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Swannell et al.

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(54) **LANDING GEAR**

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(51) **Int. Cl.**[7] **B64C 25/12**
(52) **U.S. Cl.** ..... **244/102 A**; 244/102 R
(58) **Field of Search** ..... 244/102 R, 102 A, 244/102 SL

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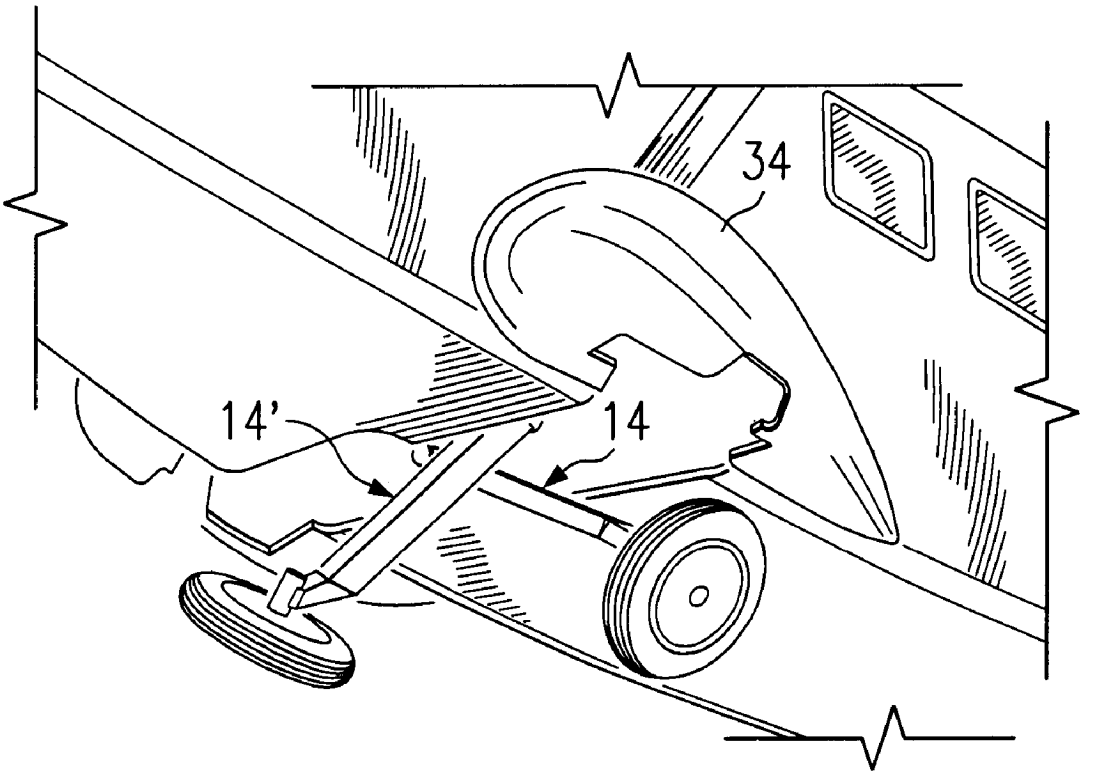
(57) **ABSTRACT**

A landing gear system for an aircraft comprising a pair of legs, each having a wheel at a distal end, a pivot point associated with each leg for allowing each leg to follow an arc-shaped path between a deployed position and a retracted position, one of the legs passing in front of the other while moving from the deployed position to the retracted position, and a linking assembly disposed between the legs for ensuring that the legs move from the deployed position to the retracted position in unison.

