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(54) **AIR ENTRAINMENT DEVICE FOR SEED DELIVERY**

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This patent is subject to a terminal disclaimer.

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**Related U.S. Application Data**

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**A01C 7/04** (2006.01)

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CPC ..... **A01C 7/084** (2013.01); **A01C 7/042** (2013.01); **A01C 7/081** (2013.01); **A01C 7/082** (2013.01)

(58) **Field of Classification Search**

CPC ..... **A01C 7/084**; **A01C 7/081**; **A01C 7/08**;  
**A01C 7/00**; **A01C 7/042**; **A01C 7/04**;  
**A01C 7/082**

See application file for complete search history.

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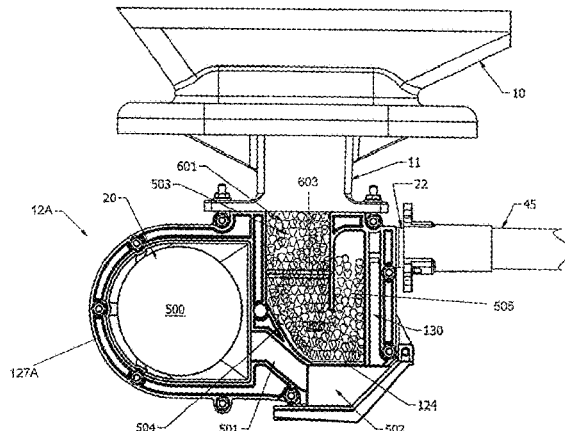
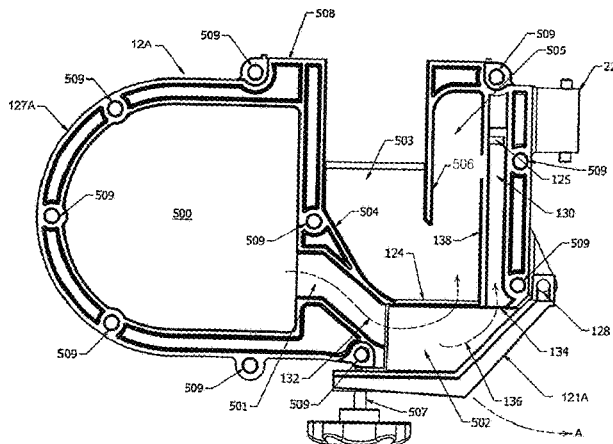
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(57) **ABSTRACT**

A seed delivery device including a frame defining at least one seed chamber. The frame includes a sidewall and an air permeable floor. Seed can be received and deposited on the air permeable floor through an input port. An air input channel is utilized to introduce an air stream into the seed chamber and direct it through the air permeable floor such that seed is lifted from the air permeable floor to an outlet port. An air bypass channel is configured to separate the air stream into a first stream that is directed through the air permeable floor and a second stream that is directed through the bypass channel and recombined with the first stream, at a point prior to the output port.

**20 Claims, 8 Drawing Sheets**



**Related U.S. Application Data**

continuation of application No. 12/829,654, filed on Jul. 2, 2010, now Pat. No. 8,448,585.

(60) Provisional application No. 61/222,792, filed on Jul. 2, 2009.

