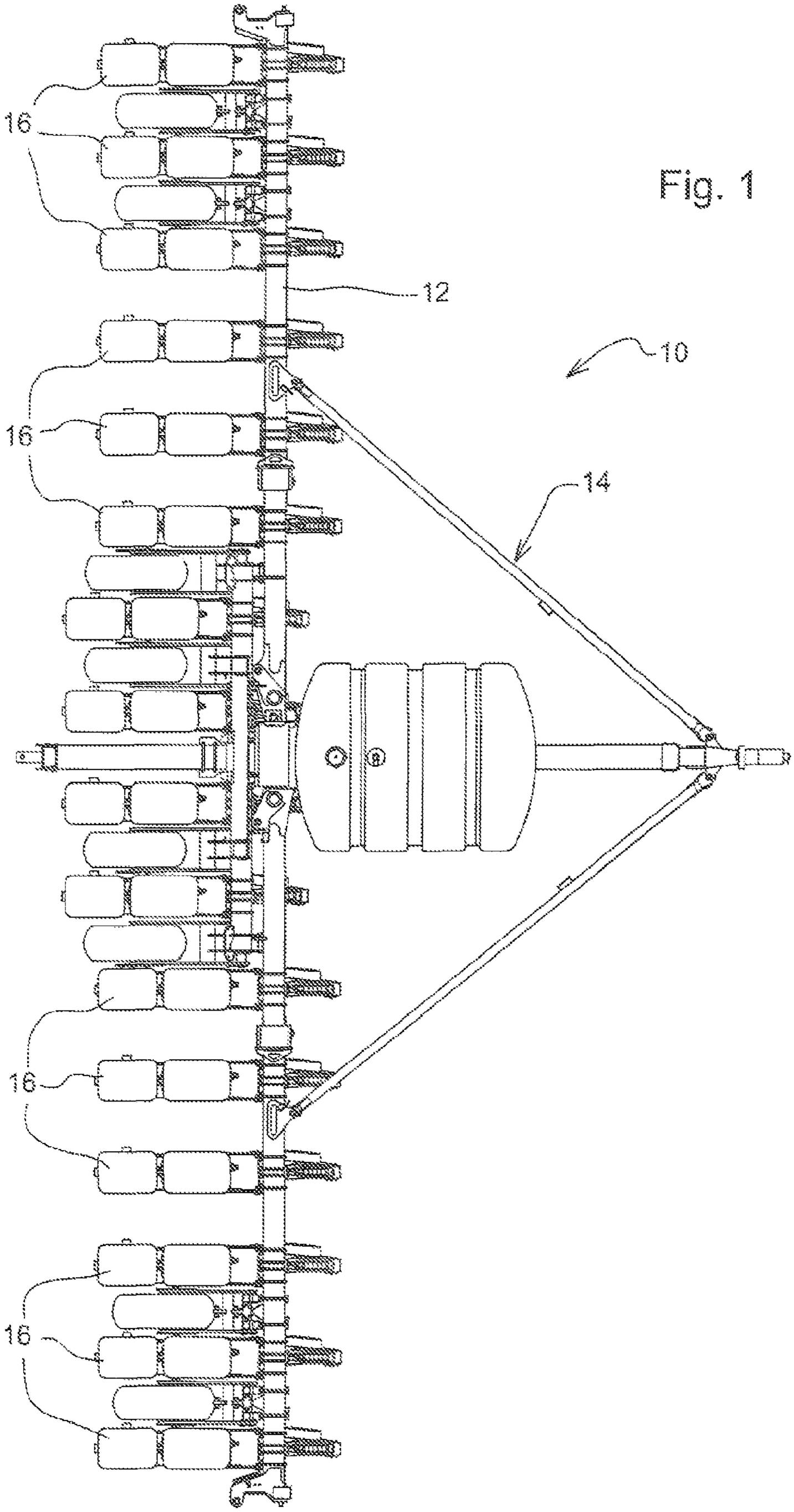


Fig. 1

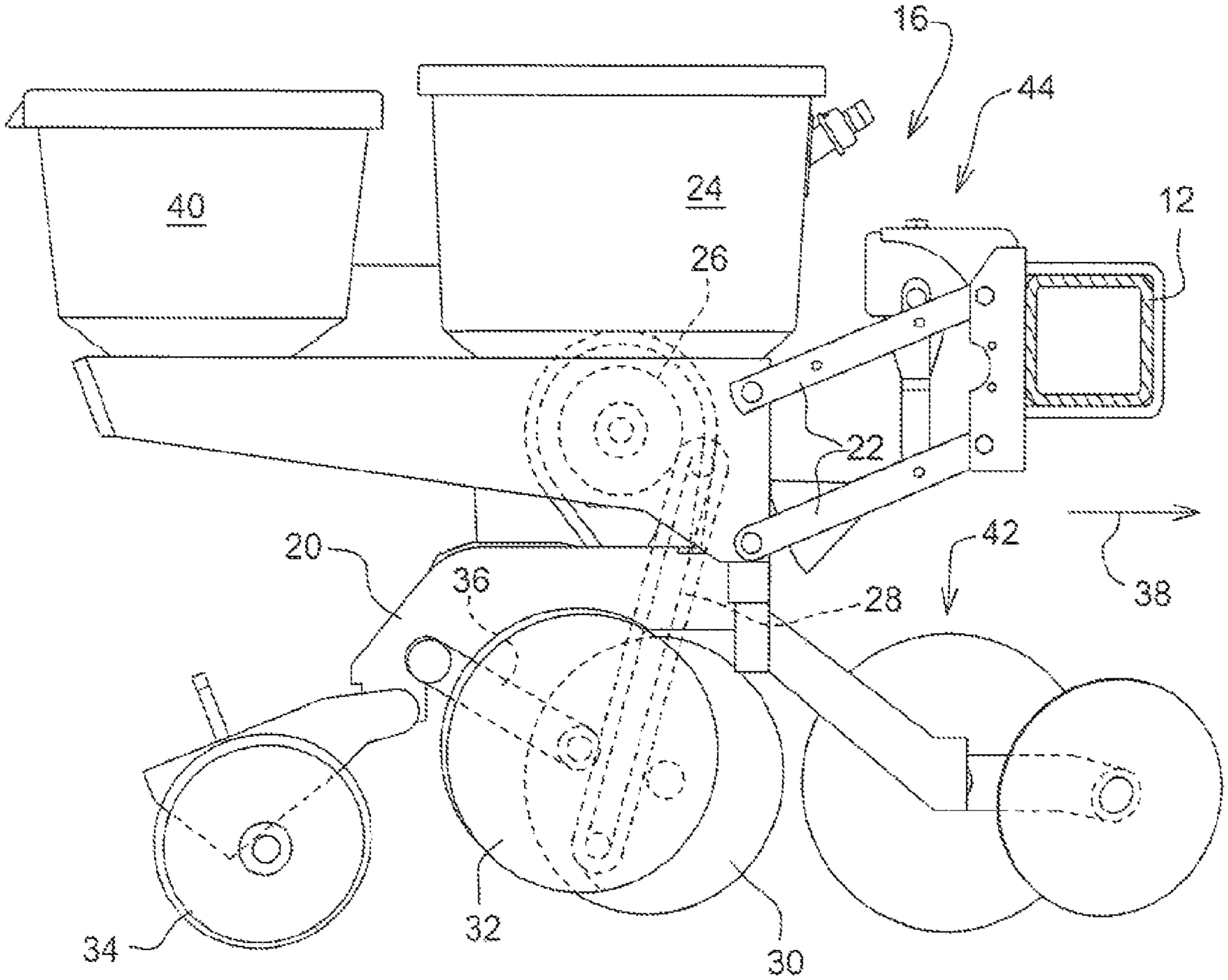
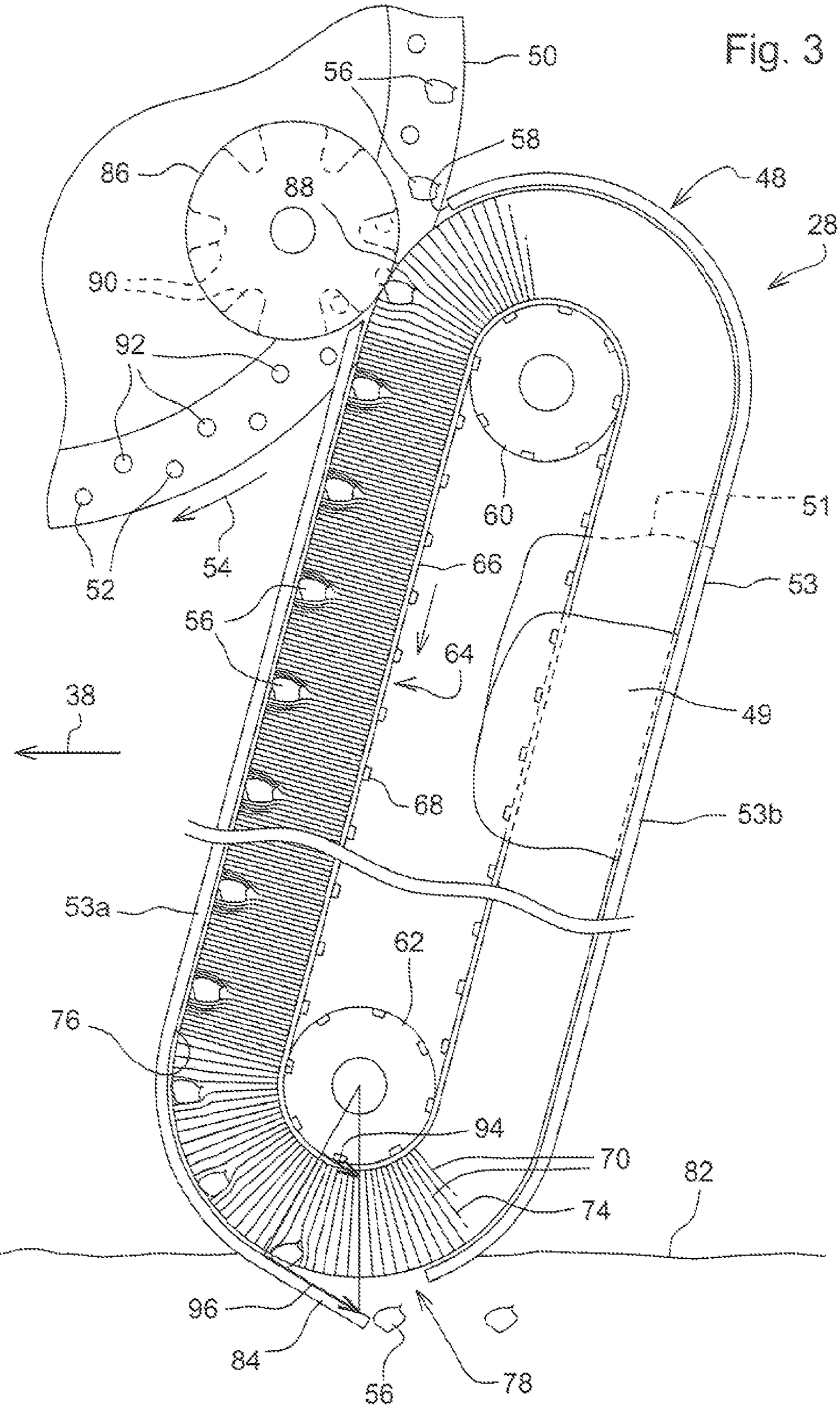


