CLAIMS

1. An autonomous system for automatically coupling, without human involvement, at least one of an air line or an electrical line of a tractor to a trailer that is configured to be pulled by the tractor, wherein the tractor comprises a fifth wheel coupling that is configured to be coupled to a kingpin of the trailer, wherein a height of the fifth wheel coupling is adjustable, the system comprising:

a trailer coupling head mounted to the trailer and that comprises at least one of an air line connector or an electrical connector;

a fifth wheel coupling height control system controllable by the autonomous system and configured to automatically control the height of the fifth wheel coupling when it is coupled to the kingpin of the trailer, to control the height of the trailer coupling head during the automatic coupling of the at least one air line or electrical line of the tractor to the trailer;

a tractor coupling head that comprises at least one of an air line connector that is configured to be operably coupled to an air line connector of the trailer coupling head or an electrical connector that is configured to be operably coupled to an electrical connector of the trailer coupling head;

a tractor coupling head carrier that is configured to removably carry the tractor coupling head;

a tractor coupling head carrier control system that is configured to move the tractor coupling head carrier toward and away from the trailer coupling head along a longitudinal axis; and

a clamping mechanism carried by the tractor coupling head and configured to establish at least two alternative clamping states, one clamping state where the tractor coupling head is clamped to and carried by the tractor coupling head carrier such that the tractor coupling head is moved as the tractor coupling head carrier is moved, and a second clamping state where the tractor coupling head is clamped to the trailer coupling head such that the tractor coupling head carrier is free to move relative to the tractor coupling head.

2. The system of claim 1, wherein the trailer coupling head comprises mechanical features that are configured to engage with mechanical features of the tractor coupling head to provide for motions of the trailer coupling head along a vertical axis that is orthogonal to the longitudinal

axis, and motions of the tractor coupling head along a transverse axis that is orthogonal to both the vertical axis and the longitudinal axis.

3. The system of claim 1, further comprising a trailer coupling frame that carries at least one extending magnetic member that is constructed and arranged to removably couple to an underside of the trailer and thereby couple the trailer coupling frame to the trailer, wherein the trailer coupling head is supported by the trailer coupling frame.

4. The system of claim 3, further comprising a flexure between the trailer coupling head and the trailer coupling frame, wherein the flexure is constructed and arranged to provide vertical compliance of the trailer coupling head relative to the trailer.

5. The system of claim 4, wherein the flexure is more compliant in one vertical direction than it is in the other vertical direction.

6. The system of claim 4, wherein the flexure is further constructed and arranged to provide rotational compliance of the trailer coupling head relative to the trailer about the longitudinal axis.

7. The system of claim 3, further comprising a pair of air lines and an electrical line that are coupled to the trailer coupling head, and a strain relief and support mechanism carried by the trailer coupling frame and that supports the air lines and the electrical line, wherein the strain relief and support mechanism comprises a differentially flexible support structure that is more flexible in the transverse direction than it is in the longitudinal direction.

8. The system of claim 1, wherein the tractor further comprises an adjustable-angle boom that carries the fifth wheel coupling, and wherein the fifth wheel coupling height control system comprises a first sensor that senses the boom angle, a second sensor that senses an angle of the fifth wheel coupling, and a controller that is configured to automatically control the height of the fifth wheel coupling based on the sensed boom angle and the sensed fifth wheel coupling angle.

9. The system of claim 1, wherein the tractor coupling head carrier comprises a linkage mechanism that is configured to allow the tractor coupling head to move along a transverse axis that is orthogonal to the longitudinal axis, and to rotate about a vertical axis that is orthogonal to both the longitudinal axis and the transverse axis.

10. The system of claim 9, wherein the linkage mechanism comprises a four-bar linkage mechanism.

11. The system of claim 10, wherein the four-bar linkage mechanism comprises a fixed link, two grounded links that are pivotably coupled to the fixed link, and a floating link that is pivotably coupled to both grounded links.

