United States Patent Application Publication	20250256537
Kind Code	A1
Publication Date	August 14, 2025
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ENDWISE TRANSPORTABLE IMPLEMENT WITH AUTOMATIC LATCHING TONGUE

Abstract

A towable implement that is shiftable between a wide field configuration and a narrow transport configuration using a folding tongue and vertically adjustable transport wheels. Shifting of the towable implement between the field and transport configurations can be accomplished primarily by hydraulic power, with little or no manual manipulation of implement components being required.

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Family ID: **1000007697305**

Appl. No.: **18/437858**

Filed: **February 09, 2024**

Publication Classification

Int. Cl.: **B60D1/42** (20060101); **A01B59/04** (20060101); **A01B73/02** (20060101)

U.S. Cl.:

CPC **B60D1/42** (20130101); **A01B59/04** (20130101); **A01B73/02** (20130101);

Background/Summary

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to towable implements that are used to perform various operations affecting soil or plants.

2. Description of the Related Art

[0002] Towable implements are pulled behind a prime mover (e.g., an operator-driven tractor or an autonomous tractor) and perform a variety of work tasks that promote, for example, agriculture crop production, property maintenance, and construction-related earthwork. Typically, it is desirable for towable implements, especially agricultural implements, to be as wide as possible so that more ground can be covered by each pass in the field, thereby saving time and fuel. However, transporting wide implements from one working location to another often requires the implement to be pulled over public roads by the prime mover. Pulling a wide implement over a public road can be dangerous for both for the driver of the prime mover and other drivers on the road.

[0003] It is, therefore, advantageous for wide towable implements to be provided with mechanisms for reducing the width of the implements during transport over roads. Some implements can be configured with multiple sections that can be folded upwardly, forwardly, or rearwardly to reduce the overall width of the implement for transport. However, the configurations of some implements are not conducive to being folded.

[0004] Another technique for reducing the width of implements during transport over a road is to rotate the implement sideways and tow the implement on the road from an end of the implement. This technique of rotating the implement to narrow its width for towing over the road is sometimes referred to as endwise transport. Over the years, various configurations for endwise transport of implements have been developed. However, conventional techniques for providing endwise transport require significant manual manipulation of various components of the implement in order to shift the implement between the widthwise working/field configuration and the endwise transport configuration.

[0005] Therefore, it would be desirable to have an implement that is readily shiftable between a widthwise field configuration and an endwise transport configuration without requiring substantial manual manipulation of implement components.

SUMMARY OF THE INVENTION

[0006] One aspect of the present invention concerns a towable implement that is shiftable between a field configuration for operation in a field and an endwise transport configuration for transporting over a road. The towable implement comprises a frame, one or more work mechanisms supported by the frame and configured to perform work in the field, and a folding tongue pivotably coupled to the frame and shiftable between an unfolded position and a folded position. The tongue is in the unfolded position when the implement is in the field configuration and the tongue is in the folded position when the implement is in the endwise transport configuration. The towable implement further comprises a brace system for supporting the tongue in the unfolded position. The brace system comprises a brace bar pivotally coupled to the frame and an alignment bar pivotally coupled to the tongue. The brace bar and the alignment bar are pivotally coupled to one another.

[0007] Another aspect of the present invention concerns a towable implement that is shiftable between a field configuration for operation in a field and an endwise transport configuration for transporting over a road. The towable implement comprises a frame, one or more work mechanisms supported by the frame and configured to perform work in the field, and a plurality of field wheels for supporting the implement in the field configuration. The towable implement further comprises a plurality of transport wheels for supporting the implement in the endwise transport configuration and a folding tongue pivotably coupled relative to the frame and shiftable between an unfolded position and a folded position. The tongue is in the unfolded position when the implement is in the field configuration and the tongue is in the folded position when the implement is in the endwise transport configuration. The towable implement comprises a field locking mechanism for selectively locking the tongue in the unfolded position. The field locking mechanism includes a spring that is manually shiftable between a locking position for maintaining

the tongue in the unfolded position and a releasing position for permitting shifting of the tongue out of the unfolded position.

[0008] Another aspect of the present invention concerns a method of operating a towable implement having a frame, transport wheels attached to the frame, field wheels attached to the frame, and a folding tongue pivotally attached to the frame. The method of operating comprises (a) towing the implement over a road while the implement is in an endwise transport configuration where the tongue extends outwardly from a first end of the frame in a folded position and the bottom of the transport wheels are lower than the bottom the field wheels, (b) shifting the implement from the endwise transport configuration to a field configuration where the tongue extends outwardly from a first side of the frame in an unfolded position and the bottom of the field wheels are lower than the bottom the transport wheels, and (c) pulling the implement in a field with a prime mover attached to the tongue of the implement while the implement is in the field configuration. The shifting of step (b) includes (i) lowering the transport wheels from a raised position to a lowered position using at least one transport wheel actuator, (ii) pivoting the tongue from the folded position to the unfolded position using at least one tongue actuator, (iii) moving a brace member from a collapsed configuration to a supporting configuration using an alignment bar pivotally coupled to the brace bar and tongue, and (iv) locking the brace member in the supporting configuration using a field locking mechanism. The lowering, pivoting, moving, and locking are carried out without manual manipulation of the transport wheels, tongue, brace member, alignment bar, or field locking mechanism.

[0009] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Other aspects and advantages of the present invention will be apparent from the following detailed description of the embodiments and the accompanying drawing figures.

Description

BRIEF DESCRIPTION OF THE FIGURES

[0010] FIG. **1** is a perspective view of a towable implement (specifically, an agricultural box drill) in a field configuration.

[0011] FIG. **2** is a perspective view of the towable implement in an endwise transport configuration.

[0012] FIG. **3** is a side view of the towable implement depicting how the transport wheels are raised and lowered when the implement is shifted between the field configuration and the endwise transport configuration.

[0013] FIG. **4** is a top view of the towable implement illustrating the manner in which the tongue shifts between an unfolded position (when the implement is in the field configuration) and a folded position (when the implement is in the endwise transport configuration).

[0014] FIG. **5** is a top enlarged view depicting the tongue in various positions during folding/unfolding and showing the mechanisms for locking the tongue in the folded and unfolded positions.