19 Claims, 13 Drawing Sheets



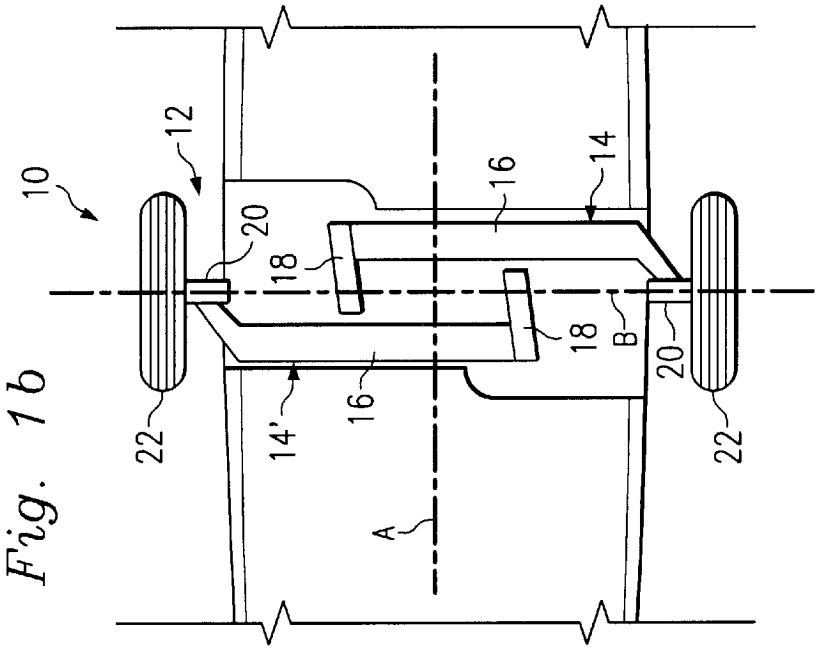


Fig. 1b

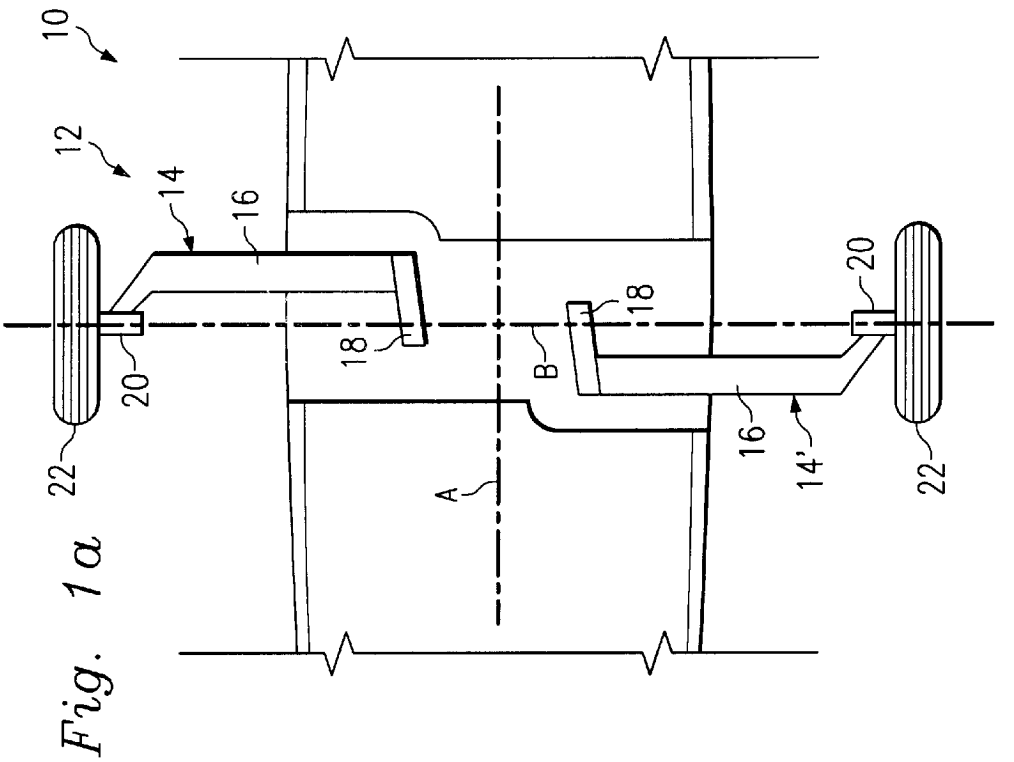


Fig. 1a

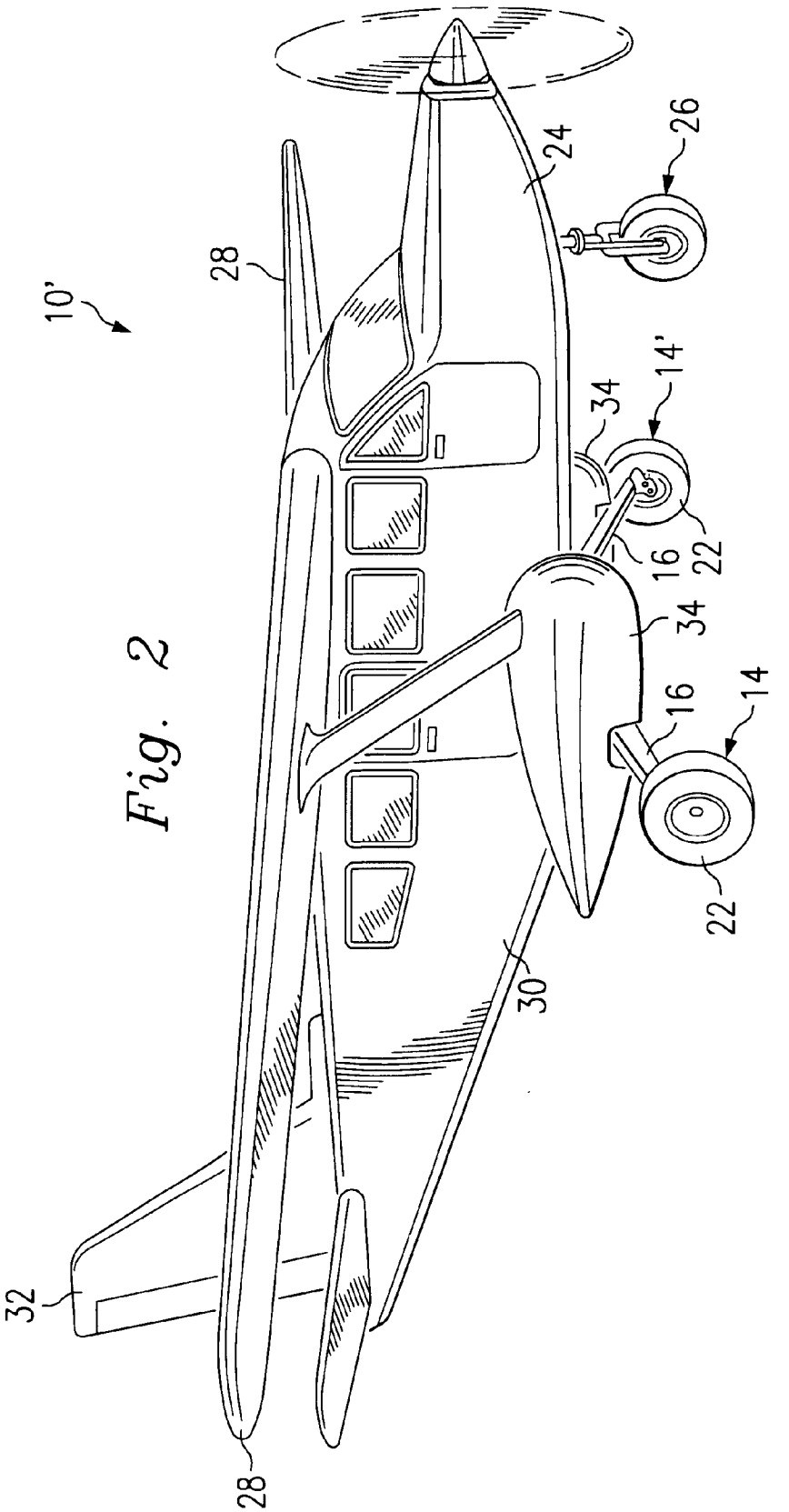


Fig. 2

Fig. 3a

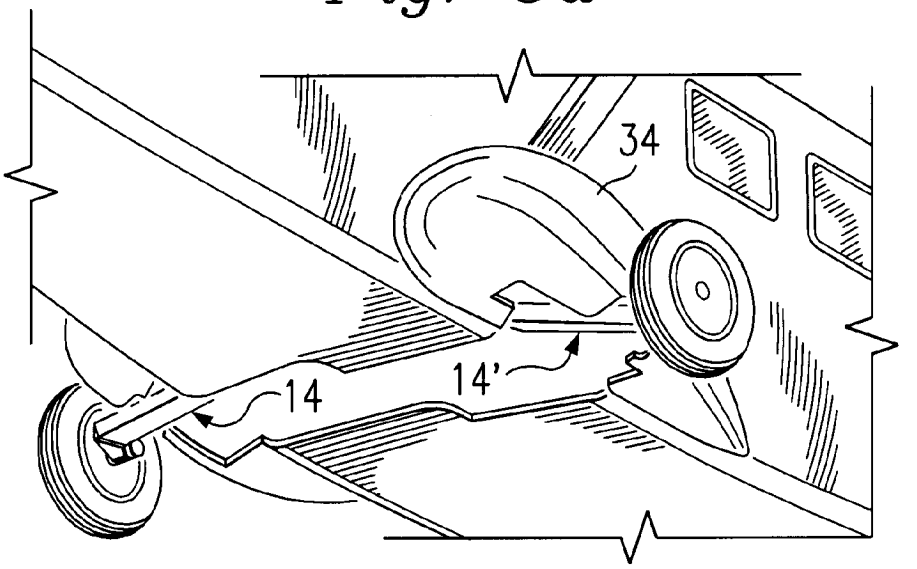
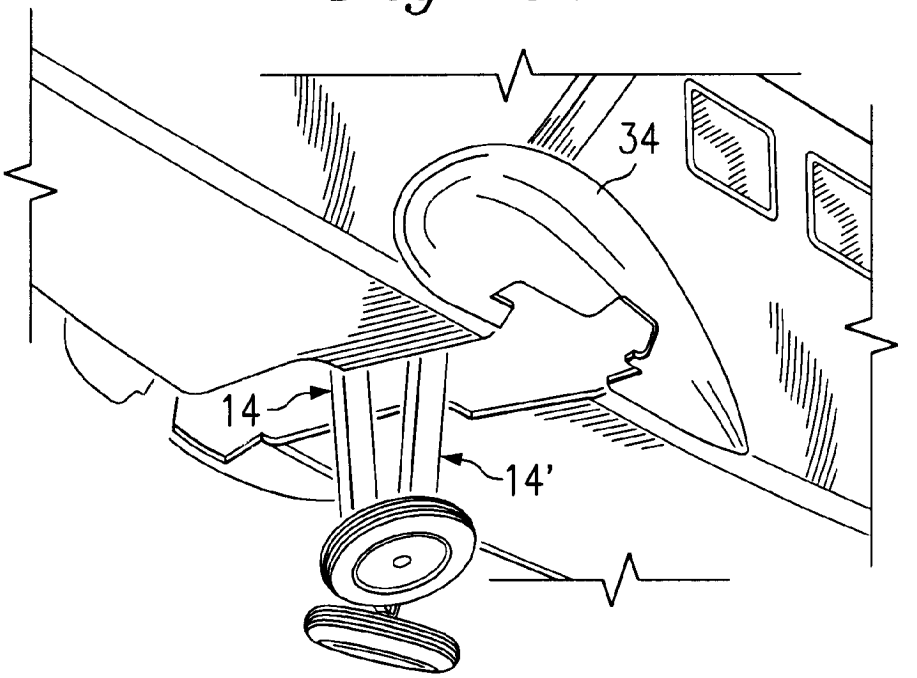