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FIG. 1

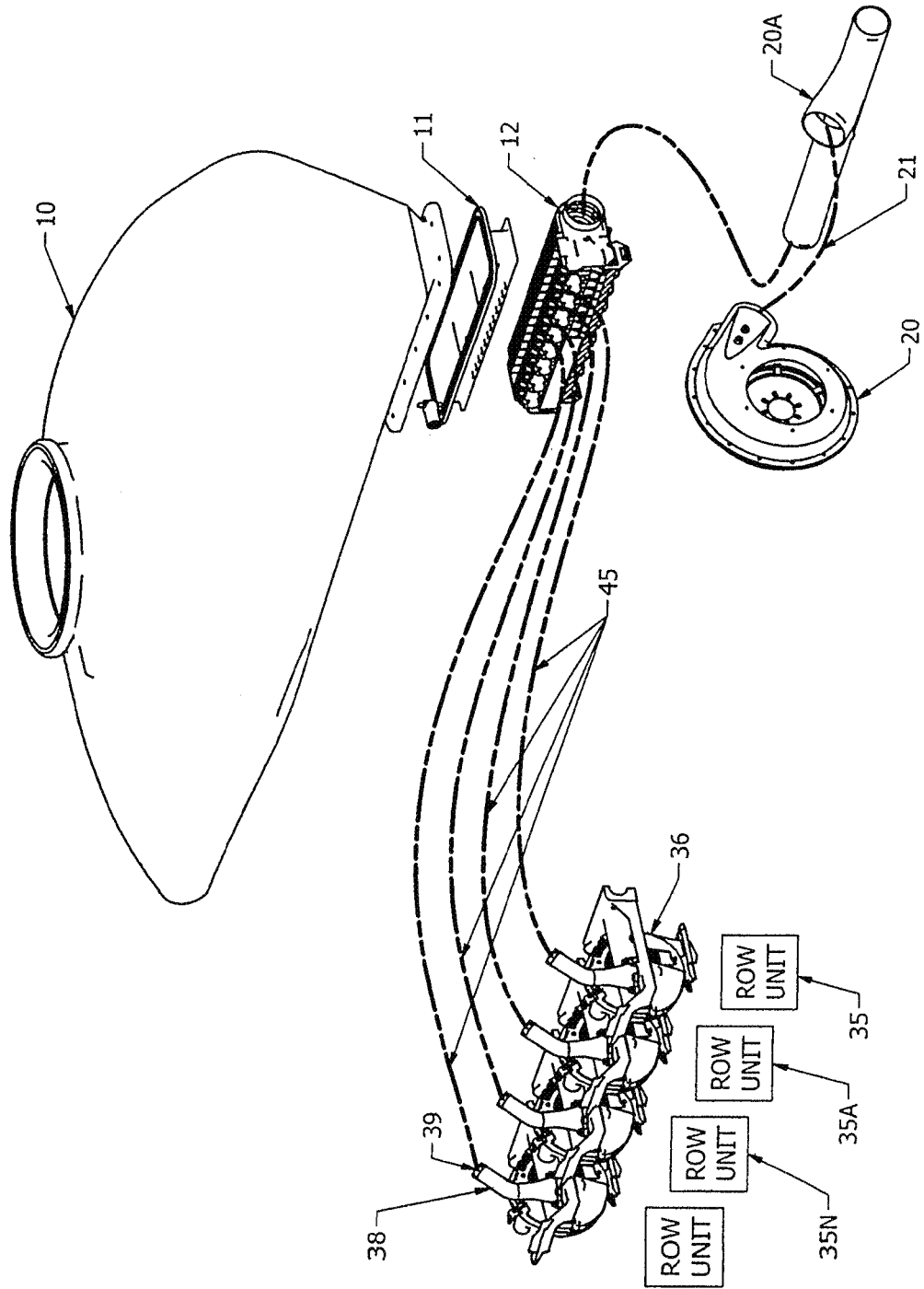


FIG. 2