[0015] FIG. **6** is an enlarged perspective view depicting the tongue immediately prior to entering the unfolded position and being locked into the unfolded position by a field locking mechanism that couples the unfolded tongue to a brace bar.

[0016] FIG. **7***a* is an enlarged perspective view depicting the field locking mechanism coupling the brace bar to the tongue, with the spring of the field locking mechanism being in a locking position.

[0017] FIG. **7***b* is an enlarged perspective view similar to FIG. **7***a*, but with the field locking

mechanism being unlocked, with its spring in a releasing position.
[0018] FIG. **8** is a hydraulic circuit diagram depicting various hydraulic components of the towable implement and the prime mover that allow the implement to be automatically shifted between the field configuration and the endwise transport configuration using input components located on or in the prime mover.
[0019] FIG. **9***a* is a flow diagram showing the major steps involved in shifting the implement from the endwise transport configuration to the field configuration.
[0020] FIG. **9***b* is a flow diagram showing the major steps involved in shifting the implement from the field configuration to the endwise transport configuration.
DETAILED DESCRIPTION
[0021] It is noted that the drawings included herewith depict a box drill as the towable implement employing the present invention. It should be understood, however, that this invention can be implemented on a variety of different types of towable implements, especially implements whose design is not amenable to being folded for over-the-road transport. Towable implements incorporating the present invention can be used for a variety of purposes, including agricultural uses (e.g., planting, tilling, treating, and harvesting), construction uses (e.g., soil grading, pulverizing, and compacting), or other land maintenance uses (e.g., spraying and mowing).
[0022] FIGS. **1** and **2** depict a towable implement **10** configured in accordance with one embodiment of the present invention. FIG. **1** shows the towable implement **10** in a field configuration, while FIG. **2** shows the towable implement **10** in an endwise transport configuration.
[0023] The towable implement **10** includes a frame **12** and one or more work mechanisms **14** attached to the frame. The entirety of the implement's **10** frame **12** is rigid (i.e., not collapsible, foldable, etc.). In the embodiment depicted in the drawings, the work mechanisms **14** include various components of a seed drill (e.g., box seeder) for planting seeds, typically in an agricultural field. However, in other embodiments, the work mechanisms **14** could be configured to perform various other work tasks, such as tilling, treating, harvesting, mowing, grading, spraying, fertilizing, etc. Additionally, it should be noted that the term “field,” as used herein, is not limited to an agricultural field, but includes any location (e.g., a construction site, a golf course, a park, etc.) where the implement is being used to perform its intended function.
[0024] The towable implement **10** includes a plurality of field wheels **16** coupled to the frame **12** and configured to support the towable implement **10** for movement on the ground in the field. The towable implement **10** also includes a folding tongue **18** configured to be attached via a hitch **20** to a prime mover, such as a tractor (not illustrated).
[0025] The towable implement **10** also includes a plurality of transport wheels **22** coupled to the frame **12** and configured to support the towable implement **10** when transported over a road. FIG. **1** shows the transport wheels **22** in a raised position, while FIG. **2** shows the transport wheels **22** in a lowered position. FIG. **1** shows the folding tongue **18** in an unfolded position, while FIG. **2** shows the folding tongue **18** in a folded position. Thus, when the implement **10** is in the field configuration shown in FIG. **1**, the tongue **18** is in the unfolded position and the transport wheels **22** are in the raised position. When the implement **10** is in the endwise transport configuration shown in FIG. **2**, the tongue **18** is in the folded position and the transport wheels **22** are in the lowered position. Thus, in certain embodiments, the towable implement **10** uses different sets of wheels (i.e., the field wheels **16** and the transport wheels **22**) with different orientations for field use and road use. Unlike certain conventional folding tongue implements, the wheels of the implement **10** described herein have a fixed orientation relative to the frame, with the field wheels **16** being oriented perpendicular to the transport wheels **22**. Additionally, unlike certain conventional adjustable width implements, the folding tongue **18** of the implement **10** described herein is a rigid member that does not collapse, disassemble, telescope, or fold on itself; rather, the tongue **18** only pivots relative to the frame **12**.
[0026] Referring now to FIGS. **1-3**, the towable implement **10** includes a transport wheel shifting

mechanism **24** (shown in FIGS. **2** and **3**) for shifting the transport wheels **22** relative to the frame **12** between the raised position (FIG. **1** and dashed lines in FIG. **3**) and lowered position (FIG. **2** and solid lines in FIG. **3**). The transport wheel shifting mechanism **24** is coupled to the frame **12** near a rear end of the frame **12**. The rear end of the frame **12** is opposite the front end **38** of the frame **12** where the tongue **18** folds for endwise transport. The transport wheel shifting mechanism **24** can include at least one transport wheel actuator **26** and a rockshaft mechanism **28**. The rockshaft mechanism **28** is pivotably coupled to the frame **12** and supports the transport wheels **22** on the frame **12**. The transport wheel actuator **26** is pivotable coupled to and extends between the frame **12** and the rockshaft mechanism **28**. The transport wheel actuator **26** is shiftable between an extended position (FIG. **2** and solid lines in FIG. **3**) and a retracted position (FIG. **1** and dashed lines in FIG. **3**).

[0027] Referring now to FIG. **3**, when the transport wheel actuator **26** is in the retracted position, the transport wheels **22** are in the raised position (dashed lines) with the bottom **30***a* of the transport wheels **22** being vertically positioned higher than the bottom **32** of the rear field wheel **16**. When the transport wheel actuator **26** is in the extended position, the transport wheels **22** are in the lowered position (solid lines) with the bottom **30***b* of the transport wheels **22** being vertically positioned lower than the bottom **32** of the rear field wheel **16**. In one embodiment of the present invention, the transport wheel actuator **26** is a hydraulic cylinder, but various other actuators can be used to cause raising and lowering of the transport wheels **22**.