12. The system of claim 11, wherein the tractor coupling head is removably coupled to the floating link.

13. The system of claim 12, wherein the floating link comprises opposed inwardly-angled funnel surfaces that are configured to engage with a mechanical feature of the trailer coupling head to provide for motion of the tractor coupling head along the transverse axis.

14. The system of claim 12, wherein the floating link comprises opposed upwardly-angled ramp surfaces that are configured to engage with a mechanical feature of the trailer coupling head to provide for motion of the trailer coupling head along the vertical axis.

15. The system of claim 9, wherein the tractor coupling head carrier further comprises a mechanical feature that is configured to engage with a centering funnel of the tractor as the tractor coupling head carrier is moved along the longitudinal axis away from the trailer coupling head toward the tractor to a home position relative to the tractor.

16. The system of claim 1, wherein the tractor coupling head carrier control system comprises a single degree of freedom linear actuator carried by the tractor and configured to move the tractor coupling head carrier toward and away from the trailer along the longitudinal axis.

17. The system of claim 1, wherein the clamping mechanism comprises a clamping arm configuration that alternately clamps to the tractor coupling head carrier and the trailer coupling head.

18. The system of claim 17, wherein:

the trailer coupling head comprises a trailer coupling head face with opposed ends and that carries two air seals and an electrical connector between the opposed ends, and the tractor coupling head comprises a tractor coupling head face with opposed ends and that carries two air

seals and an electrical connector between the opposed ends, wherein the air seals and electrical connectors of the two faces are configured to mate together when the tractor coupling head is clamped to the trailer coupling head;

the clamping arm configuration comprises two sets of clamping arms, one set proximate one end of the tractor coupling head face and the other set proximate the other end of the tractor coupling head face, wherein each set comprises a first arm that is configured to lock to the tractor coupling head carrier and a second arm that is configured to lock to the trailer coupling head; and

the clamping mechanism further comprises a rotary motor that is configured to move at least one set of clamping arms.

19. The system of claim 1, wherein the tractor coupling head further comprises mechanical features that are configured to engage with features of the trailer coupling head to align the tractor coupling head with the trailer coupling head by providing for motions of the trailer coupling head along a vertical axis that is orthogonal to the longitudinal axis, and motions of the tractor coupling head along a transverse axis that is orthogonal to both the vertical axis and the longitudinal axis.

20. A system for automatically coupling at least one of an air line or an electrical line of a tractor to a trailer that is configured to be pulled by the tractor, wherein the tractor comprises a fifth wheel coupling that is configured to be coupled to a kingpin of the trailer and an adjustable-angle boom that carries the fifth wheel coupling, wherein a height of the fifth wheel coupling is adjustable, the system comprising:

a trailer coupling head mounted to the trailer and that comprises at least one of an air line connector or an electrical connector;

a trailer coupling frame that carries at least one extending magnetic member that is constructed and arranged to removably couple to an underside of the trailer and thereby couple the trailer coupling frame to the trailer, wherein the trailer coupling head is supported by the trailer coupling frame;

a flexure between the trailer coupling head and the trailer coupling frame, wherein the flexure is constructed and arranged to provide vertical compliance of the trailer coupling head relative to the trailer, wherein the flexure is more compliant in one vertical direction than it is in

the other vertical direction, and wherein the flexure is further constructed and arranged to provide rotational compliance of the trailer coupling head relative to the trailer about a longitudinal axis;

a fifth wheel coupling height control system that is configured to automatically control the height of the fifth wheel coupling when it is coupled to the kingpin of the trailer, to control the height of the trailer coupling head, and comprises a first sensor that senses the boom angle, a second sensor that senses an angle of the fifth wheel coupling, and a controller that is configured to automatically control the height of the fifth wheel coupling based on the sensed boom angle and the sensed fifth wheel coupling angle;

a tractor coupling head that comprises at least one of an air line connector that is configured to be operably coupled to an air line connector of the trailer coupling head or an electrical connector that is configured to be operably coupled to an electrical connector of the trailer coupling head;