Fig. 3b



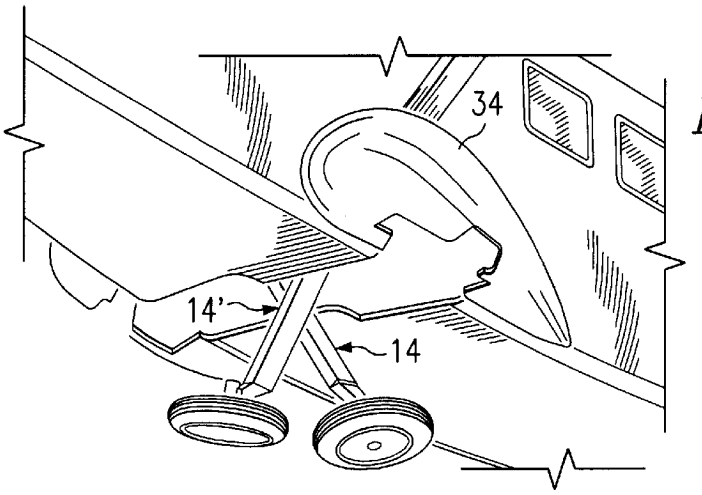


Fig. 3c

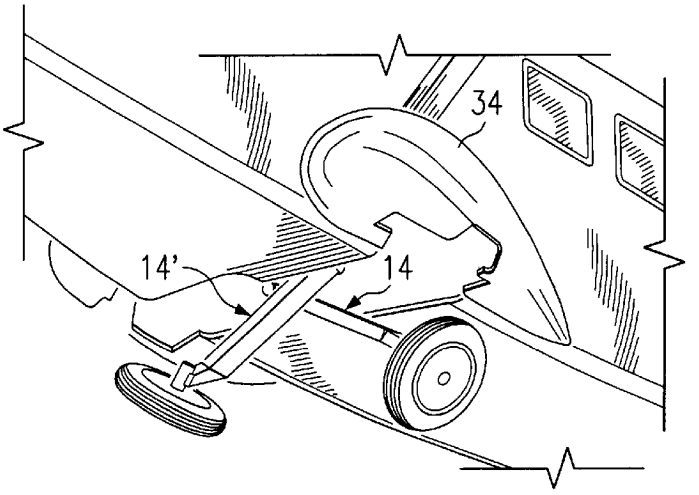


Fig. 3d

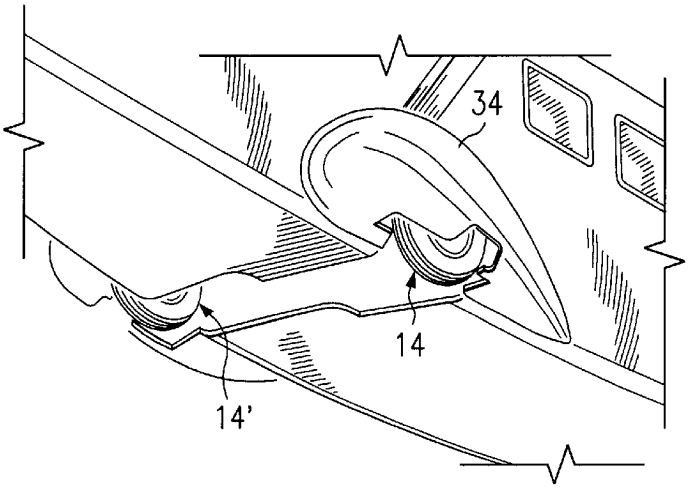