[0028] Referring to FIGS. **1**, **2**, and **4** the towable implement **10** includes a number of components configured to facilitate movement of the folding tongue **18** between the unfolded position (FIG. **1**) and the folded position (FIG. **2**), as well as locking of the tongue **18** in the unfolded position (FIG. **1**) and the folded position (FIG. **2**). Specifically, the folding tongue **18** is pivotably coupled to the frame **12** by a pivot joint **34**. Pivoting of the tongue **18** relative to the frame **12** can be powered by a tongue actuator **36**, which is pivotably coupled to and extends between the frame **12** and the tongue **18**. When the tongue actuator **36** is retracted (FIG. **1**) the tongue **18** is in the unfolded position and when the tongue actuator **36** is extended (FIG. **2**) the tongue **18** is in the folded position. In one embodiment of the present invention, the tongue actuator **36** is a hydraulic cylinder, but various other actuators can be used to cause folding and unfolding of the tongue **18**.

[0029] As shown in FIGS. **1** and **4**, when the tongue **18** is in the unfolded position, the hitch **20** of the tongue **18** extends outwardly from a first side **40** of the towable implement **10**. As shown in FIGS. **2** and **4**, when the tongue **18** is in the folded position, the hitch **20** of the tongue **18** extends outwardly from a first/front end **38** of the towable implement **10**. In the folded position, a prime mover (not shown) can be attached to the hitch **20** of the folded tongue **18** so that the towable implement **10** can be pulled lengthwise over the road using the lowered transport wheels **22**. In the unfolded position, the prime mover can be attached to the hitch **20** of the tongue **18** so that the towable implement **10** can be pulled widthwise in the field using the field wheels **16**. When shifted between the folded and unfolded positions, the tongue **18** pivots through an angle of at least 80, 90, 100, 110, or 120 degrees and/or not more than 170, 160, 150, or 140 degrees. In the illustrated embodiment, the tongue pivots through an angle of about 140 degrees when folded and unfolded.

[0030] Referring to FIG. **4**, the field width of the towable implement **10**, which is the maximum width of the implement **10** in the field configuration, is substantially greater than the transport width of the towable implement **10**, which is the maximum width of the implement **10** in the endwise transport configuration. In certain embodiments, the ratio of the field width to the transport width can be at least 1.25:1, at least 1.5:1, at least 1.75:1, or at least 2:1.

[0031] Referring to FIGS. **1-5**, the towable implement **10** can include a brace bar **42** for supporting/bracing the folding tongue **18** in the unfolded position. The brace bar **42** is pivotally coupled to the frame **12** at a proximal end of the brace bar **42**. A distal end of the brace bar **42** contacts and is locked into place with the folding tongue **18** when the tongue **18** is in the unfolded position. A field locking mechanism **44** is used to couple the distal end of the brace bar **42** to the

folding tongue **18** when the tongue **18** is in the unfolded position. When the tongue **18** is in the folded position, a transport locking mechanism **46** is used to releasably couple the folding tongue **18** to the frame **12**. Both the field locking mechanism **44** and the transport locking mechanism **46** can be automatic (e.g., spring-loaded) locking mechanisms that do not require manual input to engage and lock two components to one another. However, as described in further detail below, in certain embodiments, both the field locking mechanism **44** and transport locking mechanism **46** may require some manual manipulation for shifting between an open/releasing configuration and a closed/locking configuration, especially when the locking mechanisms **44**,**46** are spring locks that employ two-position springs. However, it is possible for the shifting of the two-position springs to be automated using, for example, electric, hydraulic, or pneumatic actuators.

[0032] As shown in FIGS. **2**, **4**, and **5**, an alignment bar **48** includes a first end that is pivotally coupled to the distal end of the brace bar **42** and a second end that is pivotally coupled to the tongue **18**. In the illustrated embodiment, the second end of the alignment bar **48** is connect to the tongue **18** at the same location (i.e., on the same axis and/or with same pin) where the tongue actuator **36** is connected to the tongue **18**. When the folding tongue **18** is shifted from the unfolded position to the folded position, the alignment bar **48** pulls the brace bar **42** toward the first side **40** of the frame **12** and holds the brace bar **42** close to the frame **12** while the tongue **18** is locked in the folded position. When the folding tongue **18** is shifted from the folded position to the unfolded position, the alignment bar **48** pushes the brace bar **42** away from the first side **40** of the frame **12** and, as perhaps best shown in FIG. **6**, positions the distal end of the brace bar **42** in alignment with the field locking mechanism **44** for locking of the brace bar **42** to the tongue **18**.

[0033] As shown in FIGS. **4** and **5**, the tongue **18** comprises a first substantially straight tongue segment (closest to the frame **12**) and a second substantially straight tongue segment (farthest from the frame **12**). The first and second segments of the tongue **18** are fixed to one another at or near the location where the brace bar **42** contacts the tongue **18** in the unfolded position. The first and second segments of the tongue **18** are angled relative to one another at an angle in the range of 100 to 170 degrees, 110 to 160 degrees, or 120 to 150 degrees. When the tongue **18** and the brace bar **42** are locked to one another in the field configuration, the segments of the tongue **18** and the brace bar **42** form a Y shape, with the two arms of the Y shape being formed by the brace bar **42** and the first tongue segment.

[0034] As shown in FIGS. **5-7** the field locking mechanism **44** includes a shiftable locking member **50** and a fixed locking member **52**. In the illustrated embodiment, the shiftable locking member **50** is shiftably coupled to the folding tongue **18**, while the fixed locking member **52** is rigidly coupled to the distal end of the brace bar **42**. However, it is possible for this to be reversed, with the shiftable locking member **50** being shiftably coupled to the distal end of the brace bar **42** and the fixed locking member **52** being rigidly coupled to tongue **18**.

[0035] Referring now to FIGS. **7***a* and **7***b*, the field locking mechanism **44** includes a spring **54** that can bias the shiftable locking member **50** to rotate in a locking direction **70***a* toward the fixed locking member **52**, so that the shiftable locking member **50** can capture and hold the fixed locking member **52** to thereby lock the tongue **18** in the unfolded position. In more detail, the shiftable locking member **50** can include a projection **55** that presents a displacement surface **56** on one side and a holding surface **58** on another side. Further, the field locking mechanism **44** can include a spring positioning structure **60** that is coupled to the tongue **18** and receives a movable extension element **62** of the spring **54**. The movable extension element **62** of spring **54** includes a spring handle **64** that allows the spring to be manually shifted between a locking position (shown in FIG. **7***a*) and an unlocking position (shown in FIG. **7***b*). The spring positioning structure **62** can include a locking spring stop **66** and a releasing spring stop **68** that are spaced apart from one another and are used to retain the spring **54** in the locking and releasing positions, respectively. In one embodiment, the locking and releasing spring stops **66**,**68** are spaced from one another by 0.5 to 6 inches, 1 to 5 inches, or 1.5 to 4 inches. In one embodiment, the spring **54** is a torsion spring that includes a

central coil extending along a central coil axis, the movable extension element **62** extending from one end of the coil, and a biasing extension element (not illustrated) extending from an opposite end of the coil. The biasing extension element extends away from the coil axis and is coupled to the shiftable locking member **50**. The movable extension element **62** extends away from the coil axis toward the spring positioning structure **60**.