Fig. 2

Fig. 3


50
56
58
86
88
48
28
90
92
60
51
52
54
66
53
56
64
38
49
68
53b
53a
62
76
94
70
82
74
96
84
56
78

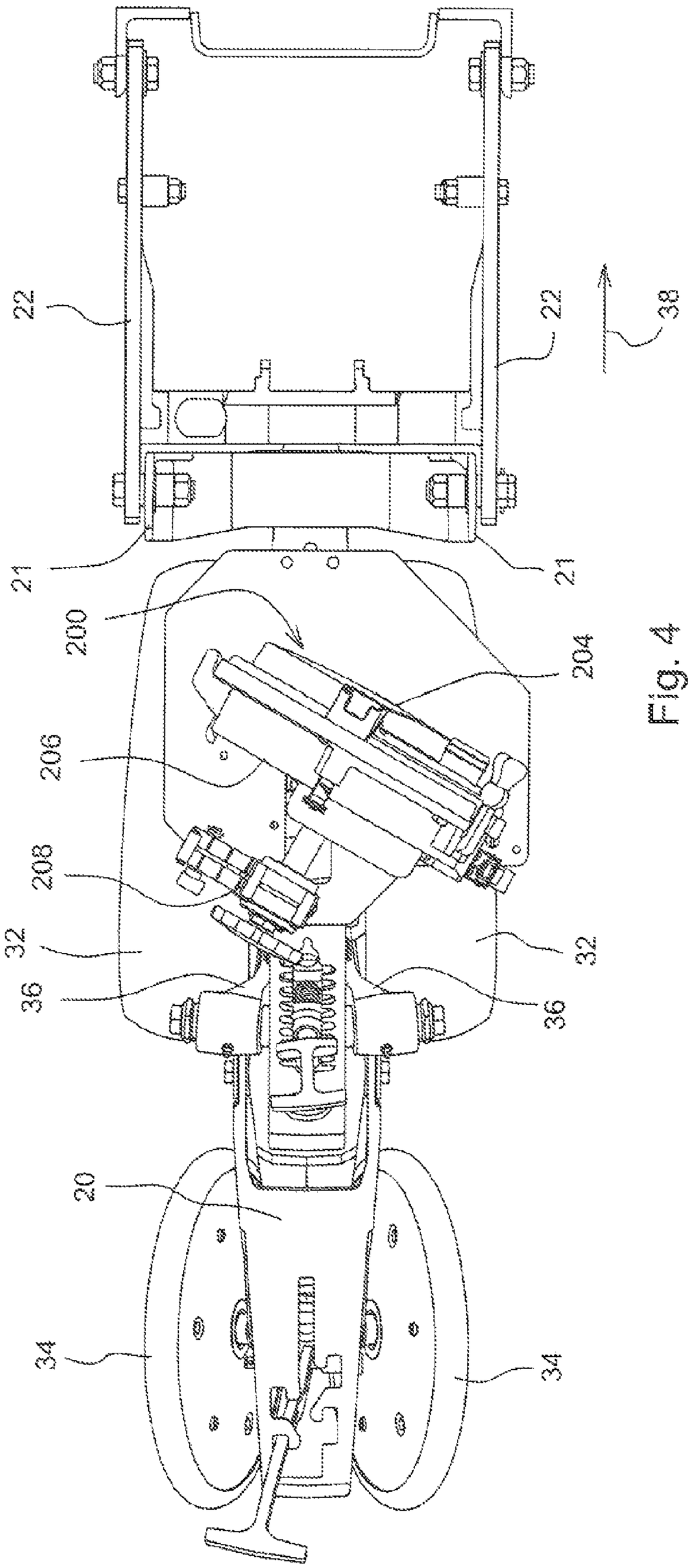