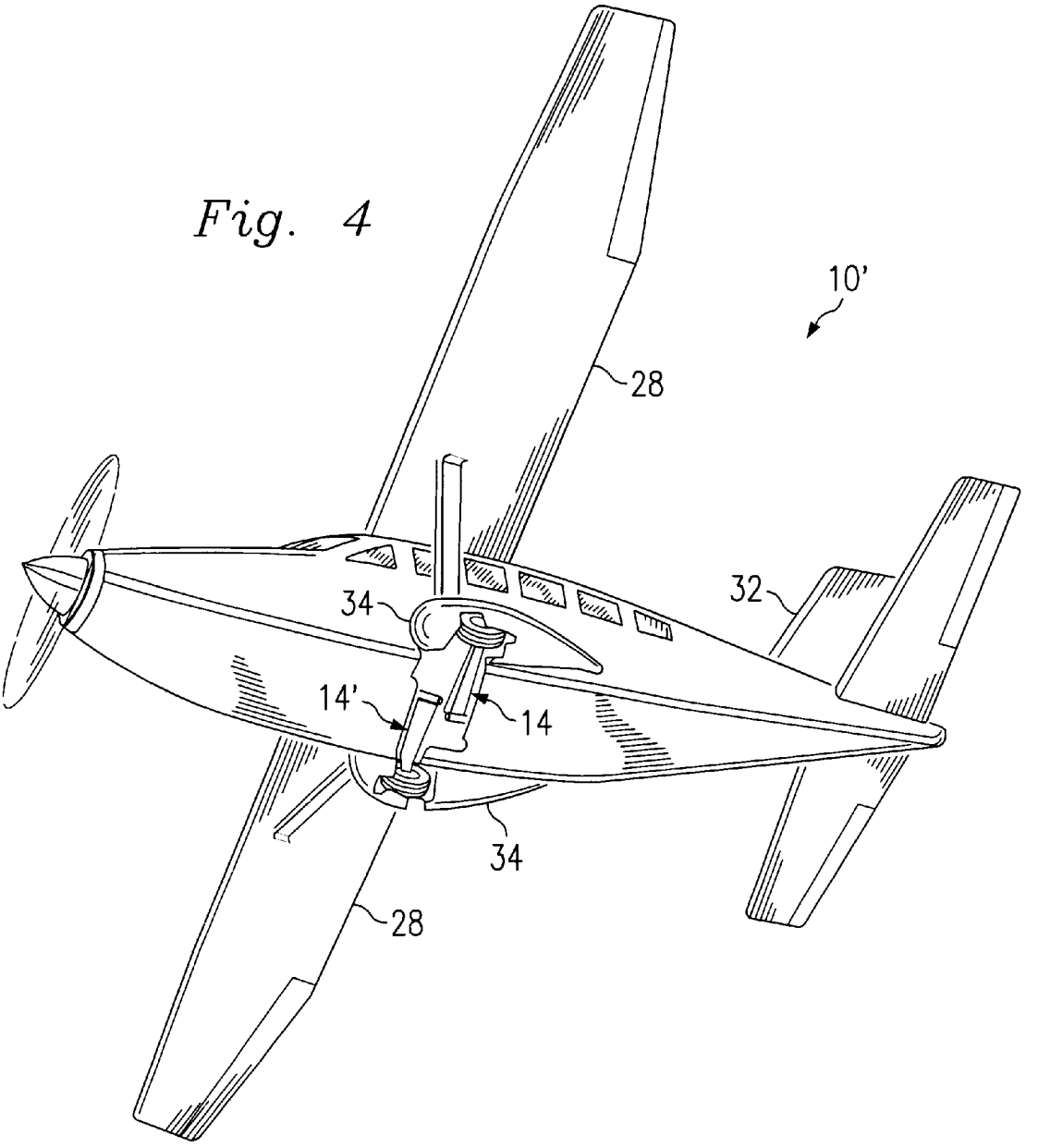


Fig. 3e

Fig. 4



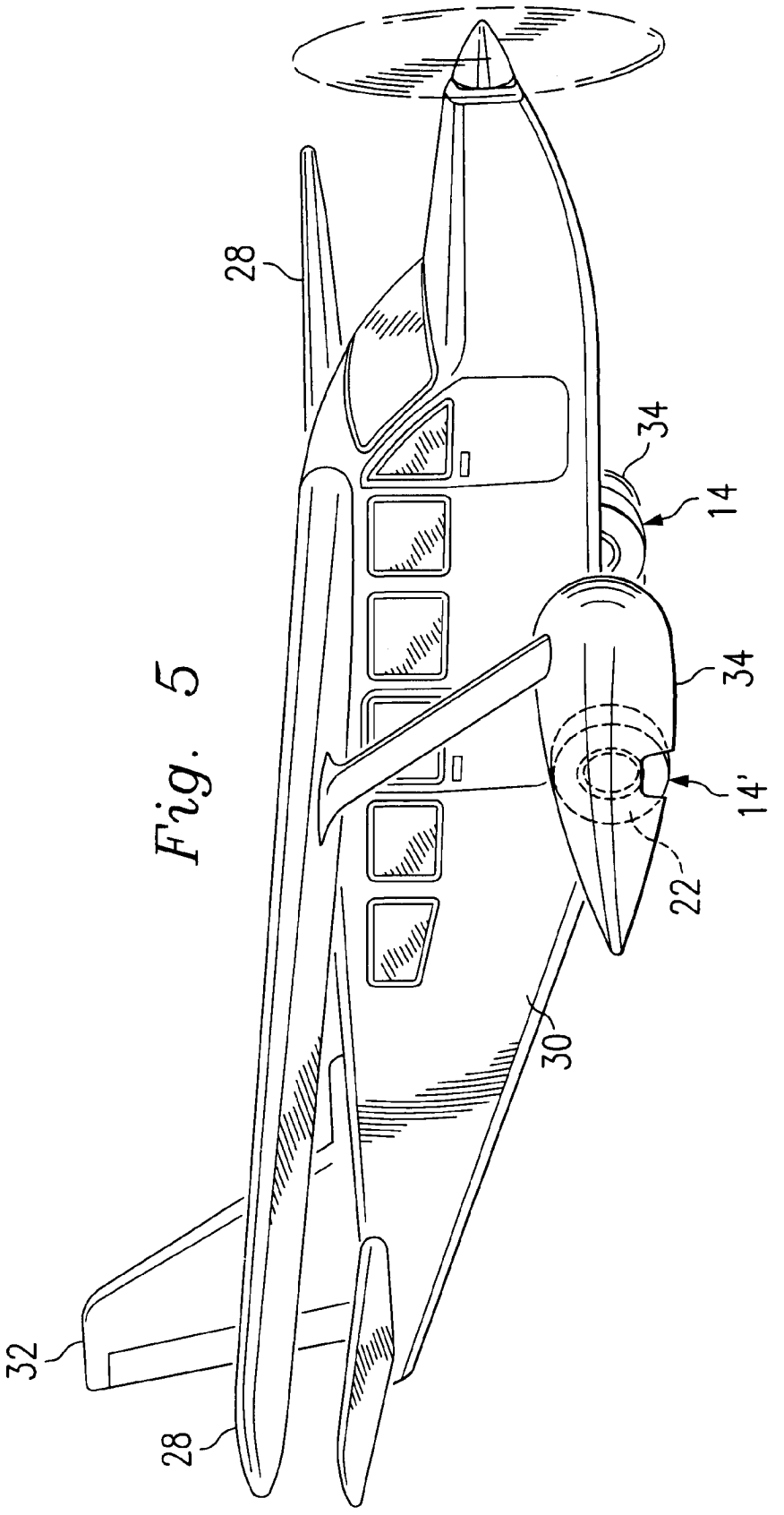
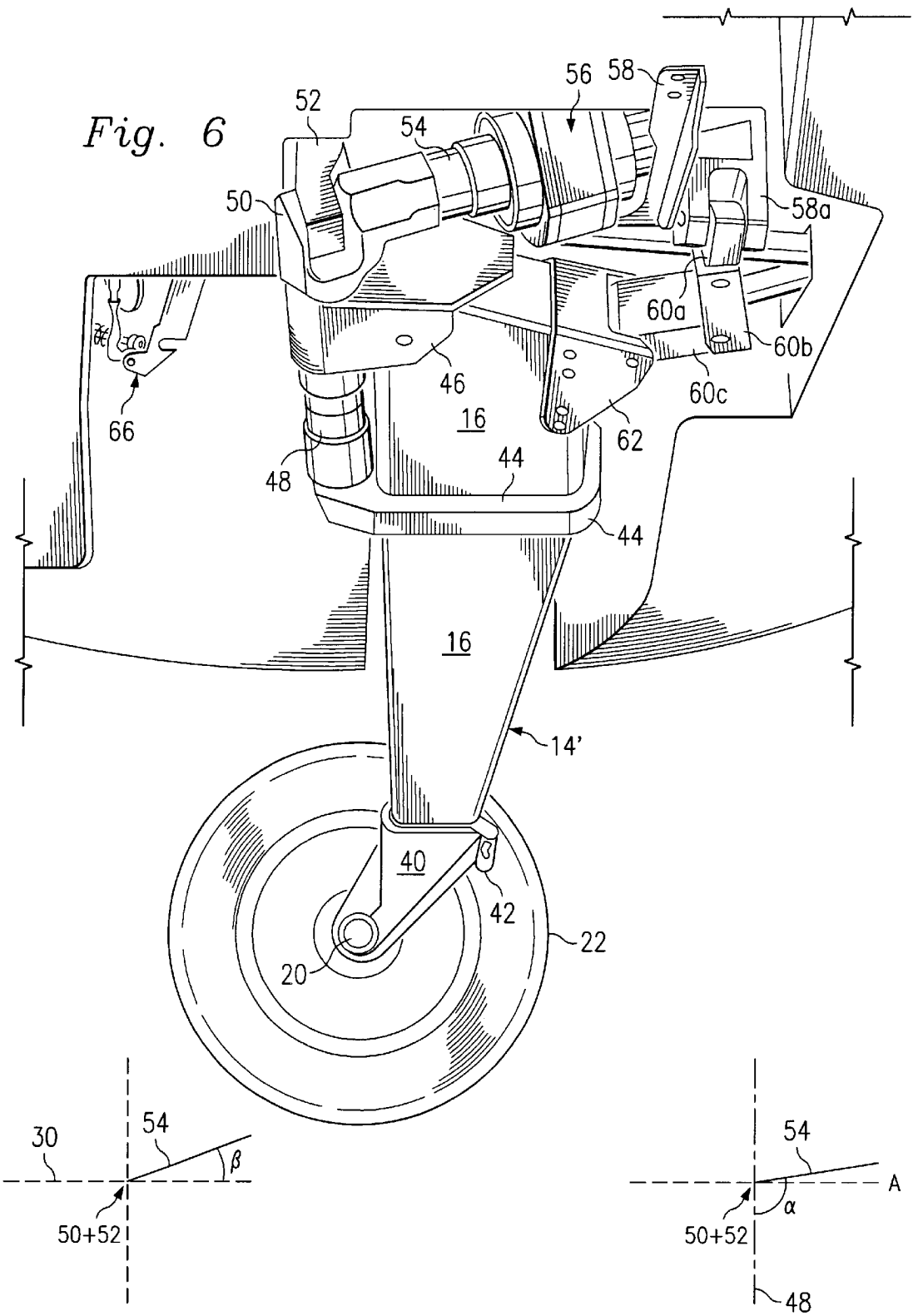