[0036] As shown in FIG. **7***a*, when the spring **54** is in the locking position with the movable extension element **62** engaging the locking spring stop **66**, the shiftable locking member **50** is biased by the spring **54** in a locking direction **70***a*. As shown in FIG. **7***b*, when the spring **54** is in the releasing position with the movable extension element **62** engaging the releasing spring stop **68**, the shiftable locking member **50** is biased by the spring **54** in a releasing direction **70***b*.

[0037] As shown in FIG. **7***a*, when the spring **54** is in the locking position and biasing the shiftable locking member in the locking direction **70***a*, the field locking mechanism **44** is configured to automatically receive and hold the fixed locking member **52**, thereby locking the distal end of the brace bar **42** in contact with the tongue **18**. In more detail, when the folding tongue **18** is being shifted from the folded position to the unfolded position and the fixed locking member **52** approaches the shiftable locking member **50** biased by the spring **54** in the locking direction **70***a*, the fixed locking member **52** engages the displacement surface **56** of the shiftable locking member **50** and causes the shiftable locking member **50** to rotate against the bias of the spring **54** (i.e., opposite the locking direction **70***a*) until the fixed locking member **52** moves past the displacement surface **56**. Once the fixed locking member **52** has moved past the displacement surface **56**, the shiftable locking member **50** is rotated in the locking direction **70***a* toward the fixed locking member **52** by the force of the spring **54** until the fixed locking member **52** is captured and held against the holding surface **58** of the shiftable locking member **50**. Thus, no manual manipulation of any locking components is necessary to lock the brace bar **42** and the tongue **18** to one another as the tongue **18** is shifted into the unfolded position.

[0038] As shown in FIG. **7***b*, when it is desired to shift the folding tongue **18** out of the unfolded position and into the folded position, the spring handle **64** can be used to manually move the movable extension element **62** from the locking spring stop **66** to the releasing spring stop **68**. Moving the spring extension element **62** to the releasing spring stop **68** causes the shiftable locking member **50** to be biased by the spring **54** to rotate in a releasing direction **70***b* away from the fixed locking member **52**. Once the spring **54** has been placed in the releasing position, the shiftable locking member **50** may automatically rotate in the releasing direction **70***b*. Alternatively, if the implement is in a position where the fixed locking member **52** is exerting a binding force against the holding surface **58** of the shiftable locking mechanism **50**, it may be necessary to move the prime mover back and forth to relieve the binding force and allow the spring **54** to automatically shift the shiftable locking member **50** out of engagement with the fixed locking member **52**, thereby decoupling the brace bar **42** and the tongue **18** and permitting the tongue **18** to be shifted out of the unfolded position.

[0039] Although not illustrated in as much detail, the transport locking mechanism **46** can have the same or a similar configuration as the field locking mechanism **54**. Thus, as shown in FIGS. **1** and **2**, the transport locking mechanism **46** can include a shiftable locking member **75** that is pivotally coupled to the frame **12** of the implement and a fixed locking member **77** that is rigidly couple to the tongue **18**. Alternatively, the shiftable locking member **75** of the transport locking mechanism **46** can be pivotally coupled to the tongue **18** and the fixed locking member **77** can be rigidly coupled to the frame **12**. The transport locking mechanism **46** can also include an adjustable spring that is manually positionable between a locking position and a releasing position. When the spring of the transport locking mechanism **46** is in the locking position, the shiftable locking member **75** is biased in a locking direction. When the spring of the transport locking mechanism **46** is in the releasing position, the shiftable locking member **75** is biased in a releasing direction that is opposite of the locking direction. Thus, to lock the tongue **18** to the frame **12**, the spring of the

transport locking mechanism must be in the locking position so that that when the tongue **18** moves into the folded position, the transport locking mechanism **46** automatically locks the tongue **18** to the frame **12**. To release the tongue **18** from the frame **12**, the spring of the transport locking mechanism **46** is manually shifted into the releasing position, so that the shiftable locking member **75** of the transport locking mechanism **46** moves out of engagement with the fixed locking member **77**, thereby permitting the tongue **18** to move out of the folded position and away from the frame **12**. Although the embodiment illustrated in the drawings employs manual shifting of the field and transport locking mechanisms **44**,**46** between their releasing and locking positions, it should be understood that various types of actuators (hydraulic, electric, pneumatic, etc.) can be used to automatically shift the locking mechanisms **44**,**46** between the releasing and locking positions.

[0040] FIG. **8** shows a hydraulic circuit of the towable implement **10** and a prime mover **72** pulling the implement **10**. The hydraulic system of the prime mover **72** includes a pressurized hydraulic fluid source **74**, a hitch (e.g., 3-point hitch) hydraulic controller **76**, and an implement hydraulic controller **78**. The hydraulic controllers **76**,**78** includes operator input mechanisms **94**,**96** for receiving operator inputs. The operator input mechanisms **94**,**96** can be, for example, a lever, a switch, a button, a touchscreen, or a microphone for receiving voice commands. If the prime mover **72** is driver-less, the operator input can be remote to the prime mover **72** or can be a programmed into the prime mover **72**.

[0041] Referring again to FIG. **8**, hydraulic connectors **80** releasably connect the hydraulic system of the prime mover **72** to the hydraulic circuit of the implement **10**. The hydraulic circuit of the implement **10** includes a first control valve **82**, a second control valve **84**, a transport wheel safety valve **86**, a plurality of transport wheel flow restrictors **88**, a tongue flow restrictor **90**, the transport wheel actuator **26**, and the tongue actuator **36**.