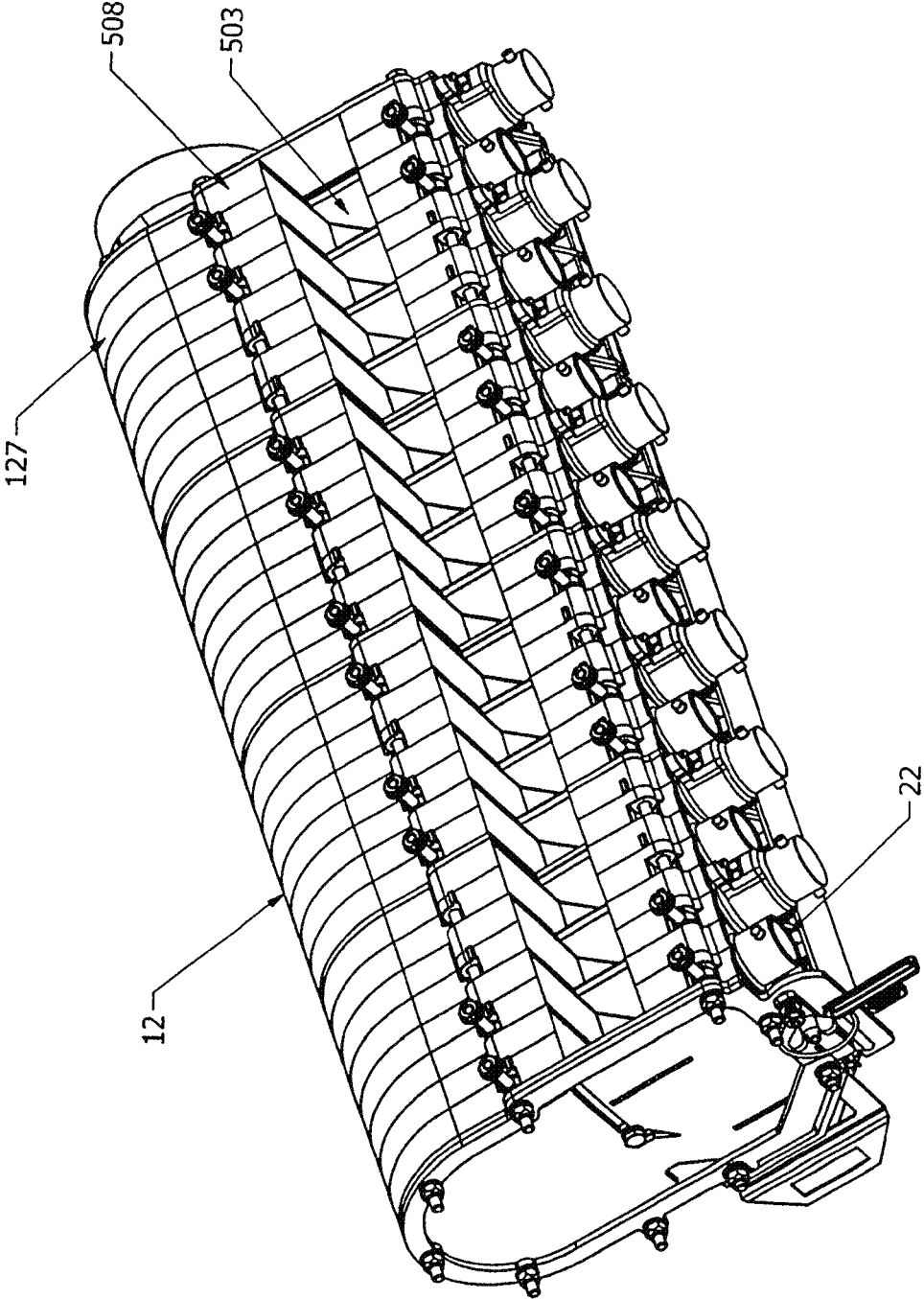


FIG. 3

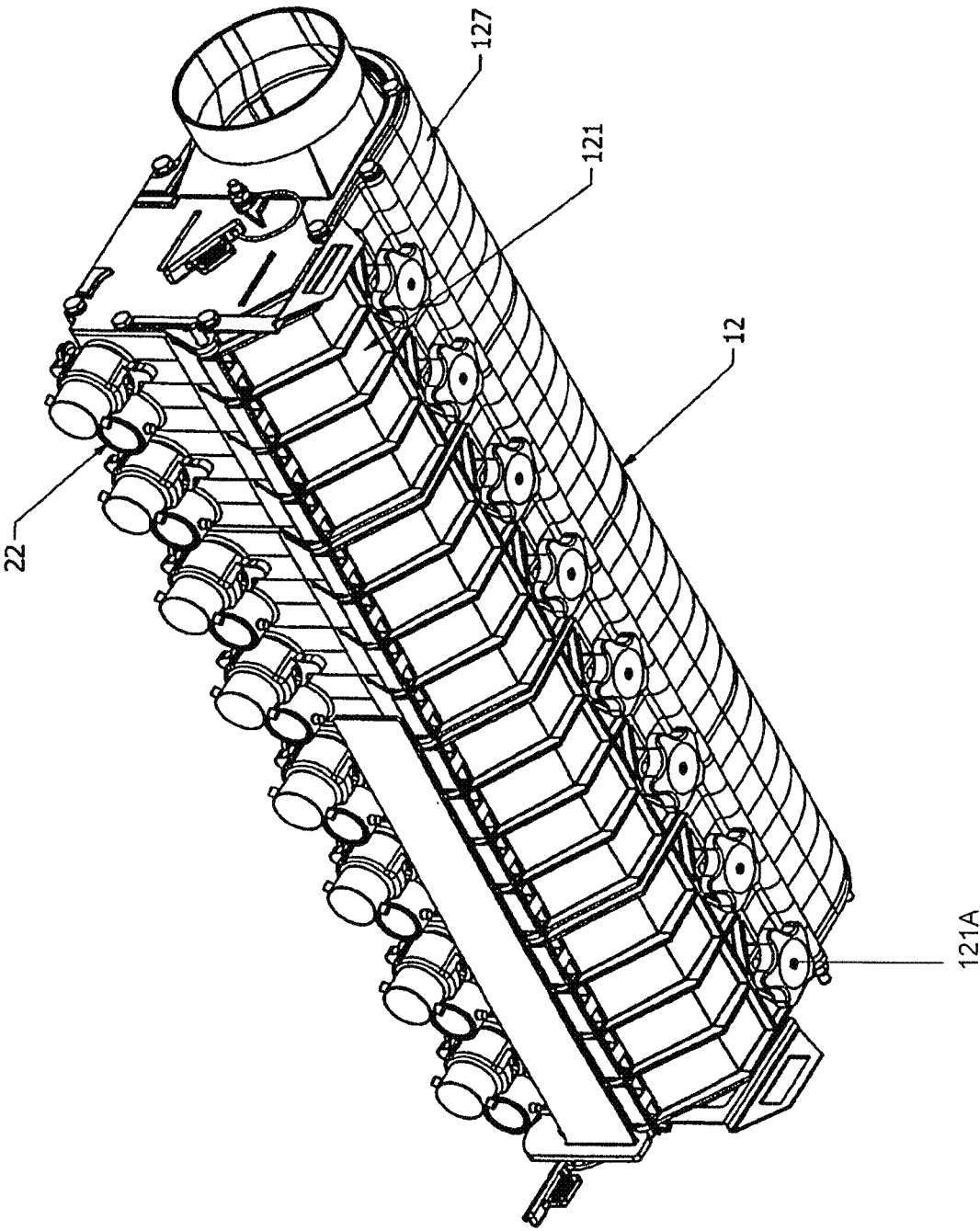


FIG. 4