Fig. 4

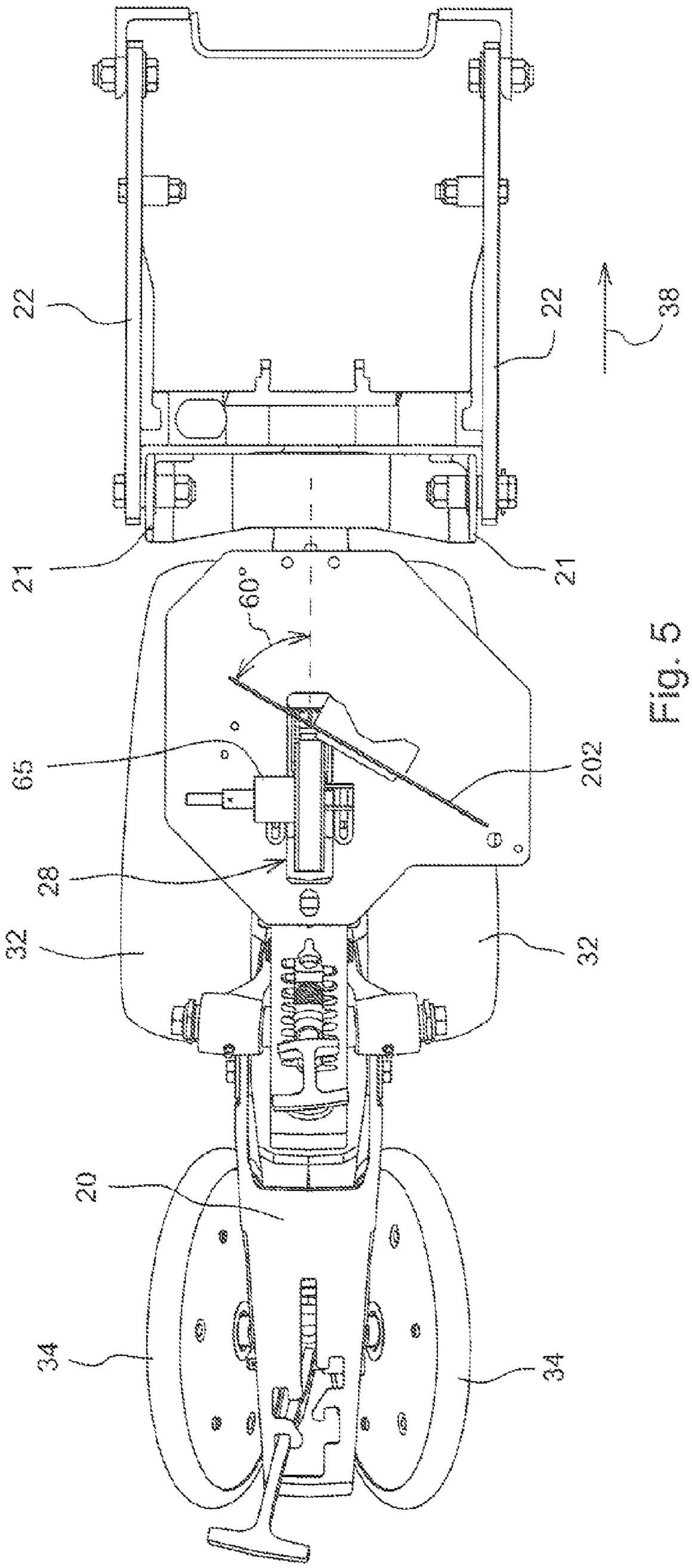


Fig. 5

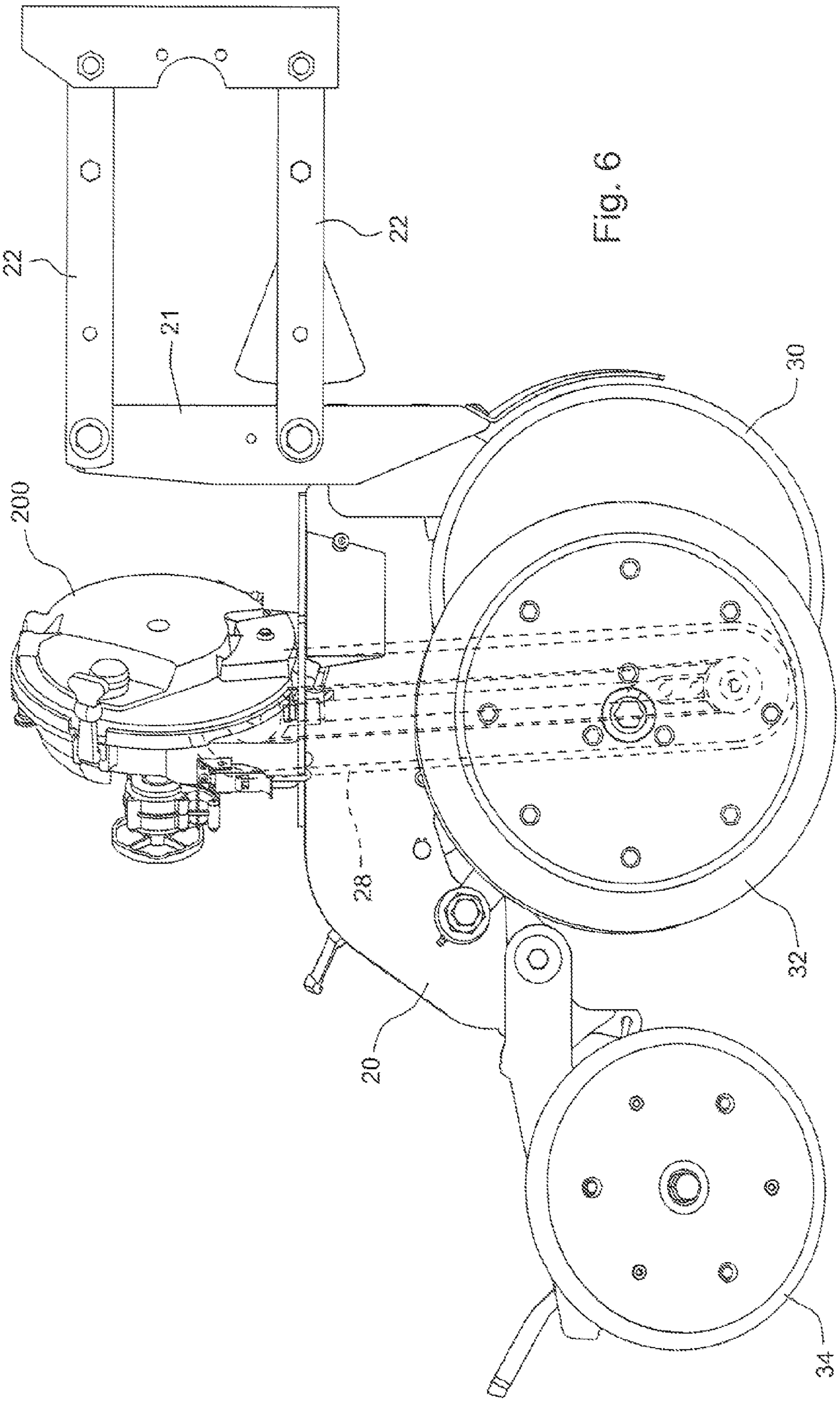
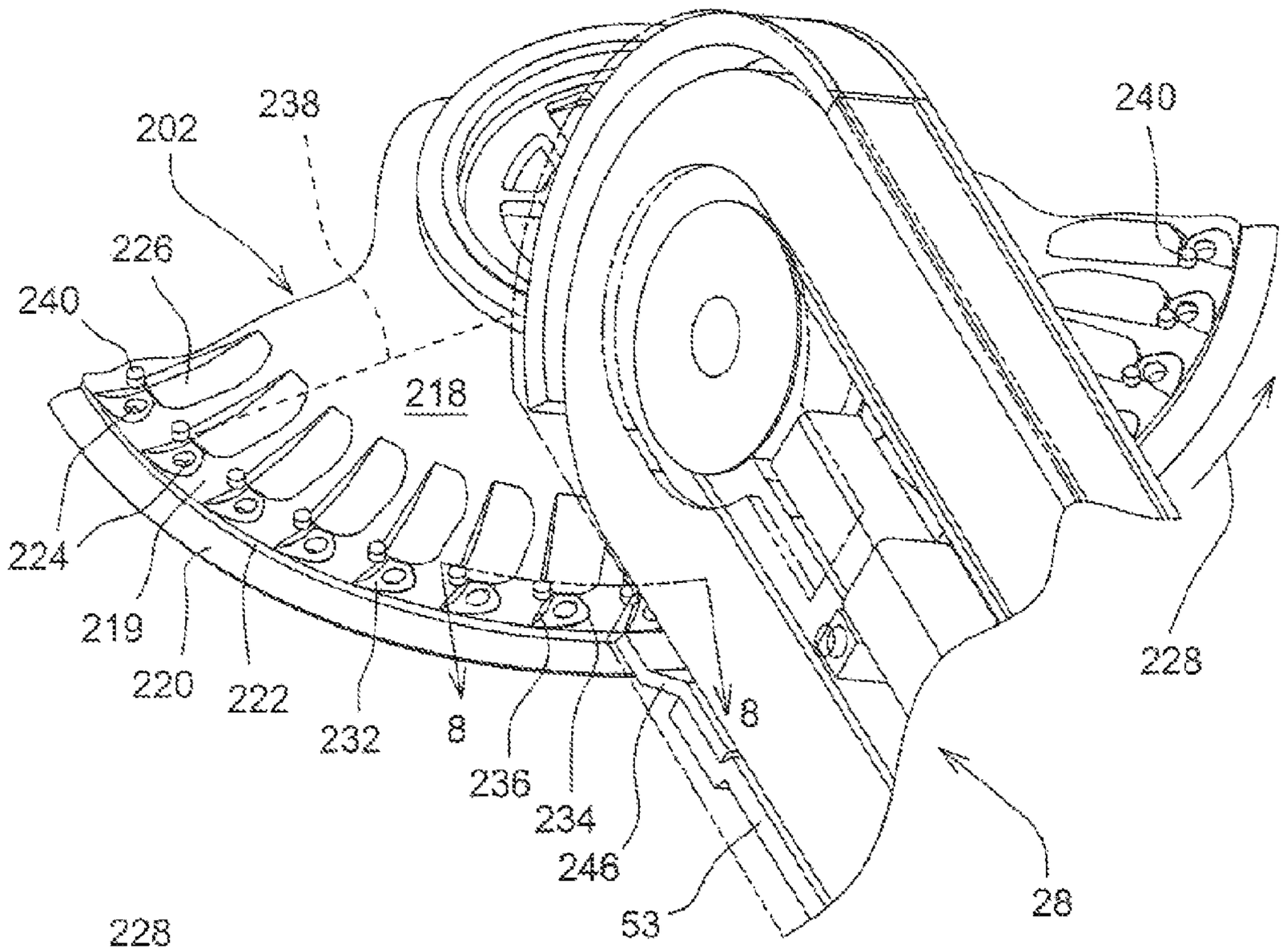