[0042] In the illustrated embodiment, the transport wheel safety valve **86** is a double pilot-operated check valve that includes two individual check valves **91** and two individual pilot lines **92**. The transport wheel safety valve **86** acts as a hydraulic lock for the transport wheels **22** by preventing any hydraulic fluid from flowing out of the transport wheel actuator **26** when the hydraulic circuit is inactive. For example, when the transport wheels **22** are fully raised for field operation or fully lowered for transport over the road, the safety valve **86** prevents flow of hydraulic fluid out of the transport wheel actuator **26**, thereby fixing the position of the transport wheels **22** until the hydraulic circuit is activated to shift out of the transport or field configuration. The transport wheel flow restrictors **88** are configured to prevent rapid up or down movement of the transport wheel **22**. Similarly, the tongue flow restrictor **90** prevents rapid rotation of the tongue **18** and frame **12** relative to one another.

[0043] In the embodiment illustrated in FIG. **8**, the first and second control valves **82**,**84** are each pilot operated pressure relief valves that open to permit actuator supply flow therethrough when a threshold pressure is reach. As described in more detail below, the first and second control valves **82**,**84** enable automatic sequential movement of the tongue **18** and transport wheels **22** in response to a single operator input. More specifically, upon receiving a single “transport” operator input at operator input mechanism **96**, the first and second control valves **82**,**84** first facilitate lowering of the transport wheels **22** with the transport actuator **26** followed by folding of the tongue **18** with the tongue actuator **36**. Upon receiving a single “field” operator input at operator input mechanism **96**, the first and second control valves **82**,**84** first facilitate unfolding of the tongue **18** with the tongue actuator **36** followed by raising of the transport wheels **22** with the transport wheel actuator **26**.

[0044] FIG. **9***a* outlines the main steps involved in shifting the towable implement **10** from the endwise transport configuration to the field configuration. In the starting endwise transport configuration, the implement **10** has (1) the tongue **18** locked in the folded position by the transport locking mechanism **46**, (2) the transport wheels **22** hydraulically locked in the lowered position by the safety valve **86**, (3) the transport locking mechanism **46** in the closed/locking position, (4) the field locking mechanism **44** in an open/releasing position, (5) the weight of the implement **10**

supported by the rear transport wheels **22** and the tongue **18** attached to the movable hitch (e.g., 3-point hitch) of the prime mover **72**, and (6) the hydraulic circuit of the implement **10** connected to the hydraulic system of the prime mover **72** by the hydraulic connectors **80**.

[0045] In step **100**, the operator manually shifts the field locking mechanism **44** from the open/releasing position into the closed/locking position by manually moving the movable extension member **62** of the field locking spring **54** from the releasing position shown in FIG. **7***b* to the locking position shown in FIG. **7***a*. However, as discussed above, it is possible for the implement **10** to be equipped with automated actuators that allow this shifting of the field locking mechanism **44** from the releasing position to the locking position to be performed without manual manipulation of the field locking spring **54**.

[0046] In step **102**, the operator manually shifts the transport locking mechanism **46** from the closed/locking position into the open/releasing position. As discussed above, the transport locking mechanism **46** can have a similar configuration to the field locking mechanism **44**, which is illustrated in detail in FIGS. **6**-**7***b*. Shifting of the transport locking mechanism **46** from the closed/locking position into the open/releasing position can be carried out by manually moving the movable extension element of the transport locking spring from the locking position to the releasing position. This either moves the shiftable locking member **75** in the releasing direction and out of engagement with the fixed locking member **77** or, if the shiftable locking member **75** and fixed locking member **77** are bound up with one another, biases the shiftable locking member **75** in the releasing direction without moving the shiftable locking member **75**. As discussed above, it is possible for the implement **10** to be equipped with automated actuators that allow this shifting of the transport locking mechanism **46** from the locking position to the releasing position to be performed without manual manipulation of the transport locking spring.

[0047] In step **104**, the operator initiates lowering of the movable hitch (e.g., 3-point hitch) of the prime mover **72** by providing an operator input to an input device **94** (e.g., a lever, switch, button, touchscreen, or microphone for receiving voice commands) operably coupled to the hitch hydraulic controller **76** on/in the prime mover **72**. When the movable hitch is lowered, the tongue **18** of the implement **10** is lowered until the front field wheel **16** (i.e., the field wheel **16** located closest to the first end **38** of the frame **12**) contacts the ground so that the weight of the implement **10** is supported by the rear transport wheels **22** and the front field wheel **16**. Having the front of the implement **10** supported on the front field wheel **16** relieves the tongue **18** from supporting the weight of the implement **10**, which allows the tongue **18** to be readily pivoted relative to the frame **12**.

[0048] In step **106**, if the shiftable locking member **75** and the fixed locking member **77** of the transport locking mechanism **46** are bound up with one another, the operator moves the prime mover **72** back and forth until the shiftable locking member **75** of the transport locking mechanism **46** is shifted into the unlocked position by the urging of the transport lock spring in the releasing direction. Thereafter, the prime mover **72** is placed in neutral for unfolding of the tongue **18**.

[0049] In step **108**, the operator initiates the actuation system for sequentially unfolding the tongue **18** and raising the transport wheels **22**. This is done by providing a single operator input to the implement input device **96** operably coupled to the implement hydraulic controller **78** on/in the prime mover **72**. Upon receiving this “field” input from operator, the implement hydraulic controller **78** initiates flow of pressurized hydraulic fluid from the pressurized hydraulic fluid source **74** of the prime mover **72** to the second control valve **84** and to the head of the tongue actuator **36**.