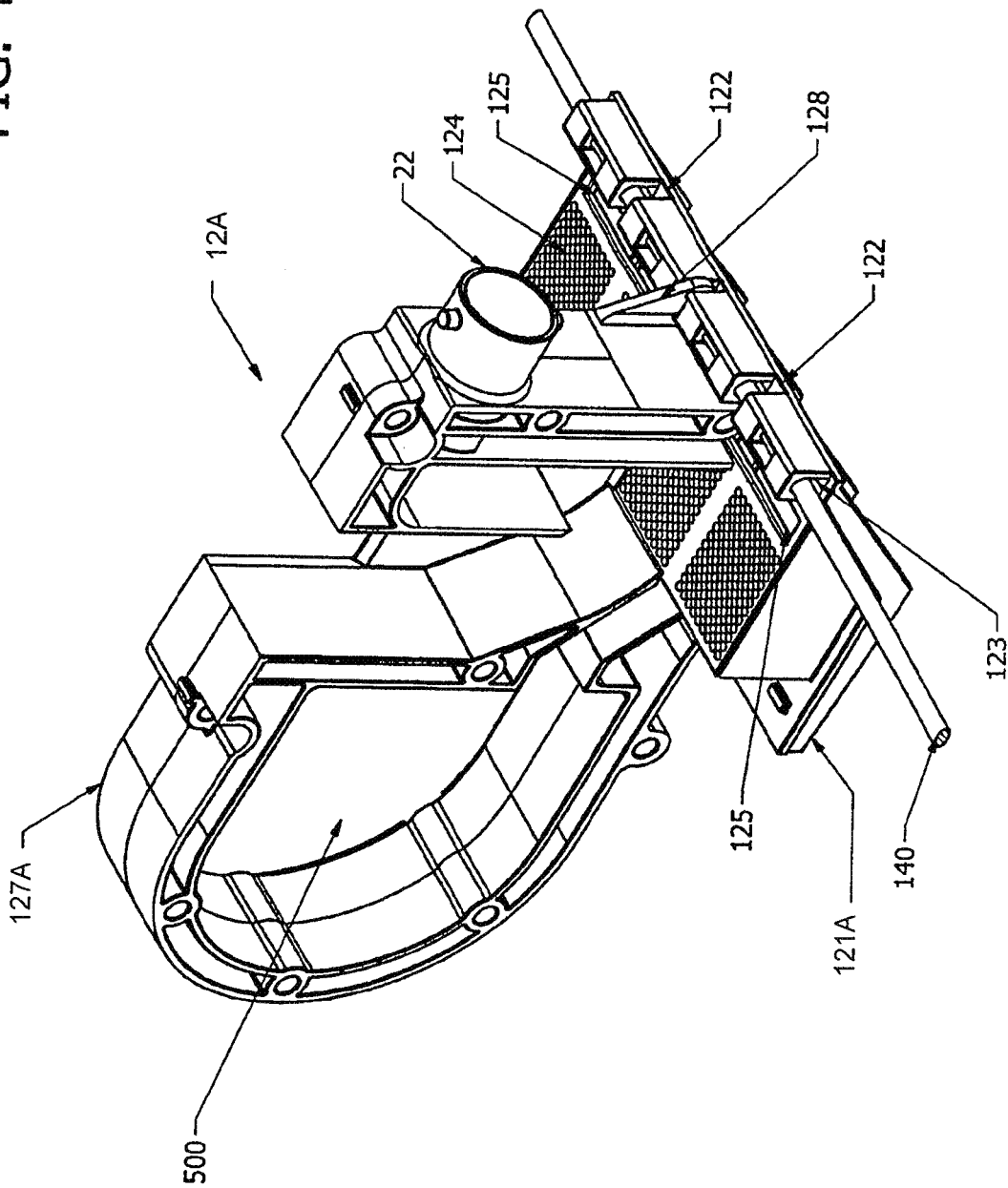


FIG. 5

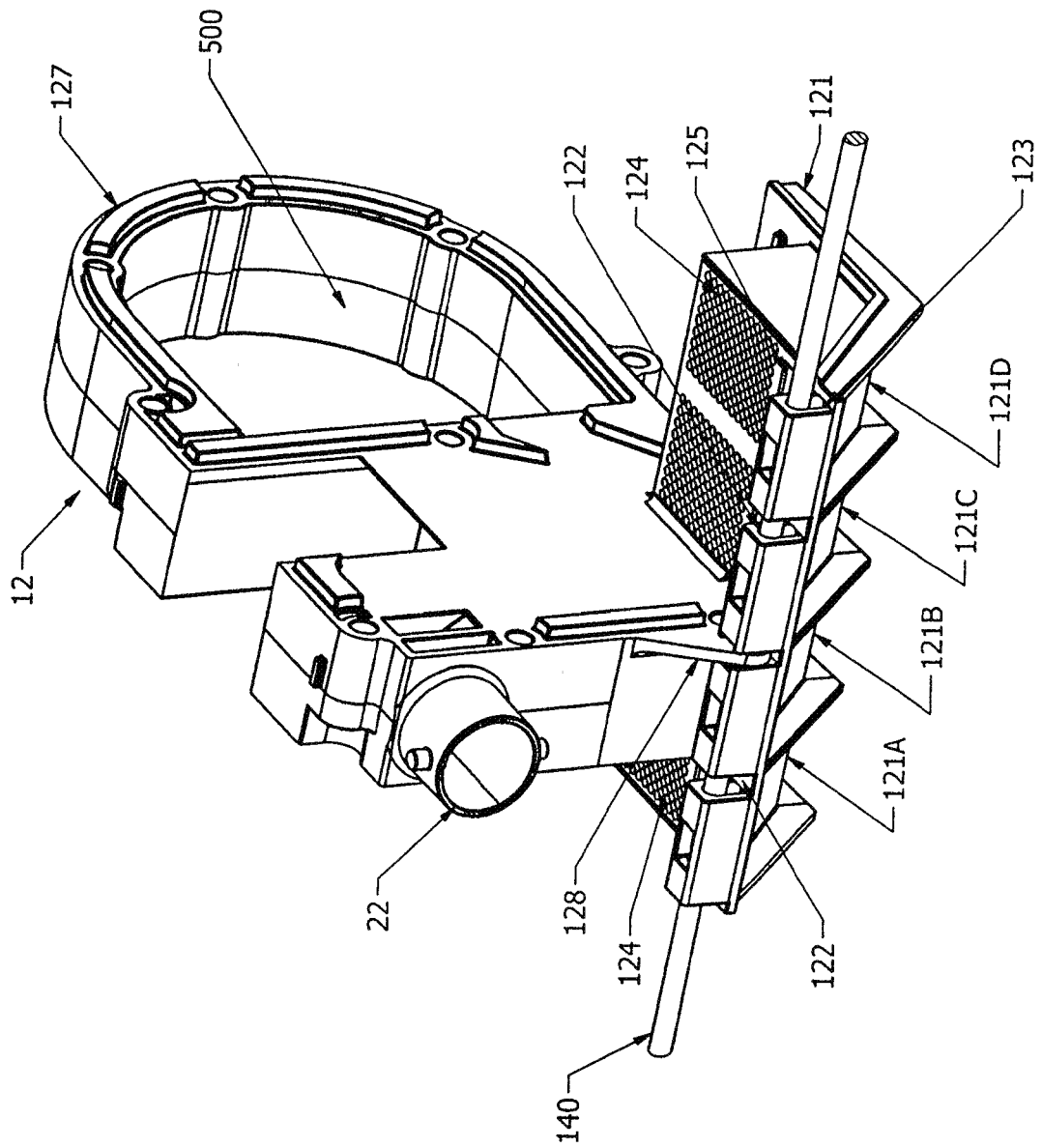
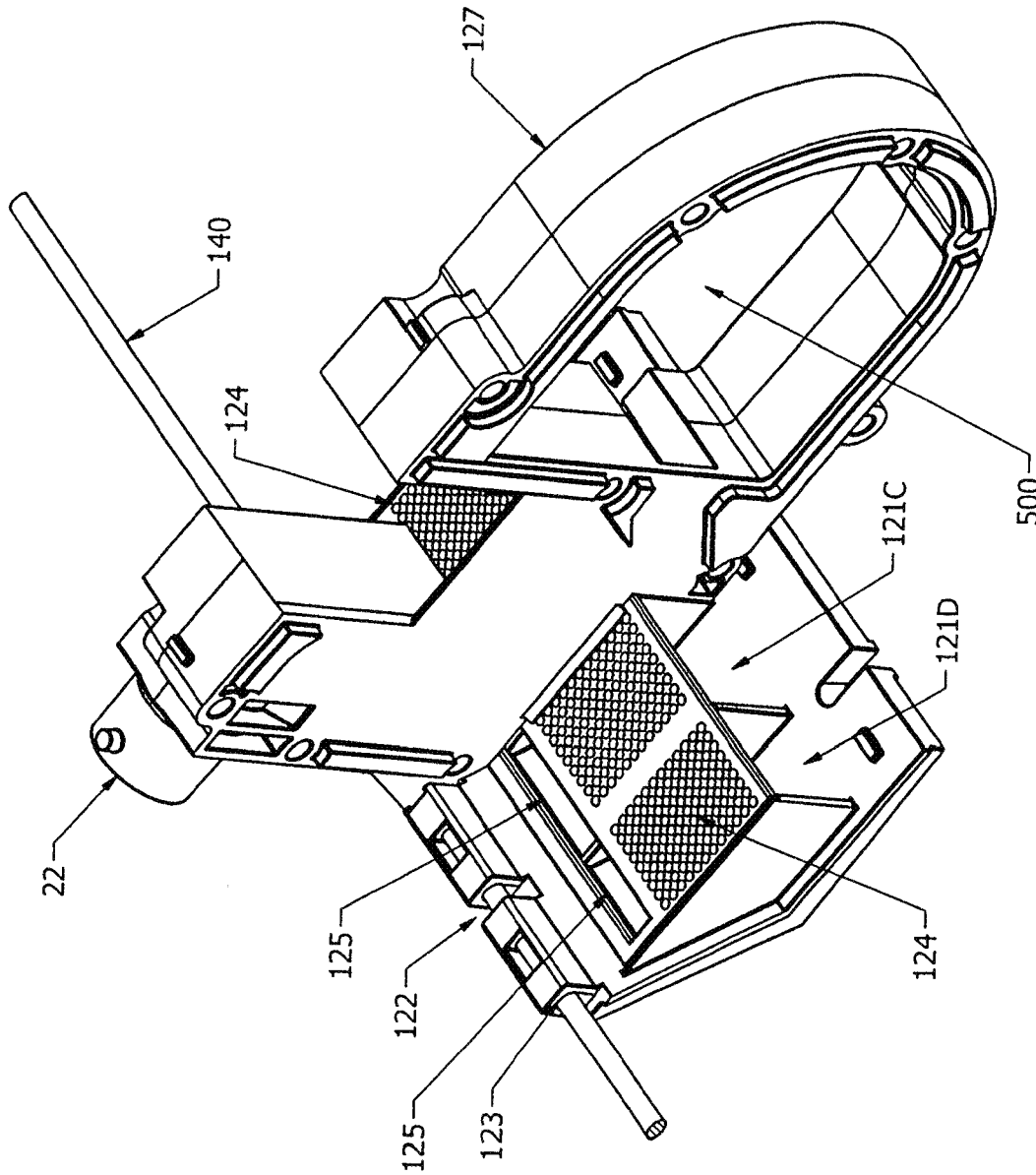