wherein the trailer coupling head comprises mechanical features that are configured to engage with mechanical features of the tractor coupling head to provide for motions of the trailer coupling head along a vertical axis that is orthogonal to the longitudinal axis, and motions of the tractor coupling head along a transverse axis that is orthogonal to both the vertical axis and the longitudinal axis;

a tractor coupling head carrier that is configured to removably carry the tractor coupling head and comprises a four-bar linkage mechanism that is configured to allow the tractor coupling head to move along the transverse axis, and to rotate about the vertical axis, and comprises a fixed link, two grounded links that are pivotably coupled to the fixed link, and a floating link that is pivotably coupled to both grounded links, wherein the tractor coupling head is removably coupled to the floating link, wherein the floating link comprises opposed inwardly-angled funnel surfaces that are configured to engage with a mechanical feature of the trailer coupling head to provide for motion of the tractor coupling head along the transverse axis, wherein the floating link comprises opposed upwardly-angled ramp surfaces that are configured to engage with a mechanical feature of the trailer coupling head to provide for motion of the trailer coupling head along the vertical axis, wherein the tractor coupling head carrier further comprises a mechanical feature that is configured to engage with a centering funnel of the tractor as the tractor coupling

head carrier is moved along the longitudinal axis away from the trailer coupling head toward the tractor to a home position relative to the tractor;

a tractor coupling head carrier control system that is configured to move the tractor coupling head carrier toward and away from the trailer coupling head along the longitudinal axis and comprises a single degree of freedom linear actuator carried by the tractor and configured to move the tractor coupling head carrier toward and away from the trailer along the longitudinal axis; and

a clamping mechanism carried by the tractor coupling head and configured to establish at least two alternative clamping states, one clamping state where the tractor coupling head is clamped to and carried by the tractor coupling head carrier such that the tractor coupling head is moved as the tractor coupling head carrier is moved, and a second clamping state where the tractor coupling head is clamped to the trailer coupling head such that the tractor coupling head carrier is free to move relative to the tractor coupling head, wherein the clamping mechanism comprises a clamping arm configuration that alternately clamps to the tractor coupling head carrier and the trailer coupling head.

21. A system for automatically coupling at least one of an air line or an electrical line of a tractor to a trailer that is configured to be pulled by the tractor, wherein the tractor comprises a fifth wheel coupling that is configured to be coupled to a kingpin of the trailer, wherein a height of the fifth wheel coupling is adjustable, the system comprising:

a trailer coupling head mounted to the trailer and that comprises at least one of an air line connector or an electrical connector;

a fifth wheel coupling height control system that is configured to automatically control the height of the fifth wheel coupling when it is coupled to the kingpin of the trailer, to control the height of the trailer coupling head;

a tractor coupling head that comprises at least one of an air line connector that is configured to be operably coupled to an air line connector of the trailer coupling head or an electrical connector that is configured to be operably coupled to an electrical connector of the trailer coupling head;

a tractor coupling head carrier that is configured to removably carry the tractor coupling head;

a tractor coupling head carrier control system that is configured to move the tractor coupling head carrier toward and away from the trailer coupling head along a longitudinal axis;

a clamping mechanism carried by the tractor coupling head and configured to establish at least two alternative clamping states, one clamping state where the tractor coupling head is clamped to and carried by the tractor coupling head carrier such that the tractor coupling head is moved as the tractor coupling head carrier is moved, and a second clamping state where the tractor coupling head is clamped to the trailer coupling head such that the tractor coupling head carrier is free to move relative to the tractor coupling head;

a trailer coupling frame that carries at least one extending magnetic member that is constructed and arranged to removably couple to an underside of the trailer and thereby couple the trailer coupling frame to the trailer, wherein the trailer coupling head is supported by the trailer coupling frame; and

a flexure between the trailer coupling head and the trailer coupling frame, wherein the flexure is constructed and arranged to provide vertical compliance of the trailer coupling head relative to the trailer.