[0050] In step **110**, the actuation system automatically unfolds the tongue **18** until the field locking mechanism **44** locks the tongue **18** in the unfolded position. During unfolding, the tongue actuator **36** forces rotation of the tongue **18** and frame **12** relative to one another, while the front of the implement **10** is supported on the front field wheel **16** and the rear of the implement **10** is supported on the transport wheels **22**. During this step, the main body of the implement **10** can

twist relative to the tongue **18** and prime mover **72**.
[0051] In addition to causing rotation of the tongue **18** and frame **12** relative to one another, unfolding the tongue **18** may also cause some forward and/or rearward movement of the prime mover **72** and/or implement **10** on the ground. This is because, as the tongue **18** unfolds, the distance between the rear transport wheels **22** of the implement **10** and the prime mover **72** decreases, while the distance between the front field wheel **16** of the implement and the prime mover **72** increases. During unfolding of the tongue **18**, the prime mover **72** (with its transmission in neutral) maybe be pulled slightly rearward because the orientation of the rear transport wheels **22** may cause more resistance to rotational movement than the front field wheel **16**.
[0052] During step **110**, pressurized hydraulic fluid is simultaneously supplied to the second control valve **84** and the head of the tongue actuator **36**. While the tongue actuator **36** is unfolding the tongue **18**, the second control valve **84** inhibits/blocks the flow of hydraulic fluid therethrough to the head of the transport actuator **26** and the first control valve **82** permits the flow of hydraulic fluid therethrough from the base of the transport actuator **36** back to the hydraulic system of the prime mover **72**. As the head of the tongue actuator **36** receives the high pressure hydraulic fluid, the tongue actuator **36** retracts, thereby causing the tongue **18** and frame **12** to rotate relative to one another. As the tongue **18** unfolds, the alignment bar **48**, pushes the brace bar **42** away from the frame **12** of the implement **12** and aligns the fixed locking member **52** on the end of the brace bar **42** with the shiftable locking member **50** on the tongue **18**. When the tongue actuator **36** reaches full retraction, the field locking mechanism **44** automatically locks the tongue **18** to the brace bar **42** in the unfolded position.
[0053] Once the tongue actuator **36** is fully retracted, the pressure of the hydraulic fluid supplied to the tongue actuator **36** and the second control valve **84** exceeds a second threshold pressure of the second control valve **84**, thereby opening the second control valve **84**. With the second control valve **84** being opened, the pressurized hydraulic fluid is supplied through the second control valve **84** to the head of the transport wheel actuator **26** to commence retraction of the transport wheel actuator **26** and raising of the transport wheels **22**.
[0054] In step **112**, the actuation system automatically raises the transport wheels **22** so that the bottom of the rear transport wheels **22** are raised above the bottom of the rear field wheel **16**. This raising of the transport wheels **22** occurs as the pressurized hydraulic fluid flows through the safety valve **86** and into the head of the transport wheel actuator **26**.
[0055] Once the transport wheels **22** are in the fully raised position, the operator can cease providing the “field” input at the implement input device **96** so that the implement hydraulic controller **78** terminates the flow of hydraulic fluid to the implement **10**. In the resulting field configuration, the tongue **18** is mechanically locked in the unfolded position by the field locking mechanism **44** and the transport wheels **22** are hydraulically locked in the raised position by the safety valve **86**. The safety valve includes a pair of pilot operated check valves **91** that prevent hydraulic fluid from exiting the base and head of the transport actuator **26** when pressurized hydraulic fluid is not being supplied to the safety valve **86** from the prime mover **72**. During operation of the implement **10** in the field configuration, the hydraulic circuit depicted in FIG. **8** is not used.
[0056] FIG. **9***b* outlines the key steps involved in shifting the towable implement **10** from the field configuration to the endwise transport configuration. In the starting field configuration, the implement **10** has (1) the tongue **18** locked in a unfolded position by the field locking mechanism **44**, (2) the rear transport wheels **22** raised and hydraulically locked in the raised position by the safety valve **86**, (3) the field locking mechanism **44** in a closed/locking position, (4) the transport locking mechanism **46** in an open/releasing position, (5) the weight of the implement **10** supported by the field wheels **16** and unfolded tongue **18** attached to the movable hitch (e.g., 3-point hitch) of the prime mover **72**, and (6) the hydraulic circuit of the implement **10** connected to the hydraulic system of the prime mover **72** by the hydraulic connectors **80**.

[0057] In step **120**, the operator manually shifts the transport locking mechanism **46** from the open/releasing position into the closed/locking position by manually moving the movable extension member of the transport locking spring from the releasing position to the locking position. This moves the shiftable locking member **75** of the transport locking mechanism **46** the locking direction and biases the shiftable locking member **75** in the locking direction. As discussed above, it is possible for the implement **10** to be equipped with automated actuators that allow this shifting of the transport locking mechanism **46** from the releasing position to the locking position to be performed without manual manipulation of the transport locking spring.
[0058] In step **122**, the operator manually shifts the field locking mechanism **44** from the closed/locking position into the open/releasing position by manually moving the movable extension member **62** of the field locking spring **54** from the locking position shown in FIG. **7***a* to the releasing position shown in FIG. **7***b*. If the shiftable locking member **50** and the fixed locking member **52** are not bound in the locked position, shifting the movable extension member **62** into the releasing position causes the shiftable locking member **50** to rotate in the releasing direction **70***b* and out of engagement with the fixed locking member **52**. However, if the shiftable locking member **50** and the fixed locking member **52** are bound in the locked position, shifting the movable extension member **62** into the releasing position causes tension in the field locking spring **54** that biases/urges the shiftable locking member **50** toward the releasing direction **70***b*. As discussed above, it is possible for the implement **10** to be equipped with automated actuators that allow this shifting of the field locking mechanism **44** from the locking position to the releasing position to be performed without manual manipulation of the field locking spring **54**.
[0059] In step **124**, if the shiftable locking member **50** and the fixed locking member **52** remain bound in the lock position after step **122**, the operator can move the prime mover **72** back and forth to until the field locking mechanism **44** becomes unbound and shifts into the open/unlocked position. Moving the prime mover **72** back and forth unbinds the shiftable locking member **50** and the fixed locking member **52**, thereby allowing the field locking spring **54** to move the shiftable locking member **50** in the releasing direction **70***b* to the releasing position. Thereafter, the transmission of the prime mover **72** can be placed in neutral.
[0060] In step **126**, the operator initiates the actuation system for sequentially lowering the transport wheels **22** and folding the tongue **18**. This is done by providing a single operator input to an implement input device **96** operably coupled to the implement hydraulic controller **78**. This "transport" operator input at the implement hydraulic controller **78** initiates flow of pressurized hydraulic fluid from the pressurized hydraulic fluid source **74** to the first control valve **82**, through the safety valve **86**, and to the base of the transport wheel actuator **26**.
[0061] In step **128**, the actuation system automatically lowers the transport wheels **22** to the lowered position so that the bottom **30***b* of the transport wheels **22** are below the bottom **32** of the rear field wheel **22**. During this step, pressurized hydraulic fluid flows past the first control valve **82**, through the safety valve **86**, and into the base of the transport wheel actuator **26**. More specifically, before entering the base of the transport wheel actuator **26**, the hydraulic fluid passes through a first passage and a first one of the check valves **91** of the safety valve **86**. Transmission of the hydraulic fluid through the first passage of the safety valve **86** pilots open (via one of the pilot lines **92**) a second one of the check valves **91** of a second passage of the safety valve **86**, thereby allowing hydraulic fluid to flow out of a head of the transport wheel actuator **26**, back through the safety valve **86**, through the second control valve **84**, and back to the hydraulic system of the prime mover **72**.
[0062] As pressurized hydraulic fluid is charged to the base of the transport wheel actuator **26**, the transport wheel actuator **26** extends toward full stroke and the transport wheels **22** are lowered relative to the frame **12**. While the transport wheel actuator **26** is lowering the transport wheels **22**, the first control valve **82** inhibits/blocks the flow of hydraulic fluid therethrough to the base of the tongue actuator **36** and the second control valve **84** permits the flow of hydraulic fluid therethrough