Fig. 5

Fig. 6



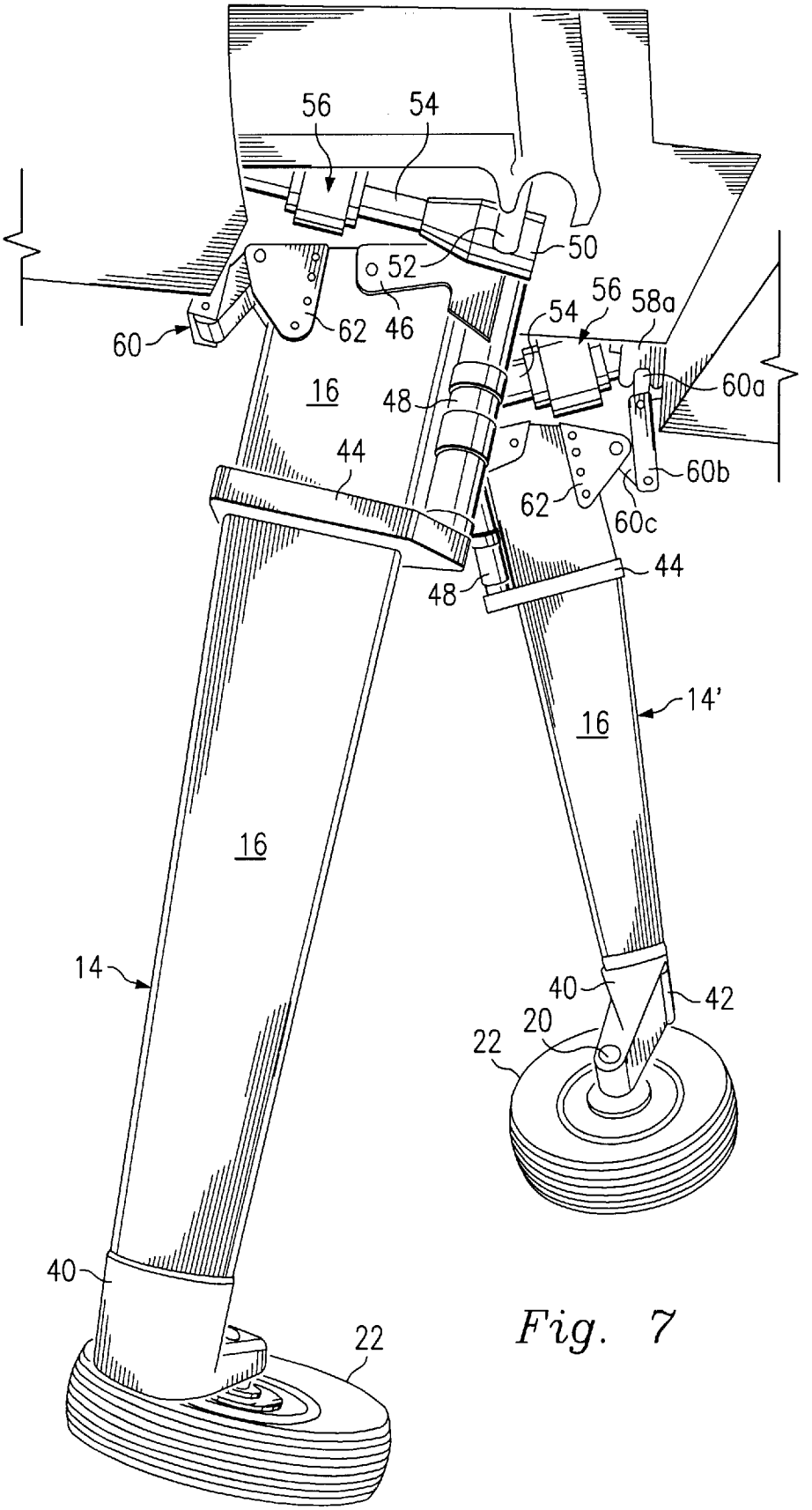


Fig. 7

Fig. 8

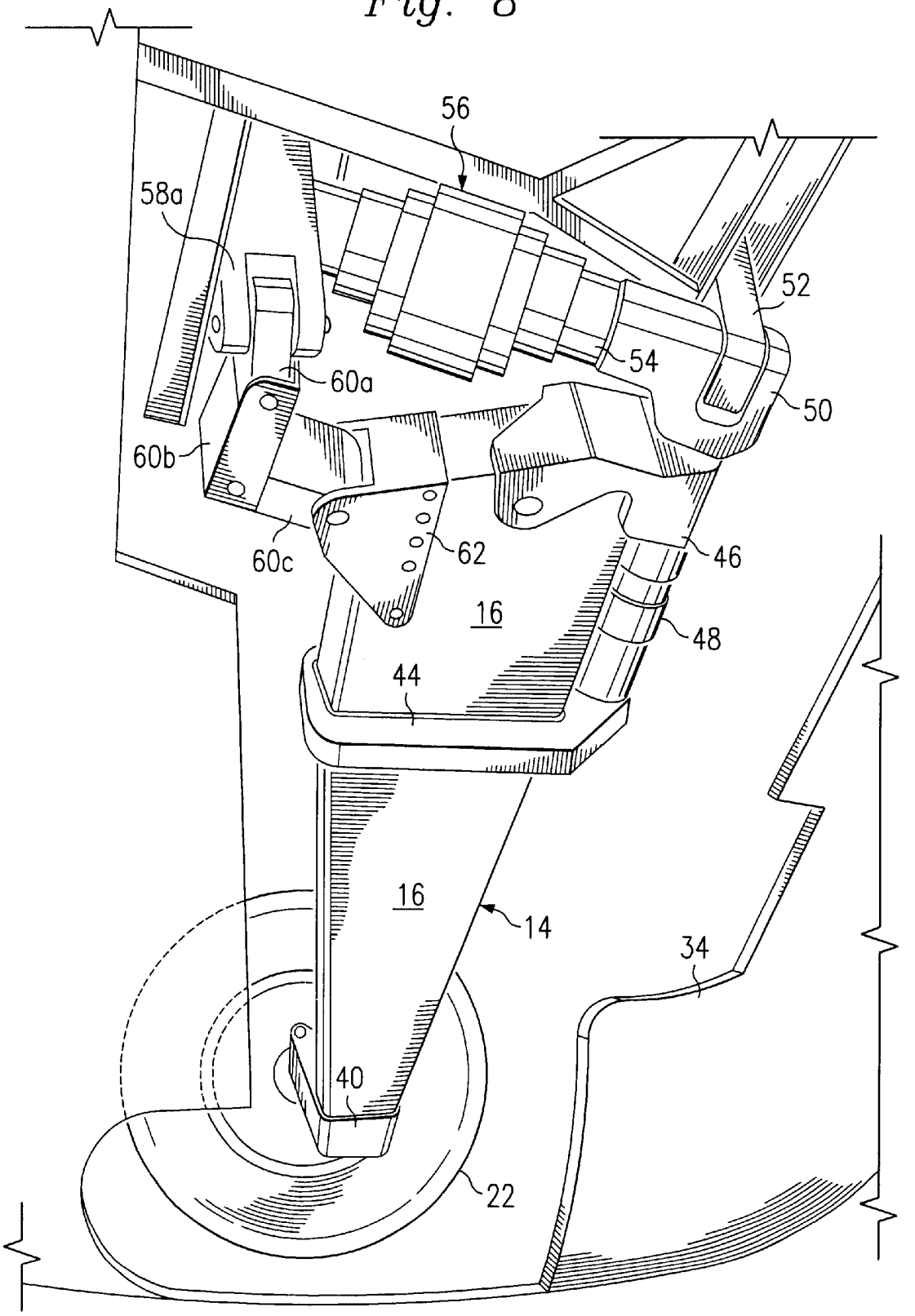
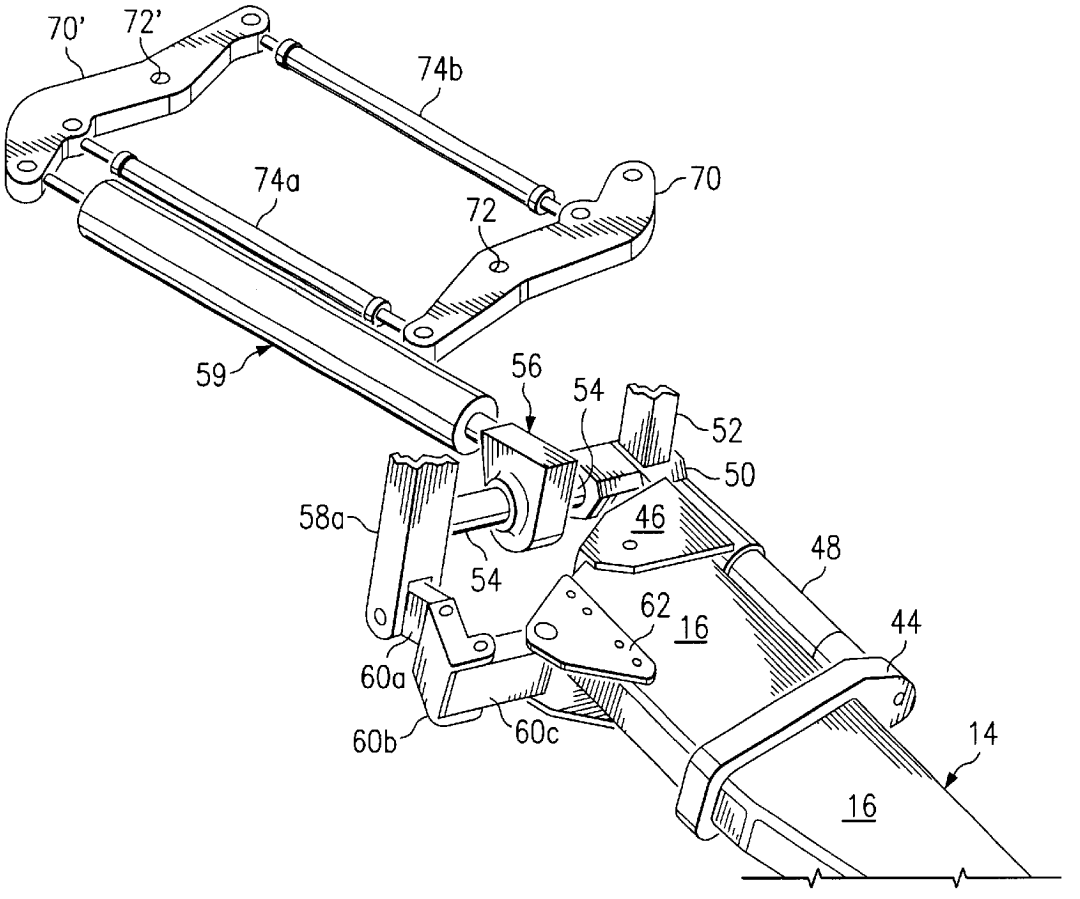