FIG. 6





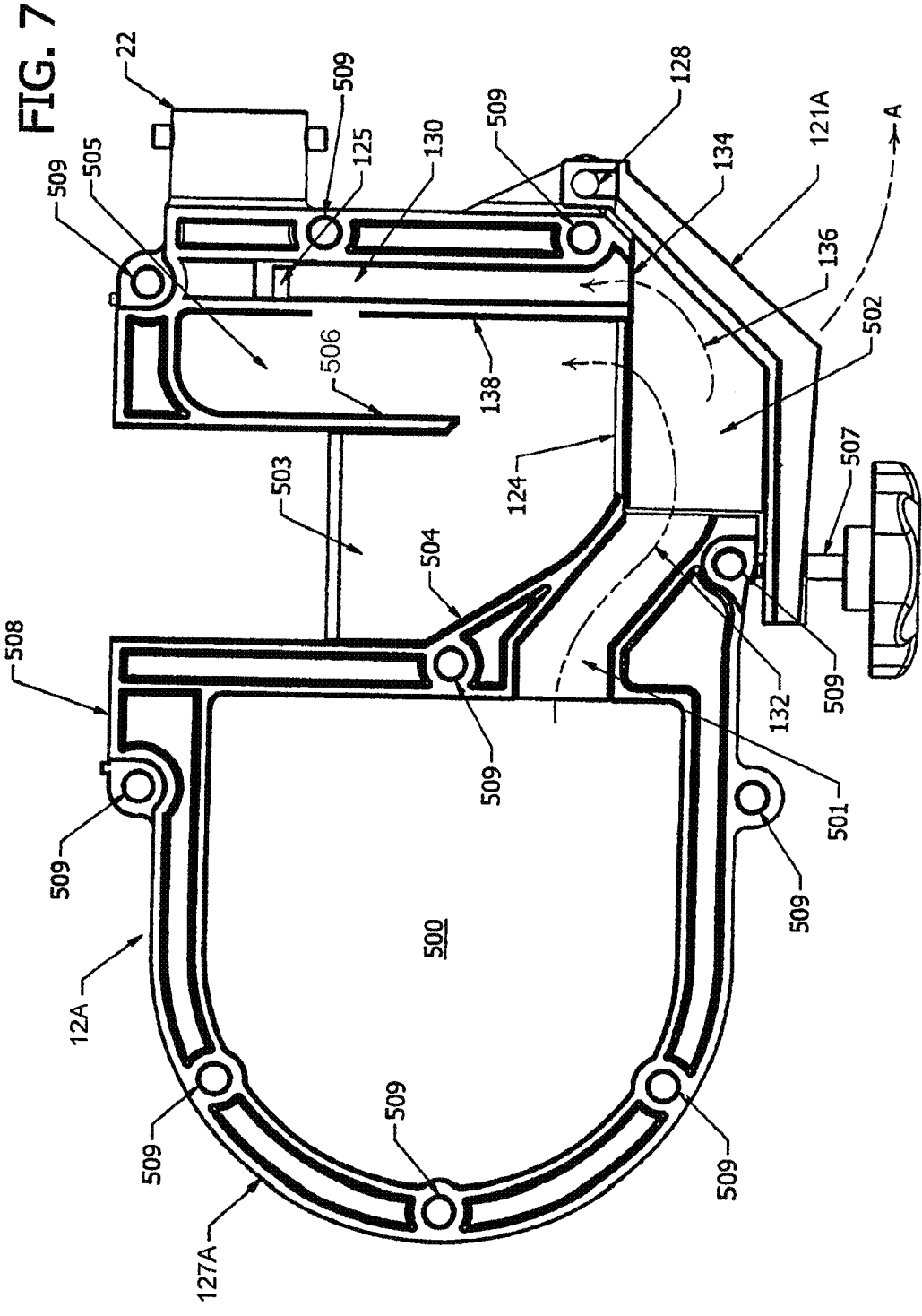
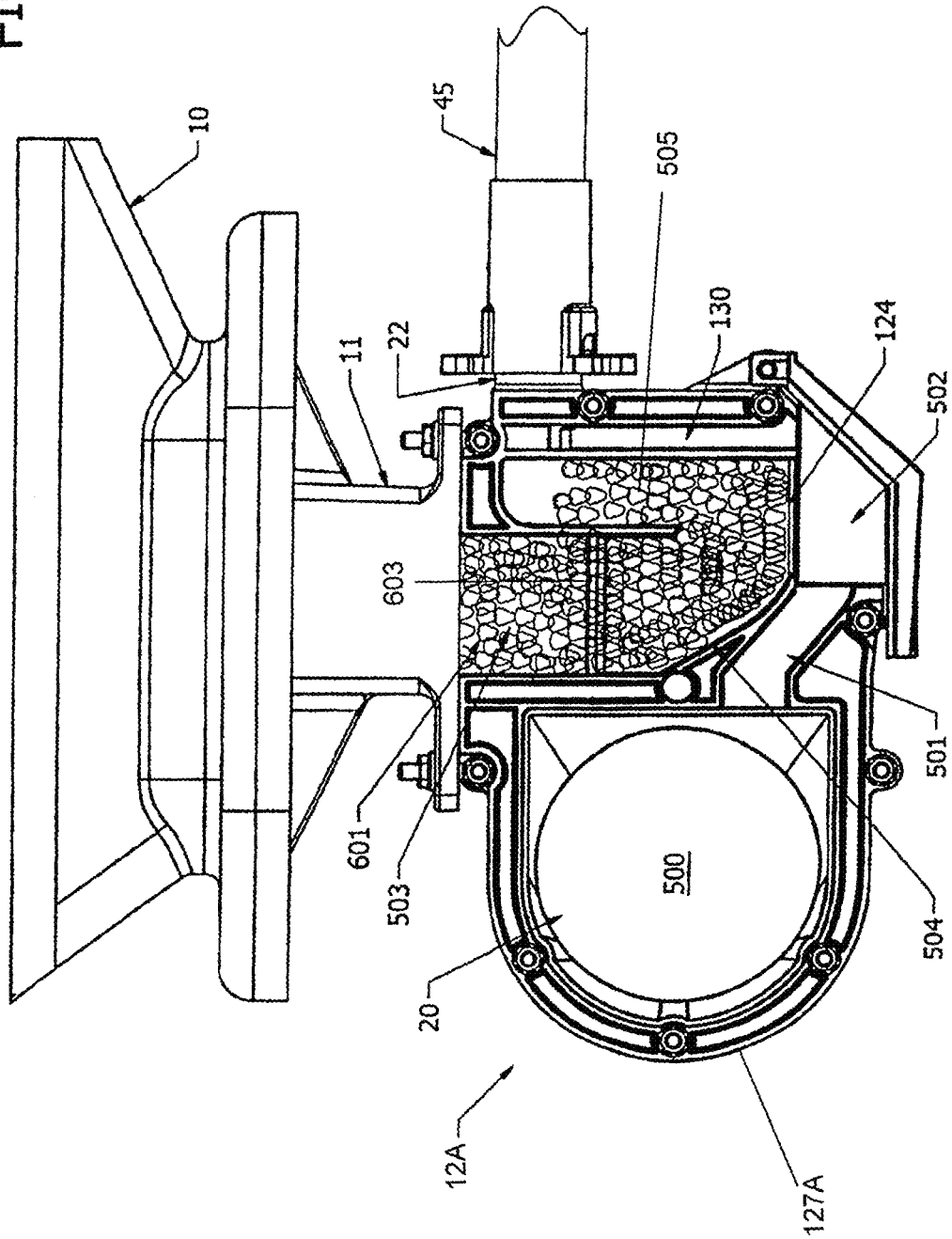