from the head of the transport wheel actuator **26** to the hydraulic system of the prime mover **72**. Once the transport wheel actuator **26** reaches full stroke, the rear of the implement **10** is supported on the transport wheels **22** and the front of the implement is supported on the front field wheel **16**. At this point, the pressure of the hydraulic fluid supplied to the transport wheel actuator **26** exceeds a first threshold pressure of the first control valve **82**, thereby opening the first control valve **82**. With the first control valve **82** being opened, the pressurized hydraulic fluid is supplied through the first control valve **82** to the base of the tongue actuator **36** to commence extension of the tongue actuator **36** and folding of the tongue **18**.

[0063] In step **130**, the actuation system automatically folds the tongue **18** (thereby twisting the main body of the implement **10** relative to the tongue **18** and prime mover **72**) until the transport locking mechanism **46** locks the tongue **18** in the folded position. As mentioned above, when the first control valve **82** has been opened by the first threshold pressure being exceeded, the first control valve **82** permits flow of s the pressurized hydraulic fluid to the base of the tongue actuator **36** to extend the tongue actuator **36** and fold the tongue **18**. As the extending tongue actuator **36** folds the tongue **18**, this folding force causes the tongue **18** and the implement **10** to rotate relative to one another, while being supported on the two rear transport wheels **22** and the front field wheel **16** (with the rear field wheel **16** being lifted off the ground). Additionally, as the tongue **18** folds, the alignment bar **48**, pulls the brace bar **42** toward the frame **12** of the implement **10**. When the tongue actuator **36** reaches full extension, the transport locking mechanism **46** automatically locks the tongue **18** to the frame **12** in the folded position.

[0064] In step **132**, the operator initiates lifting of the prime mover's movable hitch (e.g., 3-point hitch) to raise the front field wheel **16** off the ground, so that the implement **10** is only supported by the rear transport wheels **22** and tongue **18** attached to the movable hitch of the prime mover **72**. The operator initiates raising of the prime mover's hitch by providing input at the input device **94** operably coupled to the hitch hydraulic controller **76**. With the tongue **18** being folded and locked to the frame **12** and both field wheels **16** being raised off the ground and hydraulically locked by the safety valve, the implement **10** is in the endwise transport configuration and is ready to be pulled over a road.

CLAIMS NOT LIMITED TO DISCLOSED EMBODIMENTS

[0065] Although specific embodiments of the present technology have been illustrated and described herein. The following claims should not be limited to specific features described and illustrated herein, unless the claims expressly require those specific features. For example, although certain claims may require the transport and tongue actuators to be hydraulic cylinders, claims that simply call for a transport actuator or a tongue actuator should not be limited to hydraulic cylinder, but should encompass a wide variety of linear or rotary actuators suitable for actuating the movements of the tongue and transport wheels described herein. Additionally, although the hydraulic circuit diagram of FIG. **8** illustrates a specific configuration of components for accomplishing sequential operation of the tongue and transport wheel actuators, other components may be suitable for accomplishing the same purpose. For example, rather than pilot operated valves, electronically operated valves and/or sensors could be used to direct hydraulic fluid to the proper components at the proper times.

Claims

1. A towable implement that is shiftable between a field configuration for operation in a field and an endwise transport configuration for transporting over a road, the implement comprising: a frame; one or more work mechanisms supported by the frame and configured to perform work in the field; a folding tongue pivotably coupled to the frame and shiftable between an unfolded position and a folded position, wherein the tongue is in the unfolded position when the implement is in the field configuration and the tongue is in the folded position when the implement is in the

endwise transport configuration; and a brace system for supporting the tongue in the unfolded position, wherein the brace system comprises a brace bar pivotally coupled to the frame and an alignment bar pivotally coupled to the tongue, wherein the brace bar and the alignment bar are pivotally coupled to one another.

2. The towable implement of claim 1, wherein the brace bar extends between the frame and the tongue and fixes the position of the tongue relative to the frame when the tongue is in the unfolded position, wherein the brace bar does not fix the position of the tongue relative to the frame when the tongue is not in the unfolded position.

3. The towable implement of claim 2, further comprising a field locking mechanism for releasably coupling the brace bar to the tongue when the tongue is in the unfolded position, further comprising a transport locking mechanism for releasably coupling the tongue to the frame when the tongue is in the folded position.

4. The towable implement of claim 3, wherein the field locking mechanism automatically locks the brace bar to the tongue when the tongue is shifted from the folded position to the unfolded position.

5. The towable implement of claim 4, wherein the field locking mechanism is spring loaded.

6. The towable implement of claim 1, wherein the alignment bar (i) pushes the brace bar away from the frame when the tongue shifts from the folded position to the unfolded position, (ii) pulls the brace bar toward the frame when the tongue shifts from the unfolded position to the folded position, and (iii) prevents the brace bar from pivoting away from the frame when the tongue is in the folded position.

7. The towable implement of claim 6, further comprising a transport locking mechanism for selectively locking the tongue to the frame when the tongue is in the folded position, wherein the transport locking mechanism automatically locks the tongue to the frame when the tongue is shifted from the unfolded position to the folded position.