Fig. 6

Fig. 7


202
238
240
226
240
218
224
219
220
222
232
8
8
236
234
246
53
28
228
240

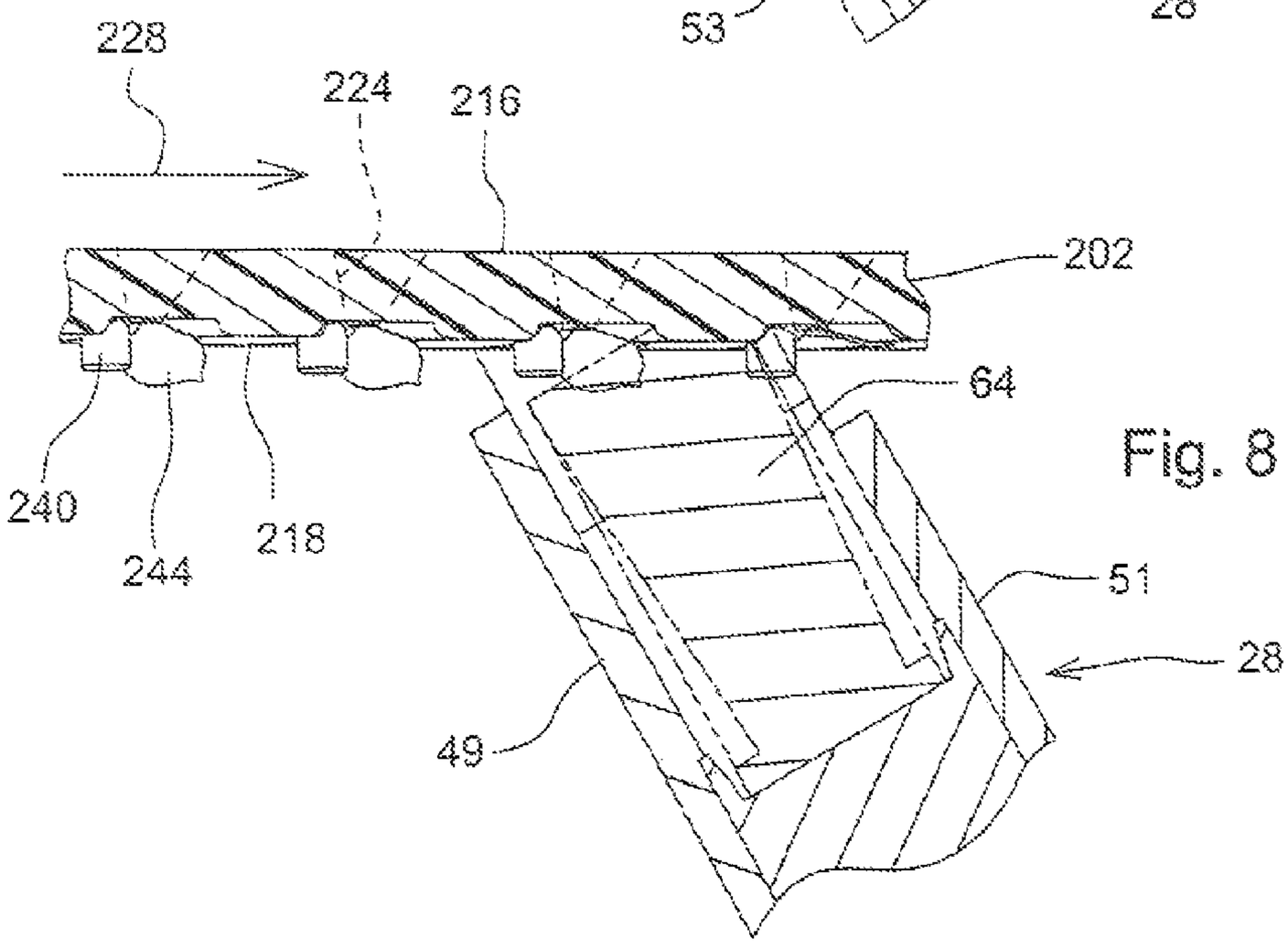

228
224
216
202
64
240
244
218
51
28
49

Fig. 8

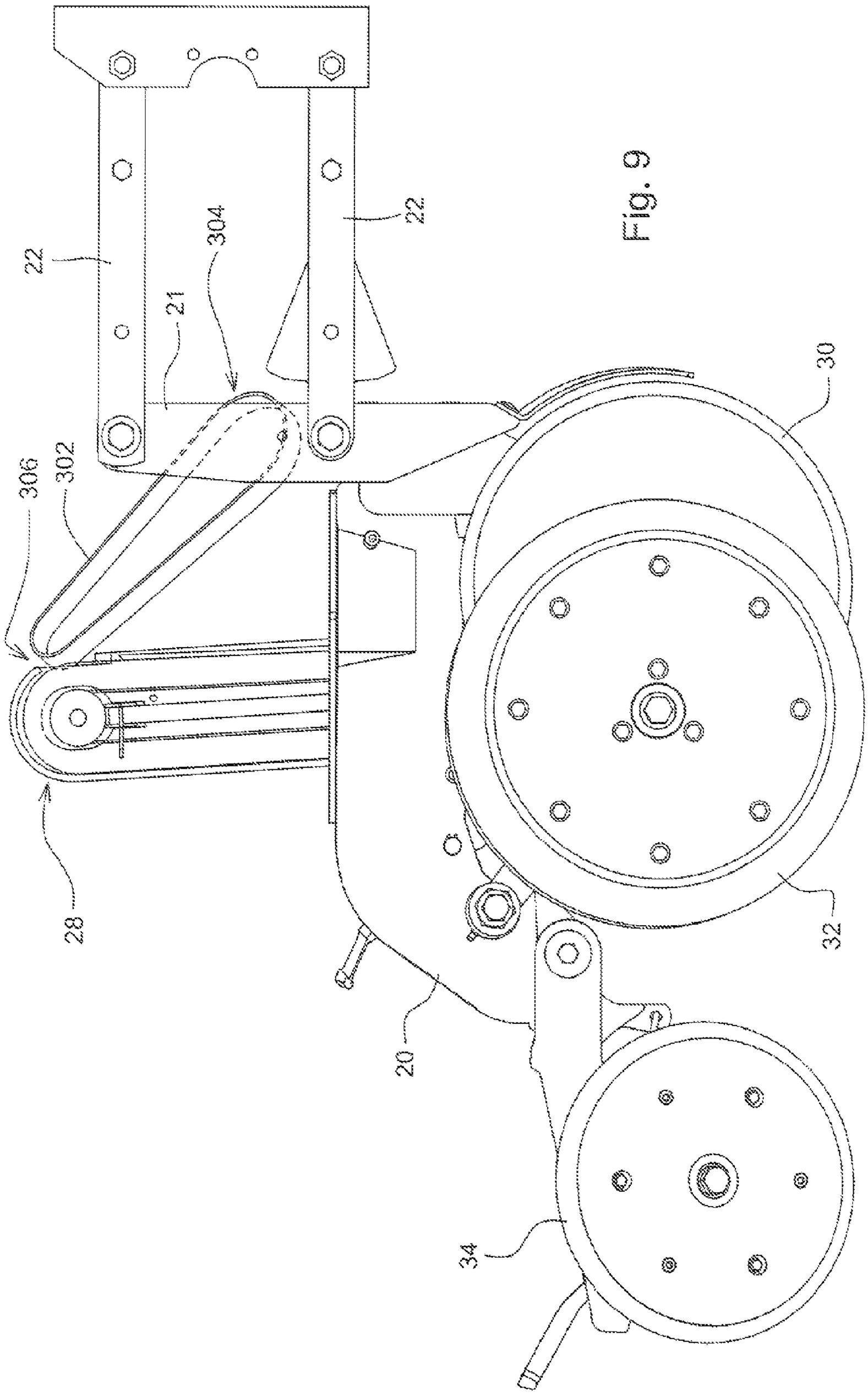


Fig. 9

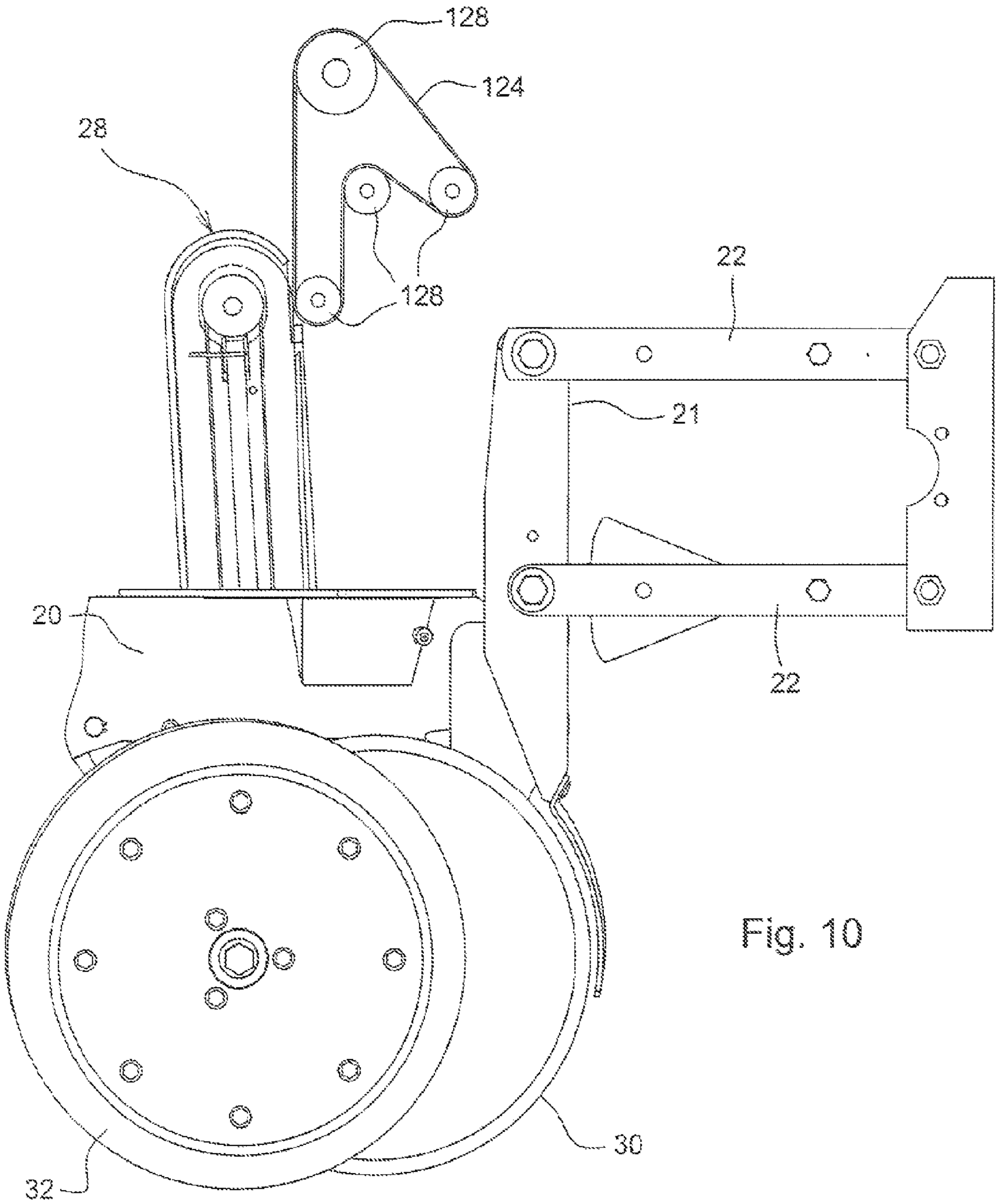


Fig. 10

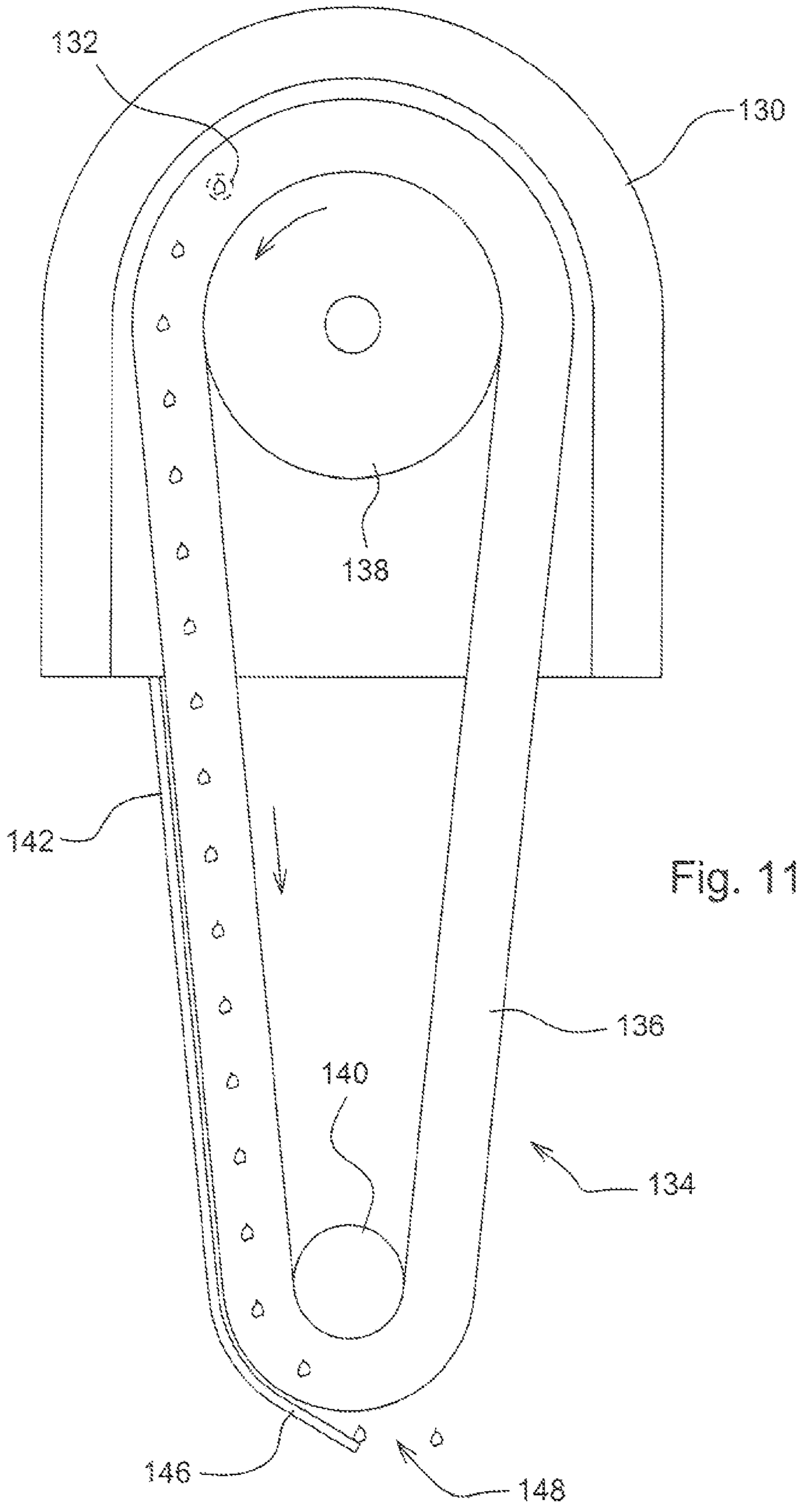


Fig. 11

SEEDING MACHINE WITH SEED DELIVERY SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application is a Continuation of U.S. patent application Ser. No. 14/504,801, filed Oct. 2, 2014, which is a Continuation of U.S. patent application Ser. No. 12/364,010, filed Feb. 2, 2009, now U.S. Pat. No. 8,850,995.