FIG. 8



## AIR ENTRAINMENT DEVICE FOR SEED DELIVERY

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. patent application Ser. No. 14/984,595, filed on Dec. 30, 2015, which is a continuation of U.S. patent application Ser. No. 13/858,876, filed Apr. 8, 2013, now U.S. Pat. No. 9,253,940, issued Feb. 9, 2016, which is a continuation of U.S. patent application Ser. No. 12/829,654, filed Jul. 2, 2010, now U.S. Pat. No. 8,448,585, issued May 28, 2013, which claims priority to U.S. Provisional Patent Application No. 61/222,792, filed Jul. 2, 2009, all of which are hereby incorporated by reference in their entirety.

### BACKGROUND OF THE INVENTION

Large scale agricultural planters typically include a plurality of individual hoppers and seed metering units. During planting, the hopper holds the mass of seed that the planter distributes onto the ground. The metering units are responsible for delivering the seed to the ground. As the planter moves over the planting surface, it is important that the metering units distribute the seed uniformly and at precise intervals to achieve proper spacing of crops. To achieve such a distribution it is important that the supply of seed to the seed meters is steady and uninterrupted. Accordingly, an apparatus for transporting seed from the hopper to the metering units is the subject of the present application.

Other features and advantages of the present invention will be apparent to those skilled in the art from the following detailed description of the illustrated embodiments, accompanied by the attached drawing wherein identical reference numerals will be used for like parts in the various views.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective diagram, partly in schematic form, of an air seed delivery system incorporating an air entrainment device in accordance with the present invention;

FIG. 2 is an upper perspective view of plural air entrainment devices employed in the system of FIG. 1;

FIG. 3 is a lower rear perspective view of plural air entrainment devices employed in the system of FIG. 1;

FIG. 4 is an upper left rear perspective view of an air entrainment device shown in FIGS. 2 and 3;

FIG. 5 is an upper right rear perspective view of an air entrainment device shown in FIGS. 2 and 3;

FIG. 6 is an upper front right perspective view of the inventive air entrainment device;

FIG. 7 is a lengthwise vertical sectional view of an air entrainment device in accordance with the present invention;

FIG. 8 is a side elevation view shown partially in section illustrating the attachment of the inventive air entrainment device to a seed hopper and the location of seeds transiting the air entrainment prior to delivery to a seed meter.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, reference numeral 10 designates a central or main seed hopper for an agricultural row crop planter. In FIG. 1, the planter's forward direction of travel is toward the upper right. The hopper 10 stores seed and feeds it through a lower distribution tray 11 (which may be

elongated laterally and mounted to the bottom of the hopper housing) under gravity. The seed is delivered directly from the distribution tray 11 to one or more air entrainment devices in an air entrainment assembly 12. The function of the air entrainment assembly 12, as described in more detail below, is to receive and distribute seed from the hopper 10 to individual seed meters 36, as will be further described below. The seed meters 36 may be conventional air seed meters, for example, the meter disclosed in U.S. Pat. Nos. 7,093,548 and 7,152,542, but other air seed meters may be used, as well, and mechanical seed meters may also be used with the present invention.

The seed meters 36 are integral with conventional planter row units schematically represented at 35, 35A . . . 35N. Thus, the seed meters 36 and row units need not be described in further detail for a complete understanding of the instant invention.

The system can be set up such that the air entrainment assembly 12 has an individual outlet conduit 45 for each individual air seed meter 36. Thus, persons skilled in the art will fully understand the invention, and all its modifications by understanding one air entrainment device 12A and its associated distribution and usage.

As shown in FIG. 1, a fan 20, or other source of pressurized air, forces air through conduit 21 (shown diagrammatically as a line, for simplicity). As explained, the conduit 21 could be a single conduit (as illustrated) or a number of separate conduits, all coupled to the same source of pressurized air, or if there are a number of seed delivery conduits, they also could be grouped so that one or more individual seed delivery conduits could be fed by a single source of pressurized air. Similarly, plural sources of pressurized air could be used with plural seed delivery conduits and seed meters.

One feature of the present invention is the flexibility with which desired systems could be arranged, without substantial increase in costs and with use of standardized, interchangeable sub-assemblies and components.

Still referring to FIG. 1, the blocks 35, 35A, 35N represent individual planter row units which may be conventional, each including a seed meter adapted to receive a seed delivery inlet assembly, such as the one designated 38. The seed meter 36 may be of the type disclosed in the above-identified U.S. patents. A seed inlet assembly 38 is mounted to and provides each individual seed meter 36 with seed. Each inlet assembly 38 includes an input port 39 that is connected to conduit 45. Seed is delivered to the seed reservoir of each meter 36 through an input port 39 within the seed inlet assembly.