8. The towable implement of claim 1, further comprising a plurality of field wheels for supporting the implement in the field configuration and a plurality of transport wheels for supporting the implement in the endwise transport configuration, wherein the field and transport wheels are oriented for travel in different directions.

9. The towable implement of claim 8, further comprising an actuation system for automatically shifting the implement between the field configuration and the endwise transport configuration, wherein the actuation system comprises a tongue actuator for shifting the tongue between the folded and unfolded positions and a transport wheel actuator for raising and lowering the transport wheels relative to the frame.

10. The towable implement of claim 1, wherein the tongue pivots through an angle of at least 100 degrees and not more than 160 degrees when shifted between the unfolded position and the folded position.

11. A towable implement that is shiftable between a field configuration for operation in a field and an endwise transport configuration for transporting over a road, the implement comprising: a frame; one or more work mechanisms supported by the frame and configured to perform work in the field; a plurality of field wheels for supporting the implement in the field configuration; a plurality of transport wheels for supporting the implement in the endwise transport configuration; a folding tongue pivotably coupled relative to the frame and shiftable between an unfolded position and a folded position, wherein the tongue is in the unfolded position when the implement is in the field configuration and the tongue is in the folded position when the implement is in the endwise transport configuration; and a field locking mechanism for selectively locking the tongue in the unfolded position, wherein the field locking mechanism includes a spring that is manually shiftable between a locking position for maintaining the tongue in the unfolded position and a releasing position for permitting shifting of the tongue out of the unfolded position.

12. The towable implement of claim 11, wherein the spring is a torsion spring.

13. The towable implement of claim 12, wherein the torsion spring has a central coil extending

along a central coil axis, a movable extension element extending from one end of the coil, and a biasing extension element extending from an opposite end of the coil, wherein the biasing and movable extension elements both extend away from the coil axis, wherein the movable extension element is manually shiftable between the locking position and the releasing position.

14. The towable implement of claim 13, wherein the locking mechanism includes a locking spring stop for retaining the movable extension element in the locking position and a releasing spring stop for retaining the movable extension element in the releasing position, wherein the field locking mechanism further includes a shiftable locking member, wherein the shiftable locking member is rotatable in a locking direction and a releasing direction, wherein the locking and releasing directions are opposite of one another, wherein the spring biases the shiftable locking member in the locking direction when the spring is in the locking position, wherein shifting the spring from the locking position to the releasing position urges the shiftable locking member in the releasing direction.

15. The towable implement of claim 14, wherein the field locking mechanism further comprises a fixed locking member that (i) is engaged and held by the shiftable locking member when the tongue is locked in the unfolded position and (ii) is not engaged and held by the shiftable locking member when the tongue is not in the unfolded position, further comprising a brace member pivotally coupled to the frame and supporting the tongue in the unfolded position, wherein the shiftable locking member is rotatably coupled to one of the tongue and the brace member and the fixed locking member is rigidly coupled to the other of the tongue and the brace member.

16. The towable implement of claim 15, wherein the shiftable locking member presents a displacement surface and a holding surface facing in different directions, wherein when the spring is in the locking position and the tongue is shifted from the folded position to the unfolded position (i) the fixed locking member engages the displacement surface of the latch and causes the latch to rotate in the releasing direction against the bias of the spring, (ii) the spring pivots the shiftable locking member in the locking direction until the holding surface of the latch engages the fixed locking member, and (iii) the spring holds the holding surface of the shiftable locking member in engagement with the locking pin to thereby lock the tongue in the unfolded position.

17. The towable implement of claim 16, wherein when the spring is shifted from the locking position to the releasing position, the spring urges the shiftable locking mechanism in the releasing direction so that the holding surface of the latch is released from engagement with the fixed locking member to thereby decouple the shiftable locking member and the fixed locking member.

18. The towable implement of claim 11, further comprising a transport locking mechanism for selectively locking the tongue to the frame when the implement is in the endwise transport configuration.

19. The towable implement of claim 11, further comprising an actuation system for automatically shifting the implement between the field configuration and the endwise transport configuration, wherein the actuation system comprises at least one tongue actuator for shifting the tongue between the folded and unfolded positions and at least one transport wheel actuator for raising and lowering the transport wheels relative to the frame.

20. A method of operating a towable implement having a frame, transport wheels attached to the frame, field wheels attached to the frame, and a folding tongue pivotally attached to the frame, the method comprising: (a) towing the implement over a road while the implement is in an endwise transport configuration where the tongue extends outwardly from a first end of the frame in a folded position and the bottom of the transport wheels are lower than the bottom the field wheels; (b) shifting the implement from the endwise transport configuration to a field configuration where the tongue extends outwardly from a first side of the frame in an unfolded position and the bottom of the field wheels are lower than the bottom the transport wheels; and (c) pulling the implement in a field with a prime mover attached to the tongue of the implement while the implement is in the field configuration, wherein the shifting of step (b) includes— (i) lowering the transport wheels

from a raised position to a lowered position using at least one transport wheel actuator, (ii) pivoting the tongue from the folded position to the unfolded position using at least one tongue actuator, (iii) moving a brace member from a collapsed configuration to a supporting configuration using an alignment bar pivotally coupled to the brace bar and tongue, and (iv) locking the brace member in the supporting configuration using a field locking mechanism, wherein the lowering, pivoting, moving, and locking are carried out without manual manipulation of the transport wheels, tongue, brace member, alignment bar, or field locking mechanism.

21. The method of operating a towable implement of claim 20, further comprising, prior to step (b), shifting the field locking mechanism into a field locking configuration, wherein the locking of step (iv) is accomplished by the field locking mechanism in the field locking configuration.

22. The method of operating a towable implement of claim 21, wherein the field locking mechanism is spring loaded.

23. The method of operating a towable implement of claim 22, wherein the shifting of the field locking mechanism includes manually moving a locking spring from a field locking position to a field releasing position.

24. The method of operating a towable implement of claim 20, wherein, during the towing of step (a), a transport locking mechanism locks the tongue to the frame in a folded position, wherein, during the pulling of step (c), the field locking mechanism locks the tongue in the unfolded position relative to the frame.