Fig. 9



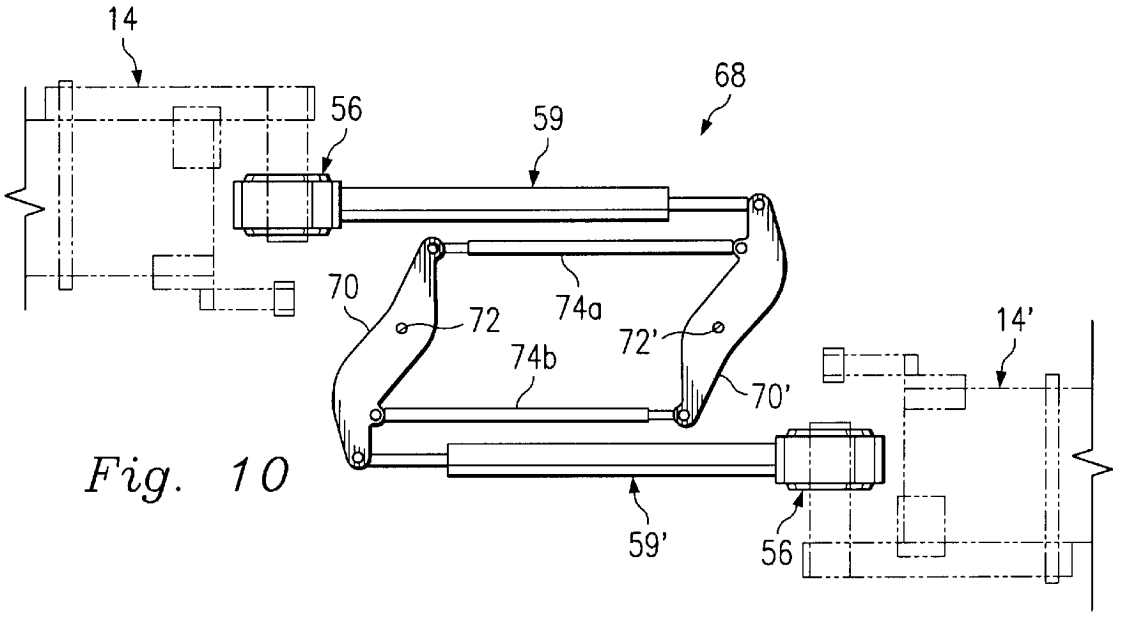


Fig. 10

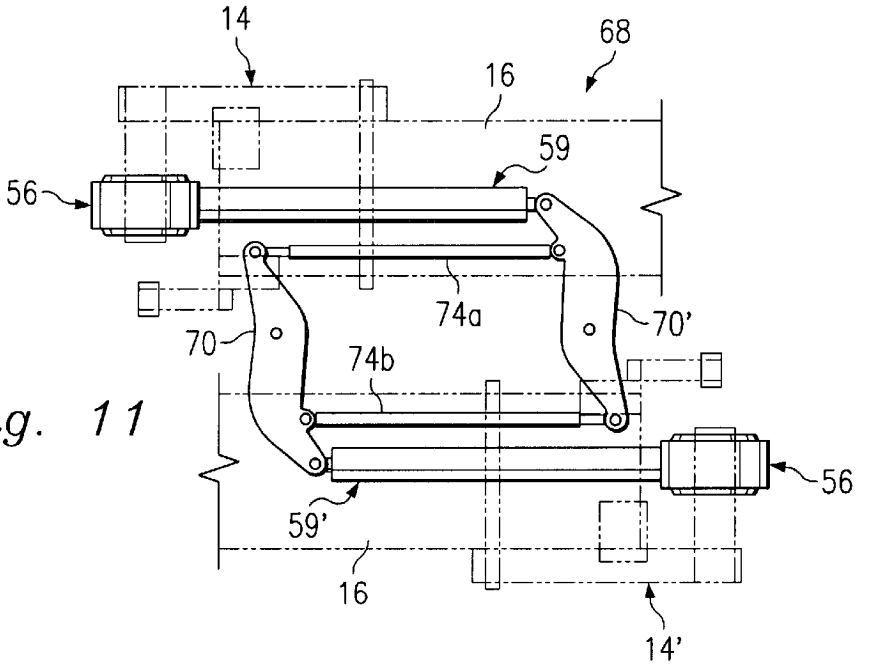
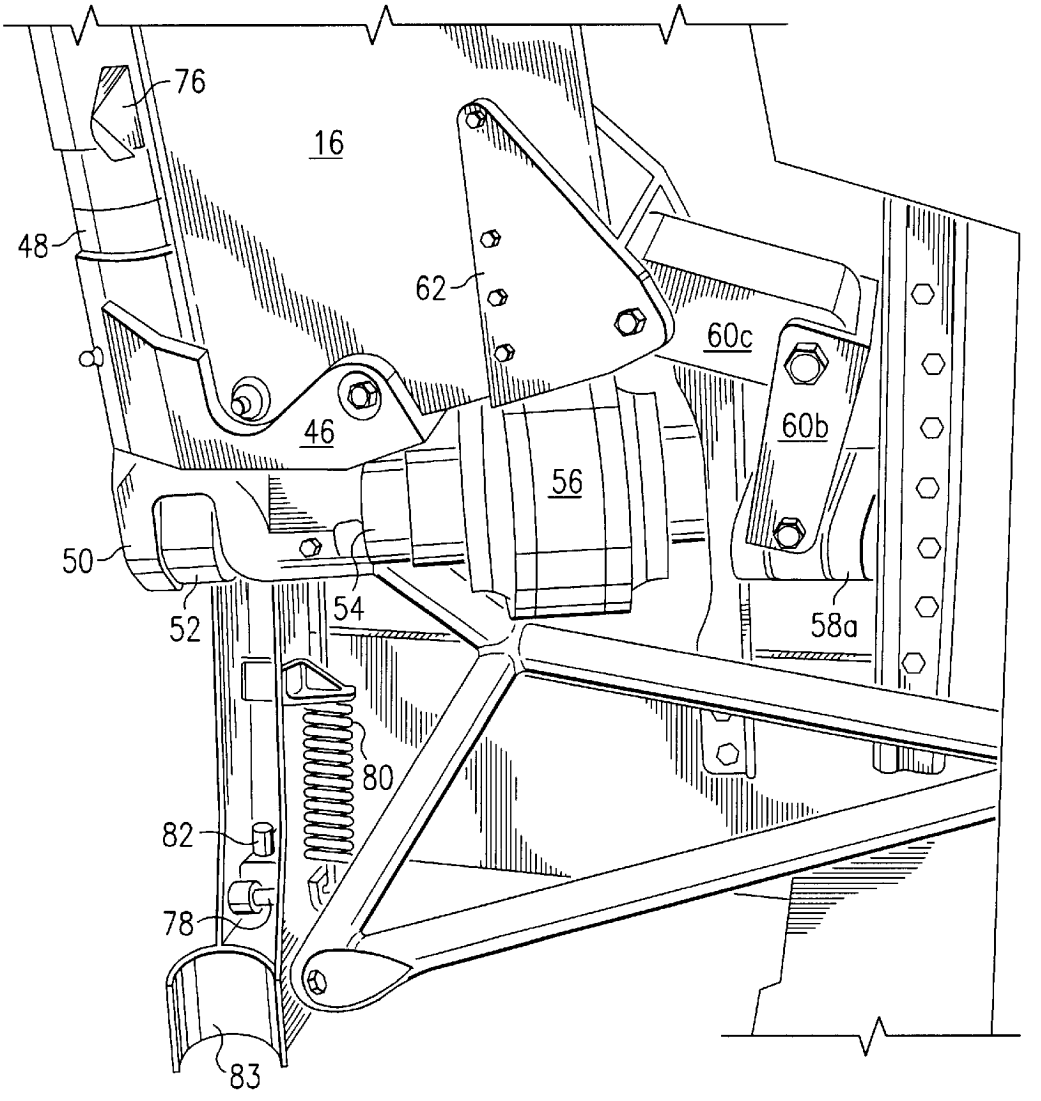


Fig. 11

Fig. 12



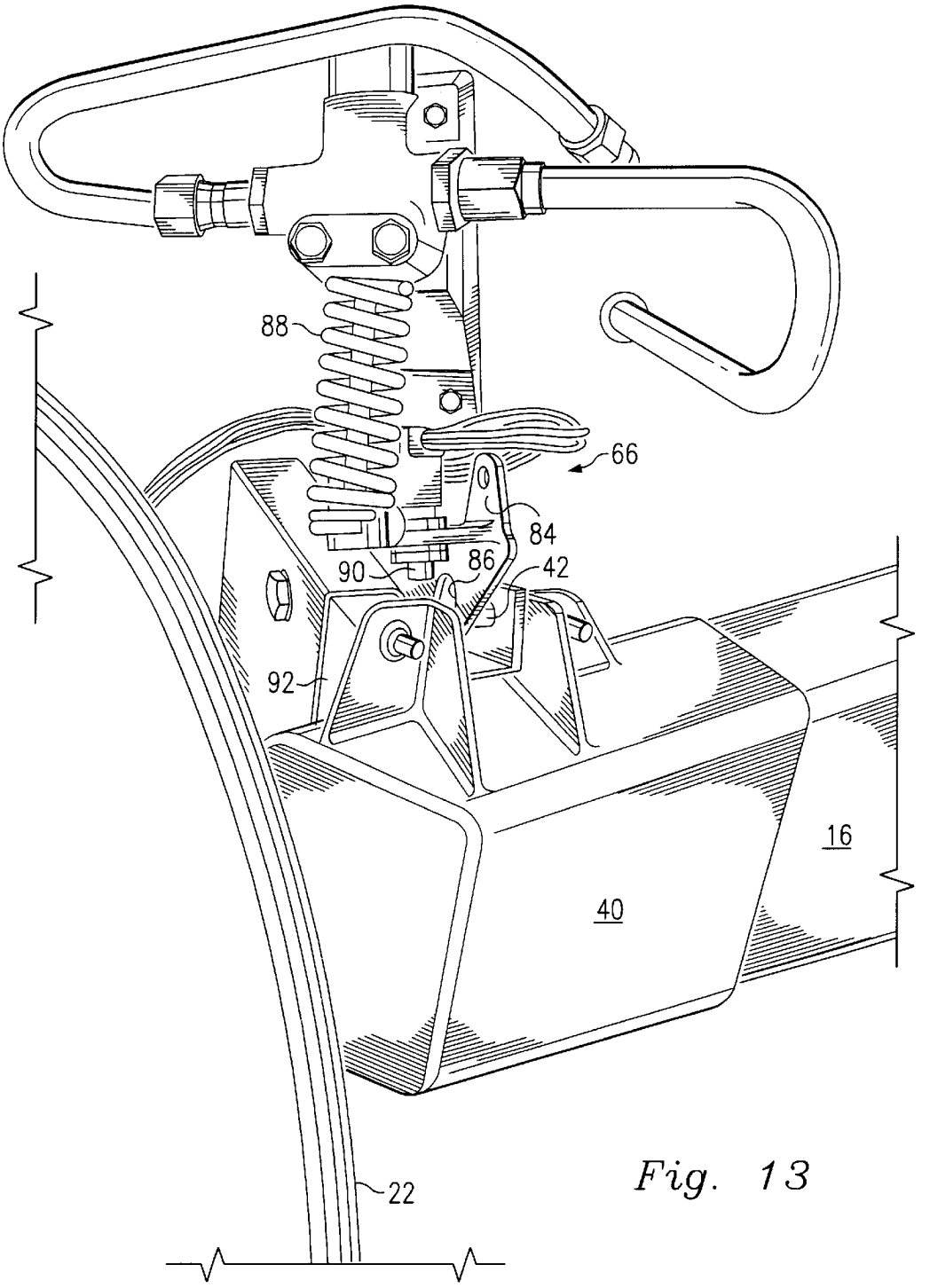


Fig. 13

LANDING GEAR

CROSS REFERENCE

This application claims the benefit of the U.S. Provisional applications Ser. No. 60/211,690 filed on Jun. 14, 2000 and Ser. No. 60/211,944 filed Jun. 16, 2000.

BACKGROUND

This invention relates to an improved retractable landing gear system for an aircraft.

Many aircraft are equipped with retractable landing gear to improve aerodynamics during flight. Such landing gear moves between a deployed (landing) position and a retracted (flying) position. As the landing gear is retracted and deployed during flight, it is important to create as little drag as possible.

However, previous retractable landing gear systems have several disadvantages. First, most landing gear is moved in a manner that presents an increased surface area of the landing gear to the airflow during retraction and deployment, thus undesirably increasing drag. Second, most landing gear is retracted into the fuselage or wing of the aircraft. This configuration can create structural problems that have to be addressed, and also complicates manufacture. Moreover, retaining the landing gear in the fuselage or wing limits the range of tire sizes that may be used, and takes up valuable space in the cargo or passenger areas of the aircraft.

Therefore, what is needed is a retractable landing gear system that does not take up space inside the aircraft, and reduces drag during retraction and deployment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1***a–b* are bottom diagrammatic views of an aircraft having landing gear according to one embodiment of the present invention.

FIG. **2** is a perspective view of an airplane with the landing gear in the deployed position.

FIGS. **3***a–e* are perspective views of the airplane with the landing gear in a series of intermediate positions moving between the deployed position to the retracted position.

FIG. **4** is a bottom perspective view of the airplane having the landing gear in the retracted position.

FIG. **5** is a side view of the airplane having the landing gear in the retracted position.

FIG. **6** is a broken away bottom perspective view of a leg of the landing gear shown in the deployed position.

FIG. **7** is a perspective view of the legs of the landing gear in an intermediate position between the deployed and retraction positions.

FIG. **8** is a broken away bottom perspective view of the leg of the landing gear shown in the retracted position.