As further shown in FIG. 1, fan 20 is connected by a manifold 20A by a means of a hose or conduit diagrammatically shown at 21. Manifold section 20A has plural outlet ports one of which is connected to an input of an associated section of the air entrainment assembly 12. The air source 20 may feed additional manifold sections, as persons skilled in the art will appreciate. The manifold sections 20A may comprise a single, integral conduit feeding pressurized air to all outlets in common. Each manifold section 20A feeds an associated air entrainment assembly 12 as will be described presently, depending on the size of the planter. Each air entrainment assembly 12 has a plurality of outlets each connected to a respective conduit 45 for providing seed under pressure to plural seed meters 36.

Referring to FIGS. 2 and 3, upper and lower perspective views of an exemplary air entrainment assembly frame 12 are respectively shown for illustrative purposes. Air entrainment assembly 12 includes a base assembly 121 and an air

distribution assembly 127. In the embodiment shown, base assembly 121 includes eight bases 121A-121H which are each shaped and configured to receive a respective air entrainment device 12A and an air distribution unit 127. Base assembly 121 may include more or less than eight bases, each adapted for attachment to a respective air distribution assembly and air entrainment device. Only one base assembly 121 is shown in the figures for simplicity. It should be noted, however, that base assembly 121 could include more or less bases and each base could include a corresponding air entrainment device depending on need. Each base is in communication with one or more air distribution assemblies 127 attached to that base.

Referring further to FIG. 4, there is shown an upper perspective view of an individual air entrainment device 12A in accordance with the present invention. Base 121 of air entrainment device 12A includes plural spaced recesses 122 in an upper portion of the air entrainment device. Each recess 122 is shaped and configured to receive a hinge portion 128 of distribution assembly 127. A screw or pin 140 is inserted through aligned apertures 123 disposed in an upper portion of base 121. The screw or pin 140 spans each recess 122 and engages a corresponding hinge portion 128 to secure base 121 to the air entrainment device 12A. Further, the hinged relationship allows base to be rotated downwardly about the connecting pin 140 to provide clean-out access for air entrainment device 12A.

Referring also to FIG. 4 as well as to FIGS. 5 and 6, which are also upper perspective views of air entrainment device 12A, additional details of the invention will now be described. Air under pressure is introduced into an air manifold 500 of the air entrainment device 12A. The air manifolds of adjacent air entrainment devices 12A are aligned with one another and form a common air distribution assembly 127 (described above) for plural air entrainment devices attached to a common base 121A. Each base 121A includes an air permeable surface or floor, such as a perforated surface 124. As will be described further herein, seed is distributed to air entrainment device 12 from hopper 10 through a seed conduit. The seed falls onto perforated surface 124. When air entrainment device 12A is operational, air flows through perforated surface 124 in the direction of arrow 132 shown in the sectional view of the air entrainment device of FIG. 7. The properties of the perforated surface 124 and the air flow cause agitation of the seeds. This agitation causes mixing and lifting of the seeds into the air flow passing through air entrainment device 12A for discharge through outlet port 22. The dimensions of perforated surface 124 can vary depending on the desired air flow and the seed transported through the air entrainment device 12A. However, openings 0.125 inch in diameter in perforated surface 124 have been shown to be effective. Similarly, the shape of the perforations in the surface 124 can vary, but substantially circular perforations have been shown to be effective.

Air entrainment device 12 further includes an air bypass channel 130 running therethrough as shown in the sectional review of FIG. 7. Air is introduced into the air bypass channel 130 via opening 134 at the lower end of the bypass channel as shown by arrow 136 in FIG. 7. The air bypass channel 130 exits into outlet port 22 via bypass outlets 125. An inner partition 138 within air entrainment device 12A separates the air flowing through the air entrainment device into two streams. A first stream passes upward through perforated surface 124 and urges seed upward within a seed and air mixing chamber 505 and through outlet port 22. A second stream bypasses perforated surface 124 (and the seed

disposed thereon), passes upward through opening 134 and into air bypass channel 130, and recombines with the first air stream at outlet port 22. With the second air stream not encumbered by seed and the cross sectional area of the bypass channel 130 appropriately dimensioned relative to the seed and air mixing chamber 505, the force and/or velocity of the second air stream through bypass channel will be generally greater than that of the first air stream. Accordingly, when recombination of the streams occurs, the second stream will assist the first stream in discharging seed through outlet port 22. This air flow feature is especially helpful in diluting seed flow to prevent blockages and to reduce seed flow in the event of a blockage. This increased air flow more effectively maintains the seed and air flow at outlet 22 as well as in downstream portions of the seed delivery system to prevent blockages. This arrangement also facilitates the flow of seed through the seed and air mixing chamber 505 and reduces the possibility of blockages within the seed entrainment device 12A. Thus, as the number of seeds within the seed throat 503 and the seed and air mixing chamber 505 increases and the air flow through this portion of the air entrainment device decreases, air flow through the air bypass channel 130 increases to clear the seed and air outlet port 22. With the seed and air outlet port 22 cleared, additional seed can be discharged from the seed and air mixing chamber 505 into the seed and air outlet port 22 allowing additional air to flow through the seed and air mixing chamber to facilitate increased seed flow.

As was described in connection with FIG. 1, air is provided from air source 20 into the air distribution unit 127A of each air entrainment device 12A. Air entrainment device 12A includes an air flow channel 500 within its air distribution unit 127A through which air from source 20 is directed. The air flow channel 500 directs air into a chamber 502 located beneath perforated surface 124 as shown in the sectional view of FIG. 7. Meanwhile, seed is provided from hopper 10 through an input port to seed throat 503 and into the seed and air mixing chamber 505. The seed is deposited on inclined wall or surface 504, which is dimensioned such that the seed is deflected onto perforated surface 124. An exemplary angle for inclined surface 504 is on the order of 52° relative to perforated surface 124. As seed is deflected onto perforated surface 124, air exits chamber 502, agitates and mixes the seed, and causes the seed to rise within the air and seed mixing chamber 505. Simultaneously, air is allowed to pass through opening 134 and into bypass channel 130. Air-entrained seed from mixing chamber 505 is then recombined with the air stream from bypass channel 130 at outlet port 22. Seed and air then flows out of outlet port 22 to an associated seed meter 36 through one of the conduits 45 as shown in FIG. 1. A partition 506 separates the seed throat 503 from the seed and air mixing chamber 505. The length of partition 506 is selected so as to limit the rate of seed flow from the seed throat 503 to the seed and air mixing chamber 505 and prevent bridging (blockage) of the seed within the seed and air mixing chamber, particularly when the planter is transiting a steep slope in a field being planted.