FIELD OF THE INVENTION

The invention relates to a seeding machine having a seed metering system and a seed delivery system for delivering seed from the meter to the ground.

BACKGROUND OF THE INVENTION

An agricultural seeding machine such as a row crop planter or grain drill places seeds at a desired depth within a plurality of parallel seed trenches formed in soil. In the case of a row crop planter, a plurality of row crop units are typically ground driven using wheels, shafts, sprockets, transfer cases, chains and the like or powered by electric or hydraulic motors. Each row crop unit has a frame which is movably coupled with a tool bar. The frame may carry a main seed hopper, herbicide hopper and insecticide hopper. If a herbicide and insecticide are used, the metering mechanisms associated with dispensing the granular product into the seed trench are relatively simple. On the other hand, the mechanisms necessary to properly meter the seeds, and dispense the seeds at predetermined relative locations within the seed trench are relatively complicated.

The mechanisms associated with metering and placing the seeds generally can be divided into a seed metering system and a seed placement system which are in series communication with each other. The seed metering system receives the seeds in a bulk manner from the seed hopper carried by the planter frame or by the row unit. Different types of seed metering systems may be used, such as seed plates, finger plates, seed disks, etc. In the case of a seed disk metering system a seed disk is formed with a plurality of seed cells spaced about the periphery of the disk. Seeds are moved into the seed cells with one or more seeds in each seed cell depending upon the size and configuration of the seed cell. A vacuum or positive air pressure differential may be used in conjunction with the seed disk to assist in movement of the seeds into the seed cell. The seeds are singulated and discharged at a predetermined rate to the seed placement or delivery system.

The most common seed delivery system may be categorized as a gravity drop system. In the case of the gravity drop system, a seed tube has an inlet end which is positioned below the seed metering system. The singulated seeds from the seed metering system merely drop into the seed tube and fall via gravitational force from a discharge end thereof into the seed trench. The seed tube may have a rearward curvature to reduce bouncing of the seed as it strikes the bottom of the seed trench and to impart a horizontal velocity to the seed in order to reduce the relative velocity between the seed and the ground. Undesirable variation in resultant in-ground seed spacing can be attributed to differences in how individual seeds exit the metering system and drop through the seed tube. The spacing variation is exacerbated by higher travel speeds through the field which amplifies the dynamic field conditions. Further seed spacing variations are caused by the inherent relative velocity difference between the seeds and the soil as the seeding machine travels through a field. This relative velocity difference causes individual seeds to bounce and tumble in somewhat random patterns as each seed comes to rest in the trench.

Various attempts have been made to reduce the variation in seed spacing resulting from the gravity drop. U.S. Pat. No. 6,681,706 shows two approaches. One approach uses a belt with flights to transport the seeds from the meter to the ground while the other approach uses two belts to grip the seed and transport it from the meter to the ground. While these approaches control the seed path and reduce variability due to dynamic events, neither approach seeks to deliver the seed with as small as possible horizontal velocity difference relative to the ground. U.S. Pat. Nos. 6,651,570, 7,185,596 and 7,343,868 show a seed delivery system using a brush wheel near the ground to regulate the horizontal velocity and direction of the seed as it exits the seeding machine. However, there is still a gravity drop between the seed meter and the brush wheel which produces variation in seed spacing.

SUMMARY OF THE INVENTION

The present invention provides a seed delivery system that removes the seed from the seed meter by capturing the seed. The delivery system then moves the seed down to a lower discharge point and accelerates the seed rearward to a horizontal velocity approximately equal to the forward travel speed of the seeding machine such that the seed, when discharged, has a low or zero horizontal velocity relative to the ground. Rolling of the seed in the trench is reduced as a result of the near zero horizontal velocity relative to the ground. Furthermore, as the seed experiences a controlled descent from the point at which it is removed from the meter to a point very near the bottom of the trench, the system becomes nearly impervious to the field dynamics experienced by the row unit. The combination of controlled descent and discharge at a substantially zero horizontal speed relative to the ground reduces seed spacing variability.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a planter having the seed delivery system of the present invention;

FIG. **2** is a side view of a row unit of the planter of FIG. **1**;

FIG. **3** is an enlarged side view of the seed delivery system of the present invention;

FIG. **4** is a top view of a planter row unit showing the metering system orientation in one alternative arrangement of the metering system and delivery system of the present invention;

FIG. **5** is a top view similar to FIG. **4** illustrating the delivery system with the meter housing removed;

FIG. **6** is a side view of the row unit of FIG. **4**;

FIG. **7** is a perspective view of the seed disk used in the seed meter shown in FIGS. **4-6**;

FIG. **8** is a sectional view along the line **8-8** of FIG. **7** illustrating the orientation of the seed disk and brush or the seed delivery system of the present invention;

FIG. **9** is a side view of a row unit showing the orientation of the delivery system of the present invention and a vacuum belt seed meter;

FIG. **10** is a side view of another orientation of the seed delivery system of the invention with a vacuum belt seed meter; and

FIG. **11** is a side view illustrating the orientation of the seed delivery system of the invention with a finger pick-up meter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. **1** an example planter or seeding machine **10** is shown containing the seed delivery system of the present invention. Planter **10** includes a tool bar **12** as part of a planter frame **14**. Mounted to the tool bar are multiple planting row units **16**. Row units **16** are typically identical for a given planter but there may be differences. A row unit **16** is shown in greater detail in FIG. **2**. The row unit **16** is provided with a central frame member **20** having a pair of upwardly extending arms **21** (FIG. **4**) at the forward end thereof. The arms **21** connect to a parallelogram linkage **22** for mounting the row unit **16** to the tool bar **12** for up and down relative movement between the unit **16** and toolbar **12** in a known manner. Seed is stored in seed hopper **24** and provided to a seed meter **26**. Seed meter **26** is of the type that uses a vacuum disk as are well known to meter the seed. Other types of meters can be used as well. From the seed meter **26** the seed is carried by a delivery system **28** into a planting furrow, or trench, formed in the soil by furrow openers **30**. Gauge wheels **32** control the depth of the furrow. Closing wheels **34** close the furrow over the seed. The gauge wheels **32** are mounted to the frame member **20** by arms **36**. The toolbar and row unit are designed to be moved over the ground in a forward working direction identified by the arrow **38**.

The row unit **16** further includes a chemical hopper **40**, a row cleaner attachment **42** and a down force generator **44**. The row unit **16** is shown as an example of the environment in which the delivery system of the present invention is used. The present invention can be used in any of a variety of planting machine types such as, but not limited to, row crop planters, grain drills, air seeders, etc.

With reference to FIG. **3**, the seed delivery system **28** is shown in greater detail. Delivery system **28** includes a housing **48** positioned adjacent the seed disk **50** of the seed meter. The seed disk **50** is a generally flat disk with a plurality of apertures **52** adjacent the periphery of the disk. Seeds **56** are collected on the apertures from a seed pool and adhere to the disk by air pressure differential on the opposite sides of the disk **50** in a known manner. The disk may have a flat surface at the apertures **52** or have seed cells surrounding the apertures **52**. The disk rotates clockwise as viewed in FIG. **3** as shown by the arrow **54**. At the top of FIG. **3**, seeds **56** are shown adhered to the disk.