FIG. **9** is a broken away top perspective view of the landing gear with the airplane removed.

FIG. **10** is a plan view of the linking assembly in the deployed position.

FIG. **11** is a plan view of the linking assembly in the retracted position.

FIG. **12** is a broken away bottom perspective view of a catch for the deployed position.

FIG. **13** is a broken away bottom perspective view of a catch for the retracted position.

DETAILED DESCRIPTION

FIGS. **1***a–b* shows an aircraft **10** equipped with retractable landing gear **12** of the present embodiment. The aircraft

10 may be an airplane, or a helicopter, or other aircraft requiring retractable landing gear. The retractable landing gear **12** is illustrated in the deployed position in FIG. **1***a* and the retracted position in FIG. **1***b*.

Turning to FIG. **1***a*, the retractable landing gear **12** comprises a pair of leg assemblies **14** and **14'**. For purposes of this specification, only one leg assembly will be discussed, and the same component reference numbers used, as the leg assemblies **14** and **14'** are identical. This is advantageous, as most conventional landing gear is composed of right-handed and left-handed legs, which complicates manufacture.

The leg assembly **14** comprises a leg **16**, attached to the aircraft **10** at a pivot point **18**. An axle **20** is located at the distal end of the leg **16**. The axle **20** is associated with a wheel **22**. It is understood that the wheel **22** may be replaced by a ski, float, or other ground contact member for support during landing and takeoff of the aircraft **10**.

An axis of symmetry, denoted by the reference numeral A, runs down the longitudinal axis of the aircraft **10**. In flight, the axis A is normally substantially aligned with airflow. A second axis of symmetry, denoted by the reference numeral B, runs transverse to axis A, and through the retractable landing gear **12**. Although the leg assemblies **14** and **14'** are oriented offset or antisymmetrical with respect to each other as a whole, the axles **20**, and therefore the wheels **22**, are aligned with axis B, and therefore with each other.

Turning to FIG. **1***b*, the leg assemblies **14** and **14'** pass by each other during retraction, as will be explained in greater detail with reference to the subsequent Figures. Thus, when in the retracted position, the wheel **22** associated with leg assembly **14** is on the opposite side of the aircraft **10** as compared to its deployed position (FIG. **1***a*).

Referring now to FIGS. **2**, **3***a–e*, and **4**, an airplane, given the reference numeral **10'**, is equipped with the retractable landing gear **12**. The retractable landing gear **12** is illustrated in the deployed position in FIG. **2**. The airplane **10'** has many conventional features, including a nose **24**, a nose wheel **26**, a wing **28**, a fuselage **30**, and a tail **32**.

A pair of pods **34** according to the present embodiment are attached to the fuselage **30**. As will be explained, when the retractable landing gear **12** is in the retracted position, each pod **34** receives the wheel **22** of the leg assemblies **14** or **14'** disposed opposite the pod. For example, with reference to FIG. **2**, in the retracted position, the near pod **34** receives the far wheel **22** (from leg assembly **14'**), and far pod **34** receives the near wheel (from leg assembly **14**). It is understood that the width of the pod **34** is a function of the size of the wheel **22**, and thus the present embodiment could allow use of a vast range of wheel sizes (including widths) by providing pods of appropriate dimensions.

To accomplish retraction from the deployed position (FIG. **2**), the leg **16** moves on the pivot point **18** through a series of intermediate positions (FIGS. **3***a–e*). Drag does not appreciably increase from the deployed position (FIG. **2**) to the intermediate positions (FIGS. **3***a–e*), as the wheels **22** remain substantially parallel to the airflow.

As can be seen from FIGS. **3***a–e*, the leg assemblies **14** and **14'** pass by each other during retraction. To avoid contact between the wheels **22**, the leg assemblies **14** and **14'** each move in an arc relative to axis B (FIGS. **1***a–b*). The radius of the arc required is dependent upon the radius of the wheel **22** used, as the wheels of the leg assemblies **14** and **14'** must pass each other at the midpoint of the intermediate position.

Finally, the leg assemblies **14** and **14'** reach the retracted position (FIG. **4**). This position is aerodynamically

favorable, but unlike conventional retractable landing gear, the retractable landing gear **12** of the present embodiment will support the fuselage **30** of the airplane **10'** in the event of an emergency landing.

One advantage of the present invention is that no landing gear doors are required, thus simplifying manufacture and preventing icing of the gear doors from becoming a safety factor. In one embodiment, the legs **16** are tapered in cross section, and thus more aerodynamic. Moreover, in this embodiment, the thinner cross section is rotated to allow a smaller aperture in the pod **34** for receiving the leg.

Referring to FIG. **5**, the wheels **22** project below the fuselage **30**. Thus, while the pods **34** may be damaged or destroyed during an emergency landing, landing with the landing gear in a retracted position can occur without significant damage to the fuselage **30** proper, as the wheels prevent the fuselage from making prolonged contact with the runway.

Referring now to FIGS. **6**, **7** and **8**, one embodiment of the retractable landing gear **12** is shown. Beginning with the wheel **22**, a wheel mounting **40** supports the wheel and axle **20**. The wheel mounting **40** is connected to one end of the leg **16**. It is understood that for simplicity of illustration, conventional landing gear components such as bearings, brakes, and other ancillary components are not depicted.

The wheel mounting **40** has an associated uplock roller **42**, which will be discussed in greater detail with reference to FIG. **13**.

The other end of the leg **16** is connected to the airplane **10'** via the pivot point **18**. In this embodiment, the pivot point **18** is formed by a group of components, as will be discussed.

A first bracket **44** surrounds the leg **16**. A second bracket **46** is disposed at the end of the leg **16**, and a first pivot member **48** extends between the first bracket **44** and the second bracket **46**. The pivot member **48** terminates in a U-shaped fitting **50**, which receives an extrusion **52** of the fuselage **30**, thus pivotally connecting the leg **16** to the airplane **10'**. In one embodiment, the extrusion **52** is part of a billet that runs across the airplane **10'**.

A second pivot member **54** is received in a side of the fitting **50**, and passes through a rack and pinion assembly **56** to be received by a first knuckle bracket **58**. The second pivot member **54** allows rotation of the leg **16** to be driven via the rack and pinion assembly **56**. In an alternative embodiment, the first pivot member **48**, the fitting **50**, and the second pivot member **54** may be replaced by one integral piece. Although a number of angles are contemplated between the first pivot member **48** and the second pivot member **54**, in one embodiment, an angle a is approximately ninety seven and a half degrees along a plane defined by the leg **16**.

Similarly, in one embodiment, an angle p between the second pivot member **54** and a horizontal plane, such as defined by the fuselage **30**, is approximately twenty five degrees. Together, these angles αand βcooperate to define the arc traveled by the leg assemblies **14** and **14'** relative to axis B (FIGS. **1***a–b*). It can be appreciated that while angle βis the same for both of the leg assemblies **14** and **14'**, upon installation in the airplane **10'**, the arcs of the respective leg assemblies **14** and **14'** will be mirror images of each other.

The first knuckle bracket **58** has a U-shaped end **58***a* for receiving a knuckle assembly **60**. The knuckle assembly **60** comprises a sequence of three pivotally connected intermediate members **60***a–c*. A second knuckle bracket **62** is disposed on the leg **16**, and connects to the knuckle member **60***c*. As the second pivot member **54** is positioned at an angle to the horizontal and the chosen plane of rotation of the leg **16**, the knuckle assembly **60** acts to translate the rotation about the second pivot member. As the leg **16** moves in its arc, the knuckle assembly **60** expands, contracts, and expands again to prevent binding.

An uplock assembly **66** is disposed adjacent to the landing gear, as will be discussed with reference to FIG. **13**. In summary, the uplock assembly **66** captures the uplock roller **42** of the opposite leg assembly **14** to retain the leg in the retracted position.

In one embodiment, the present invention allows the use of a spring leg (not depicted) to absorb the primary landing loads. This type of landing gear is also lighter than other types of landing gear that incorporate pneumatic (shock-absorber type) hardware.

Turning to FIG. **7**, the leg assemblies **14** and **14'** are shown in one of the intermediate positions. This intermediate position is characterized by rotation along the second pivot member **54**. The knuckle assembly **60** contracts to allow rotation, while still connecting the leg **16** to the airplane **10'**. The legs **16** stay apart as a result of the arcs they travel, and are able to pivot about the first pivot member **48**, which ensures that the legs may be maintained in the most aerodynamically efficient position.

Turning to FIG. **8**, the leg assembly **14** is shown in the retracted position, with the leg assembly **14'** and the uplock assembly **66** removed to simplify the Figure. The knuckle assembly **60** expands to accommodate the leg's **16** position, flat against the fuselage **30**. Also, the wheel **22** is drawn up into the pod **34**, creating minimal drag.

Referring now to FIGS. **9**,**10**, and **11**, the rack and pinion assembly **56** of each leg **16** is actuated by a ram **59** to produce rotation of the leg **16**. Turning to FIG. **9**, the ram **59** is connected to a linking assembly **68**, which is shaped substantially like a parallelogram. Although removed to simplify the Figure, it is understood that a second ram **59'**(FIG. **10** and FIG. **11**) is connected between the linking assembly **68** and the leg assembly **14** (not depicted). The linking assembly **68** is disposed between the leg assemblies **14** and **14'** to ensure that the legs **16** move in unison. This unison movement during retraction and deployment balances the drag experienced by the airplane **10'**.