Also shown in FIG. 7 are details of the attachment of base 121A to air entrainment device 12A at hinge 128. Air entrainment device 12A includes plural bolts 507 to secure base 121A to the air entrainment device when in use. Bolts 507 can be removed or released allowing base 121A to be rotated in the direction of arrow A such that seed can be removed from seed throat 503, mixing chamber 505, perforated surface 124, and/or outlet port 22 for cleaning out the air entrainment device 12A. Air entrainment device 12A

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further includes a mounting flange **508** that can be used to secure multiple air entrainment devices together, or in the case of an end unit, to attach an end cover. Mounting flange **508** includes apertures **509** adapted to receive bolts, pins, screws, etc., for securing plural air entrainment devices together.

Referring to FIG. **8**, there is shown a partially cutaway side elevation view of air entrainment device **12A** in operation. An air source (not shown) provides air through flow channel **500** air distribution unit **127A** to air entrainment device **12A**. Air flows from air distribution unit **127A** through channel **501**, into chamber **502**, and upward through perforated surface **124**. Air engages seed **601** that is deposited in seed throat **503**, contacts angled surface **504**, and is deflected onto perforated surface **124**. This seed **601** is lifted upward through air and mixing chamber **505**. A second stream of air flows upward through air bypass channel **130** and is recombined with the air-entrained seed at outlet port **22**. The seed is then provided to a seed meter **36** through conduit **45**. A trap insert **603** is removably inserted in the air entrainment device **12A** distribution so as to subtend its seed throat **503** to stop the flow of seed from hopper **10** should the operator find it necessary, such as during transit over non-planting area, or when its base **121A** is lowered to clear blockage or remove a foreign object or unwanted material.

While particular embodiments have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made without departing from the broader aspects of Applicants' contribution. The actual scope of the protection sought is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.

What is claimed is:

1. An agricultural planter, comprising:
  - an air entrainment assembly comprising a plurality of air entrainment devices, each of said plurality of air entrainment devices comprising:
    - a. a seed inlet,
    - b. an air inlet,
    - c. a first channel wherein seed and air combine,
    - d. a second channel wherein air from the air inlet bypasses the first channel, and
    - e. an outlet wherein the combination of the seed and air of the first channel combine with the air from the second channel;
 wherein the seed and air are directed from the outlet to at least one of a plurality of row units positioned on a toolbar of the agricultural planter.
2. The agricultural planter of claim 1, further comprising one or more hoppers for holding seed, the one or more hoppers providing seed to the plurality of air entrainment devices.
3. The agricultural planter of claim 2, further comprising a distribution tray positioned at least partially between the one or more hoppers and the air entrainment assembly.
4. The agricultural planter of claim 1, further comprising a fan operatively connected to the air inlets of the plurality of air entrainment devices.
5. The agricultural planter of claim 1, further comprising a plurality of outlet conduits between the outlets of plurality of air entrainment devices and the at least one of the plurality of row units.
6. The agricultural planter of claim 1, wherein each of the plurality of air entrainment devices further comprises a detachable base member to allow for the removal of seed from within the plurality of air entrainment devices.

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7. The agricultural planter of claim 6, wherein the detachable base member comprises a mechanical fastener connected to a portion of the plurality of air entrainment devices to allow for access to within each of the plurality of air entrainment devices.

8. The agricultural planter of claim 7, wherein the detachable base member is rotatably mounted to the plurality of air entrainment devices to allow for rotational opening of the detachable base member.

9. The agricultural planter of claim 1, wherein the outlet is substantially normal to the first channel.

10. The agricultural planter of claim 1, wherein the outlet is substantially normal to the second channel.

11. A method for delivering seed from one or more hoppers to a row unit of a planter including a plurality of row units positioned on a toolbar, the method comprising:

delivering seed from the one or more hoppers to an air entrainment device, said air entrainment device comprising a seed inlet, an air inlet, a first channel wherein seed and air combine, a second channel wherein air from the inlet bypasses the first channel, and an outlet wherein the combination of the seed and air of the first channel combine with the air from the second channel;

providing airflow to the air entrainment device such that a first air stream of the airflow is directed towards the first channel and seed, and a second air stream is directed towards the second channel, and wherein the first air stream combines with seed; and

combining the first and second air streams of the airflow and seed before the seed passed through the outlet to deliver the seed to one of the row units of the planter.

12. The method of claim 11, further comprising lifting at least some of the seed with the first air stream of the airflow before combining the air streams.

13. The method of claim 11, wherein the airflow provided to the air entrainment device is substantially normal to the direction of the first and second airstreams.

14. The method of claim 11, further comprising increasing the velocity of the airflow at the air entrainment device before splitting the airflow between the first and second air streams.

15. The method of claim 11, wherein the first air stream agitates and lifts an amount of seed to direct the combined air stream and seed towards an outlet.

16. The method of claim 11, wherein the airflow for the seed delivery device is provided by a fan.

17. A method for delivering seed from one or more hoppers to a plurality of row units of a planter positioned on a toolbar, the method comprising:

providing an air entrainment device corresponding to each row unit of the planter, said air entrainment device including an air and seed mixing channel and an air bypass channel;

adding seed from the one or more hoppers to each of the seed delivery devices, with the seed being positioned adjacent the air and seed mixing channel;

providing airflow to the seed delivery device such that a first air stream of the airflow is directed towards the air and seed mixing channel, and a second air stream is directed towards the air bypass channel, and wherein the first air stream combines with seed; and

combining the first and second air streams of the airflow and seed to deliver the seed to one of the row units of the planter.

18. The method of claim 17, further comprising combining the first air stream with the seed and the second air

stream at an outlet port for delivering to the row unit associated with the air entrainment device.

**19.** The method of claim **18**, further comprising delivering the seed to the row unit via a conduit between the seed delivery device and the row unit, and wherein the seed delivery to the row unit automatically stops when the row unit does not require additional seed delivered. 5

**20.** The method of claim **18**, wherein the first air stream and seed and the second air stream combine before leaving the seed delivery device via the outlet. 10

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