The seed delivery system housing **48** has spaced apart front and rear walls **49** and **51** and a side wall **53** therebetween. An upper opening **58** in the housing side wall **53** admits the seed from the metering disk **50** into the housing. A pair of pulleys **60**, **62** are mounted inside the housing **48**. The pulleys support a belt **64** for rotation within the housing. One of the pulleys is a drive pulley while the other is an idler pulley. The belt has a base member **66** to engage the pulleys and elongated bristles **70** extending therefrom, The bristles are joined to the base member at proximal, or radially inner, ends of the bristles. Distal, or radially outer, ends **74** of the bristles touch, or are close to touching, the inner surface **76** of the housing side wall **53**. A lower housing opening **78** is formed in the side wall **53** and is positioned as close to the bottom **80** of the seed trench as possible. As shown, the lower opening **78** is near or below the soil surface **82** adjacent the trench. The housing side wall forms an exit ramp **84** at the lower opening **78**.

Returning attention to the upper portion of FIG. **3**, a loading wheel **86** is provided adjacent the upper opening **58**. The loading wheel is positioned on the opposite side of the seeds **56** from the brush **64** such that the path of the seeds on the disk brings the seeds into a nip **88** formed between the loading wheel and the distal ends **74** of the bristles **70**. At the location of the nip **88**, the air pressure differential across the seed disk **50** is terminated, freeing the seed from the apertures **52** in the disk. The bottom surface of the loading wheel, facing the seed disk **50**, has recesses **90** formed therein. The recesses **90** receive seed agitators **92** projecting from the seed disk **50**. The moving agitators, by engagement with the recesses in the loading wheel, drive the loading wheel in a clockwise rotation.

In operation, the belt **64** is rotated in a counterclockwise direction. As the belt curves around the pulleys, the bristles will naturally open, that is, separate from one another as the distal ends of the bristles travel a larger circumferential distance around the pulleys than the inner ends of the bristle at the belt base member. This produces two beneficial effects as described below. The seeds are transferred from the seed meter to the delivery system as the seeds are brought by the disk into the nip **88**. There the seeds are pinched off the seed disk between the loading wheel and the bristles **70** to remove the seed from the seed disk and seed meter. The seeds are captured or entrapped in the bristles by insertion of the seed into the bristles in a radial direction, that is from the ends of the bristles in a direction parallel to the bristle length. This occurs just as the belt path around the pulley **60** ends, when the bristle ends are closing back together upon themselves, allowing the bristles to close upon, and capture the seeds therein. As the belt continues to move, the bristles move or convey the seeds downward to the housing lower opening. The side wall **53** of the housing cooperates with the bristles **70** to hold the seed in the brush bristles as the seed is moved to the lower opening.

The lower opening **78** and the ramp **84** are positioned along the curved belt path around the pulley **62**. The bristle distal ends thus cause the linear speed of the seeds to accelerate relative to the speed of the belt base member **66** and the housing as shown by the two arrows **94** and **96**. The seeds are then propelled by the bristles over the ramp **84** and discharged through the lower opening **78** into the seed trench. The angle of the ramp **84** can be selected to produce the desired relationship between the seed vertical and horizontal speeds at discharge. The forward travel direction of the row unit is to the left in FIG. **3** as shown by the arrow **38**. At the discharge, the horizontal speed of the seed relative to the ground is minimized to reduce roll of the seed in the trench.

The belt shown in FIG. **3** has relatively long bristles. As a result of the long bristles and the seed loading point being at the end of the curved path of the brush around the pulley **60** results in the seeds being loaded into the belt while the bristles have slowed down in speed. The bristle speed at loading is thus slower than the bristle speed at the discharge opening as the belt travels around the pulley **62**. This allows in the seed to be loaded into the belt at a relatively lower speed while the seed is discharged at the lower end at a desired higher speed. As described above, it is preferred that the horizontal velocity of the seed at the discharge be equal to the forward travel speed of the planter but in the rearward direction such that the horizontal velocity of the seed relative to the ground is close to or equal to zero. The long bristles can be used to increase the speed of the seed as it

travels around the pulley. However, a short bristle brush can be used as well. With a short bristle brush, there will be little acceleration in the speed of the seed as the seed travels around the pulleys. The belt will have to be driven at a speed to produce the desired horizontal velocity of the seed at the discharge. Even with a short bristle brush, the seed is still accelerated in the horizontal direction. As the belt travels around the pulley, the direction of travel of the seed changes from the predominantly vertical direction, when the seed is moved downward from the seed meter, to a predominantly horizontal direction at the discharge. This produces an acceleration of the seed velocity in the horizontal direction.

With the delivery system **28**, the seed is captured by the delivery system to remove the seed from the seed meter. The seed is then moved by the delivery system to the seed discharge point where the seed is accelerated in a rearward horizontal direction relative to the housing. From the seed meter to the discharge, the seed travel is controlled by the delivery system, thus maintaining the seed spacing relative to one another.

In the embodiment shown in FIG. **3**, the seed disk and the front and rear walls **49**, **51** of the housing **48** lie in planes that are generally parallel one another. As shown, the plane of the delivery system is generally parallel to the direction of travel of the row unit. Other relationships between the seed meter and delivery system are shown and described below.

As shown in FIG. **3**, the side wall **53** is divided by the upper and lower openings **58**, **78** into two segments, **53***a* and **53***b*. Segment **53***a* is between the upper and lower openings in the direction of belt travel while the segment **53***b* is between the lower and upper openings in the direction of belt travel. It is the gaps in the side wall **53** that form the upper and lower openings. It should be understood, however, that the delivery system will function without the segment **53***b* of the side wall. It is only the segment **53***a* that functions together with the belt bristles to deliver the seed from the meter to the seed trench. Thus, the term "upper opening" shall be construed to mean a open area before the side wall segment **53***a* in the direction of belt travel and the term "lower opening" shall mean an open area after the side wall segment **53***a* in the direction of belt travel.

With reference to FIGS. **4-7**, the delivery system **28** is shown in combination with the seed meter and row unit structure in an alternative arrangement of the seed meter and delivery system **28**. The seed meter **200** is shown mounted to the row unit with the seed disk **202** in a vertical orientation but at an angle to the forward travel direction shown by the arrow **38**. FIG. **4** shows of the seed meter orientation in the row unit without the delivery system **28**. The seed meter includes a housing having two halves **204** and **206** releasable joined together in a known manner. The seed meter is driven through a transmission **208** coupled to a drive cable, not shown.

In FIG. **5** only the seed disk **202** of the meter is shown with the seed delivery system **28**. As previously mentioned, the seed disk **202** is in a vertical orientation but it does not lie in a plane parallel to the forward direction **38**. Instead, the meter is oriented such that the disk is at a 60° angle relative to the forward direction when viewed from above. The seed of delivery system **28** is generally identical to that shown in FIG. **3** and is driven by a motor **65**. The delivery system, including of the brush belt **64**, is generally vertical and aligned with the fore and aft direction of the planter such that the angle between the brush and the seed disk is approximately 60°. The angle between the delivery system and a seed disk produces a partial "cross feed" of the seed into the brush. That is, the seed is fed into the brush at an angle to the lengthwise direction of the bristles. This is in contrast to FIG. **3** where the seed enters the brush in a direction substantially parallel to the lengthwise direction of the brush bristles. If the brush and seed disk were oriented at 90° to one another, a total cross feed would be produced with seed entering the brush perpendicular to the bristles.

The seed disk **202** is shown enlarged in FIGS. **7** and **8**. The disk **202** has opposite sides, a vacuum side **216** and seed side **218**. The seed side **218** has a surface **219** near the periphery that defines a reference plane. The reference plane will be used to describe the features of the disk near the disk periphery. An outer peripheral lip **220** is recessed from the reference plane. The peripheral lip **220** creates a radially outward edge face **222**. A circumferential row of spaced apart apertures **224** is arranged around a circular path radially inward of the edge face **222**. Each aperture extends through the disk between the vacuum side **216** and the seed side **218**. Radially inward of each aperture **224**, there is a radially elongated recess **226**. The recess **226** is recessed axially into the disk from the reference plane. In operation, the disk rotates in a counterclockwise direction as indicated by the arrow **228**. During rotation, the recesses **226** agitate the seed in the seed pool.