The linking assembly **68** comprises a first pivot arm **70**, the first pivot arm turning on a pivot point **72** attached to the fuselage **30**. A pair of guide arms **74***a–b* are attached to the first pivot arm **70**, connecting the first pivot arm to a second pivot arm **70'**. The second pivot arm **70'** turns on a pivot point **72'** attached to the fuselage **30**.

Turning to FIG. **10**, the linking assembly **68** is shown in the deployed position (e.g., FIG. **6**). In this position, the rams **59** and **59'** are relatively extended. Turning to FIG. **11**, the linking assembly **68** is shown in the retracted position (e.g., FIG. **8**). In this position, the rams **59** and **59'**are relatively contracted.

Referring now to FIG. **12**, the leg **16** has a hook **76** which cooperates with a deployment catch **78**. The deployment catch **78** is releaseable, but acts to keep the leg **16** locked in the deployed position while engaged. The deployment catch **78** is biased by a spring **80**, and a sensor means **82** is provided to confirm deployment of the leg **16**. A cupped rest **83** is attached to the fuselage **30** and receives a portion of the first pivot member **48** when the leg **16** is in the deployed position. In one embodiment, the rest **83** is part of a billet that runs across the airplane **10'**. In operation, a pilot or other control means determines whether the landing gear need be retracted or deployed. For moving from the deployed posi-

tion of the landing gear **12** to the retracted position, the deployment catch **78** is released, the hydraulic rams **59** and **59'**(FIG. **10**) are activated by control means, causing the second pivot member **54**, and hence leg **16**, to rotate via the rack and pinion assembly **56**. The leg assemblies **14** and **14'** pass through the intermediate positions, rotating along the first pivot member **48** as well, eventually reaching a point where the leg **16** rests against the fuselage **30**.

Referring now to FIG. **13**, the uplock assembly **66** captures the uplock roller **42** (FIG. **6**) of the leg **16** to retain the leg in the retracted position. The uplock assembly comprises a retraction catch **84** having a slot **86** for engaging the uplock roller **42**. The retraction catch **84** is releaseable, but acts to keep the leg **16** locked in the retracted position while engaged. The retraction catch **84** is biased by a spring **88**, and a sensor means **90** is provided to confirm retraction of the leg **16**. The leg **16** rests against a stop **92** in the retracted position.

For moving from the retracted position of the landing gear **12** to the deployed position, the retraction catch **84** (FIG. **13**) is released, the hydraulic rams **59** and **59'**(FIG. **10**) are activated by control means, causing the second pivot member **54**, and hence leg **16**, to rotate via the rack and pinion assembly **56**. The leg assemblies **14** and **14'** pass through the intermediate positions, rotating along the first pivot member **48** as well, eventually reaching a point where the leg **16** rests against the rest **83**. Simultaneously, the deployment catch **78** (FIG. **12**) captures the hook **76** of the leg **16** to retain the leg in the deployed position.

One advantage of the previously described embodiments is that it teaches a retractable landing gear system that does not take up space in the airplane's cargo area, and reduces drag during retraction and deployment.

Another advantage of the previously described embodiments is that it is scalable to larger aircraft. For example, in prior systems for retractable landing gear for smaller aircraft, the wheels are retracted towards the rear of the plane into wheel wells within the fuselage of the plane. The wheel wells are located behind the last row of seats in the aircraft. This prior design would not scale well with increased aircraft size because the wheel wells would take up valuable passenger space in the cabin.

However, the present embodiment, with it's lateral displacement of the wheels below the fuselage, does not suffer from such problems. Elimination of wheel wells inside the fuselage preserves flat floor space in the interior of the aircraft for cargo and or passengers.

It is understood that all spatial references, such as vertical, horizontal, radial, and lateral are only for the purposes of explanation of the drawings. This disclosure shows and describes illustrative embodiments, however, the disclosure contemplates a wide range of modifications, changes, and substitutions. Such variations may employ only some features of the embodiments without departing from the scope of the underlying invention. Accordingly, any appropriate construction of the appended claims will reflect the broad scope of the underlying invention.

What is claimed is:

1. A landing gear system for an aircraft comprising:

a pair of legs, each having a wheel at a distal end;

a pivot point associated with each leg for allowing each leg to follow an arc-shaped path between a deployed position and a retracted position, one of the legs passing in front of the other while moving from the deployed position to the retracted position; and

a linking assembly disposed between the legs for ensuring that the legs move from the deployed position to the retracted position in unison.

2. The system of claim **1** further comprising pods mounted to the aircraft for receiving the wheels in the retracted position.

3. The system of claim **1** further comprising a knuckle assembly attached to each leg to encourage each leg to follow the arc-shaped path between the deployed position and the retracted position.

4. The system of claim **1** wherein the linking assembly comprises:

a first rack and pinion assembly attached to a first of the legs;

a second rack and pinion assembly attached to a second of the legs;

first and second rams for actuating the first and second rack and pinion assemblies;

a first pivot arm attached to the first ram, and a second pivot arm attached to the second ram, each pivot arm turning on a pivot point, the first and second pivot arms being linked by a pair of guide arms to allow unison movement of the legs.

5. The system of claim **1** wherein the pivot point comprises:

an extrusion; and

first and second pivot members attached to each of the legs and pivotally mounted to the extrusion at a set of predetermined angles.

6. The system of claim **1** wherein the wheels extend below a fuselage of the aircraft in the retracted position.

7. The system of claim **1** further comprising a deployment catch associated with each leg to lock the leg in the deployed position.

8. The system of claim **1** further comprising an uplock assembly associated with each leg to retain the leg in the retracted position.

9. A method for retracting landing gear in an aircraft, comprising:

providing a pair of identical spring legs;

pivotally connecting the legs to the aircraft;

rotating the legs in a plane transverse to the longitudinal axis of the aircraft, thereby moving the legs between a deployed position and a retracted position;

passing one leg in front of the other, such that a wheel on a first side of the aircraft in the deployed position is on a second opposite side of the longitudinal axis of the aircraft in the retracted position, wherein the pair of identical spring legs are mounted on the aircraft such that a longitudinal axis of each leg is substantially perpendicular to the longitudinal axis of the aircraft at both the deployed and the retracted positions of the pair of identical spring legs.

10. The method of claim **9** further comprising linking the legs to allow them to move in unison.

11. A landing gear system for an aircraft comprising:

a pair of anti-symmetrically oriented spring legs for moving between a deployed position and a retracted positions the retracted position of the wheel being located on the opposite side of the longitudinal axis of the aircraft from the deployed position, wherein the pair of anti-symmetrically oriented spring legs are mounted on the aircraft such that an longitudinal axis of each leg is substantially perpendicular to the longitudinal axis of the aircraft at both the deployed and the retracted positions of the pair of sprig legs; and

means for passing one leg in front of the other while moving from the deployed position to the retracted position.

12. The system of claim 11 wherein each leg follows an arc-shaped path between the deployed position and the retracted position.

13. The system of claim 11 further comprising a linking assembly disposed between the legs for ensuring that the legs move from the deployed position to the retracted position in unison.

14. The system of claim 11 further comprising a knuckle assembly attached to each leg to encourage each leg to follow an arc-shaped path between the deployed position and the retracted position.

15. The system of claim 11 wherein the means for passing one leg in front of the other while moving from the deployed position to the retracted position is a pivot point mounted at a set of predetermined angles.

16. The system of claim 11 wherein the means for passing one leg in front of the other while moving from the deployed position to the retracted position comprises:

an extrusion; and

first and second pivot members attached to each of the legs and pivotally mounted to the extrusion at a set of predetermined angles.

17. The system of claim 16 wherein the angles comprise:

an angle of approximately ninety seven and a half degrees between the first pivot member and the second pivot member along a plane defined by the leg; and

an angle of approximately twenty five degrees between the second pivot member and a horizontal plane.

18. The system of claim 11 further comprising a deployment catch associated with each leg to lock the leg in the deployed position.

19. The system of claim 11 further comprising an uplock assembly associated with each leg to retain the leg in the retracted position.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,464,168 B1
DATED : October 15, 2002
INVENTOR(S) : Graham Swannell et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 3,
Line 50, change “angle a” to -- angle α --.
Line 53, change “angle p” to -- angle β --.
Line 56, change “αand βcooperate” to -- α and β cooperate --.
Line 59, change “βis” to -- β is --.

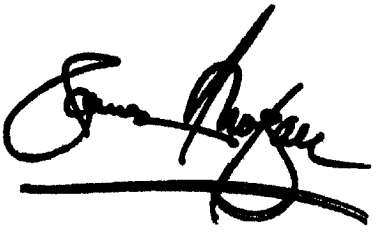
Column 4,
Line 38, change “59'(FIG.” to -- 59' (FIG. --.
Line 54, change “59'are” to -- 59' are --.

Column 5,
Lines 3 and 20, change “59'(FIG.” to -- 59' (FIG. --.

Column 6,
Line 57, change “positions” to -- position, --.

Signed and Sealed this

Fifteenth Day of April, 2003



JAMES E. ROGAN
Director of the United States Patent and Trademark Office