22. A system for automatically coupling at least one of an air line or an electrical line of a tractor to a trailer that is configured to be pulled by the tractor, wherein the tractor comprises a fifth wheel coupling that is configured to be coupled to a kingpin of the trailer, wherein a height of the fifth wheel coupling is adjustable, the system comprising:

a trailer coupling head mounted to the trailer and that comprises at least one of an air line connector or an electrical connector;

a fifth wheel coupling height control system that is configured to automatically control the height of the fifth wheel coupling when it is coupled to the kingpin of the trailer, to control the height of the trailer coupling head;

a tractor coupling head that comprises at least one of an air line connector that is configured to be operably coupled to an air line connector of the trailer coupling head or an

electrical connector that is configured to be operably coupled to an electrical connector of the trailer coupling head;

a tractor coupling head carrier that is configured to removably carry the tractor coupling head;

a tractor coupling head carrier control system that is configured to move the tractor coupling head carrier toward and away from the trailer coupling head along a longitudinal axis; and

a clamping mechanism carried by the tractor coupling head and configured to establish at least two alternative clamping states, one clamping state where the tractor coupling head is clamped to and carried by the tractor coupling head carrier such that the tractor coupling head is moved as the tractor coupling head carrier is moved, and a second clamping state where the tractor coupling head is clamped to the trailer coupling head such that the tractor coupling head carrier is free to move relative to the tractor coupling head;

wherein the tractor coupling head carrier comprises a linkage mechanism that is configured to allow the tractor coupling head to move along a transverse axis that is orthogonal to the longitudinal axis, and to rotate about a vertical axis that is orthogonal to both the longitudinal axis and the transverse axis; wherein the linkage mechanism comprises a four-bar linkage mechanism; wherein the four-bar linkage mechanism comprises a fixed link, two grounded links that are pivotably coupled to the fixed link, and a floating link that is pivotably coupled to both grounded links; wherein the tractor coupling head is removably coupled to the floating link; and wherein the floating link comprises opposed inwardly-angled funnel surfaces that are configured to engage with a mechanical feature of the trailer coupling head to provide for motion of the tractor coupling head along the transverse axis.

23. A system for automatically coupling at least one of an air line or an electrical line of a tractor to a trailer that is configured to be pulled by the tractor, wherein the tractor comprises a fifth wheel coupling that is configured to be coupled to a kingpin of the trailer, wherein a height of the fifth wheel coupling is adjustable, the system comprising:

a trailer coupling head mounted to the trailer and that comprises at least one of an air line connector or an electrical connector;

a fifth wheel coupling height control system that is configured to automatically control the height of the fifth wheel coupling when it is coupled to the kingpin of the trailer, to control the height of the trailer coupling head;

a tractor coupling head that comprises at least one of an air line connector that is configured to be operably coupled to an air line connector of the trailer coupling head or an electrical connector that is configured to be operably coupled to an electrical connector of the trailer coupling head;

a tractor coupling head carrier that is configured to removably carry the tractor coupling head;

a tractor coupling head carrier control system that is configured to move the tractor coupling head carrier toward and away from the trailer coupling head along a longitudinal axis; and

a clamping mechanism carried by the tractor coupling head and configured to establish at least two alternative clamping states, one clamping state where the tractor coupling head is clamped to and carried by the tractor coupling head carrier such that the tractor coupling head is moved as the tractor coupling head carrier is moved, and a second clamping state where the tractor coupling head is clamped to the trailer coupling head such that the tractor coupling head carrier is free to move relative to the tractor coupling head;

wherein the tractor coupling head carrier comprises a linkage mechanism that is configured to allow the tractor coupling head to move along a transverse axis that is orthogonal to the longitudinal axis, and to rotate about a vertical axis that is orthogonal to both the longitudinal axis and the transverse axis; and wherein the tractor coupling head carrier further comprises a mechanical feature that is configured to engage with a centering funnel of the tractor as the tractor coupling head carrier is moved along the longitudinal axis away from the trailer coupling head toward the tractor to a home position relative to the tractor.