Surrounding each aperture **224** is a tapered recess, or shallow seed cell, **232** that extends axially into the disk from the reference plane. Seed cell **232** begins at a leading edge **234** in the direction of rotation of the disk and is progressively deeper into the seed side **218** to a trailing edge formed by an axially projecting wall **236**. The tapered recess or seed cell **232** reduces the vacuum needed to pick-up and retain seed in the apertures **224**. The seed cell also enables the seed to sit lower relative to the seed side **218** of the disk, allowing the seed to be retained while the seed singulator removes doubles or multiples of seed from the apertures **224**. In addition, the recess wall **236** agitates seed in the seed pool, further aiding in seed pick-up. The wall **236** extends lengthwise in a predominately radial direction as shown by the dashed line **238**. The walls **236**, while predominately radial, are inclined to the radial direction such that the inner end of the wall **236** is leading the outer end of the wall in the direction of rotation. Immediately following each wall **236**, as the disk rotates, is a projection, or upstanding peg **240** extending axially from the disk seed side. The pegs engage seed in the seed pool for agitation to aide in seed pick-up. The pegs **240** are located slightly radially inward of the circular path of apertures **224** to avoid interference with the seed singulator.

With reference to FIG. **8**, the disk **202** is shown in operation and in position relative to the belt **64** in the delivery system **28**. As seeds **244** are carried by the disk **202** into the bristles of the brush **64**, the wall **236** and the pegs **240** act to push the seed **244** into the bristles of the brush **64** and assist in keeping the seed from being knocked off the disk upon the seed's initial contact with the brush bristles. Once the seed is inserted into the brush bristles, the vacuum from the opposite side of the disk is cut-off, allowing the brush to sweep the seed off the disk in a predominately radial direction relative to the disk. An insert **246** overlies the lip **220** at the point of seed release to hold the seed in the brush bristles in the transition between the disk and the side wall **53** (FIG. **3**) of the delivery system housing. The disk **202** is inclined to the length of the brush bristles at approximately a 60 degree angle. This produces the partial cross-feed of the seed into the brush bristles.

FIG. **9** shows the brush belt seed delivery system **28** in combination with a vacuum belt metering system having a metering belt **302**. The vacuum belt meter is fully described

in U.S. Pat. No. 7,918,168 incorporated herein by reference. The belt **302** picks-up seed at a pick-up region **304** at a lower, front location of the belt's path and transports it to the delivery system at a release region **306** at an upper, rear location of the belt's path. In this arrangement of the belt meter and the brush delivery system, the delivery system is again partially cross fed with seeds from the meter.

Another arrangement of the delivery system together with a vacuum meter belt is shown in FIG. **10**. The delivery system **28** is in-line with the belt meter **124**. This allows the distal ends of the brush bristles to sweep over the surface of the metering belt **126** to capture the seed therefrom. The meter belt **126** is wrapped around pulleys **128**. The metering belt **124** is similar and functions as the belt **302** mentioned above.

The delivery system of the present invention can also be used with seed meters other than air pressure differential meters. For example, with reference to FIG. **11**, a finger pick-up meter **130** is shown, such as that described in U.S. Pat. No. 3,552,601 and incorporated herein by reference. Seed is ejected from the meter through an opening **132**. The delivery system **134** has a brush belt **136** wrapped about pulleys **138** and **140**. As shown, the belt pulley **138** shares a common drive shaft with finger pick-up meter **130**. A hub transmission such as a spherical continuously variable transmission or a three speed hub can be used to drive the belt **136** at a different speed from the meter **130**. The delivery system housing includes a side wall **142**. A ramp **146** is formed at the lower end of the wall **142** adjacent the lower opening **148**. At the upper end of the delivery system, the upper opening is formed in the housing rear wall adjacent the opening **132** through which seeds are ejected from the seed meter. The seeds are inserted laterally into the brush bristles in a complete cross-feed. As in the other embodiments, the seed is captured in the brush bristles, moved downward to the lower opening, accelerated rearward and discharged through the lower opening **148**.

The endless member of the delivery system has been described as being a brush belt with bristles. In a broad sense, the bristles form an outer periphery of contiguous disjoint surfaces that engage and grip the seed. While brush bristles are the preferred embodiment, and may be natural or synthetic, other material types can be used to grip the seed such as a foam pad, expanded foam pad, mesh pad or fiber pad.

Having described the preferred embodiment, it will become apparent that various modifications can be made without departing from the scope of the invention as defined in the accompanying claims.

The invention claimed is:

1. A seed delivery apparatus comprising:

an elongated housing having a first opening through which seed is received into the seed delivery apparatus, a second opening through which seed exits the seed delivery apparatus, and an elongated interior chamber along which seed is conveyed from the first opening to the second opening; and

an endless member positioned within the elongated housing, the endless member movable within the elongated interior chamber of the elongated housing to receive seed from the first opening and convey seed to the second opening, the endless member shaped to maintain contact with a top of each seed conveyed by the endless member along the elongated interior chamber between the first and second openings of the elongated housing.

2. The seed delivery apparatus of claim **1**, wherein the endless member is movable about at least two rotatable members.

3. The seed delivery apparatus of claim **1**, wherein the endless member is elongated and moves seed along a path from a first elevation adjacent the first opening to a second elevation lower than the first elevation and adjacent the second opening.

4. The seed delivery apparatus of claim **3**, wherein the path includes a substantially straight portion along which the seed remains stationary with respect to that portion of the endless member within which the seed is received.

5. The seed delivery apparatus of claim **3**, wherein in at least a portion of the path, the endless member accelerates seed received therein.

6. The seed delivery apparatus of claim **1**, wherein bristles of the endless member maintain contact with a top of each seed conveyed by the endless member.

7. The seed delivery apparatus of claim **1**, wherein the endless member is also shaped to maintain contact with a bottom of each seed conveyed by the endless member along the elongated interior chamber between the first and second openings of the elongated housing.

8. A seed delivery apparatus comprising:

an elongated housing having a first opening through which seed is received into the seed delivery apparatus, a second opening through which seed exits the seed delivery apparatus, and an elongated interior chamber along which seed is conveyed from the first opening to the second opening; and

an endless member positioned within the elongated housing, the endless member shaped and positioned to receive seed from the first opening, the endless member also movable to push the seed along the elongated interior chamber of the elongated housing toward the second opening.

9. The seed delivery apparatus of claim **8**, wherein the endless member is movable about at least two rotatable members.

10. The seed delivery apparatus of claim **8**, wherein the endless member is elongated and moves seed along a path from a first elevation adjacent the first opening to a second elevation lower than the first elevation and adjacent the second opening.

11. The seed delivery apparatus of claim **10**, wherein the path includes a substantially straight portion along which the seed remains stationary with respect to that portion of the endless member within which the seed is received.

12. The seed delivery apparatus of claim **10**, wherein in at least a portion of the path, the endless member accelerates seed received therein.

13. The seed delivery apparatus of claim **8**, wherein bristles of the endless member push the seed along the elongated interior chamber of the elongated housing toward the second opening.

14. The seed delivery apparatus of claim **8**, wherein the endless member is also shaped to push the seed out of the endless member and out of the second opening of the elongated housing.

15. A method of delivering a seed from a seed meter to a furrow, the method comprising:

receiving the seed through a first opening defined in a housing;

receiving the seed within an endless member in the housing at a first elevation;

driving the endless member about at least two axes spaced apart from one another;

pushing the seed downward to a second elevation lower than the first elevation by driving the endless member;

discharging the seed from the endless member at the lower elevation; and

discharging the seed from a second opening defined in the housing.

16. The method of claim **15**, wherein driving the endless member comprises moving the endless member along a path having a substantially straight portion; the method further comprising maintaining the seed stationary with respect to that portion of the endless member within which the seed is received while moving through the substantially straight portion.

17. The method of claim **15**, wherein pushing the seed downward comprises conveying the seed at a first velocity, the method further comprising accelerating the seed to a second velocity greater than the first velocity.

18. The method of claim **17**, wherein accelerating the seed to the second velocity occurs immediately prior to discharging the seed from the endless member.

19. The method of claim **17**, wherein accelerating the seed to the second velocity comprises moving the seed about one of the two axes.

20. The method of claim **15**, wherein the endless member is a bristle belt.

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