

BOOM MEMBER FOR REFUELING AIR VEHICLES

TECHNOLOGICAL FIELD

The presently disclosed subject matter relates to in-flight refueling systems for refueling air vehicles, in particular to boom-type in-flight refueling systems.

5 BACKGROUND

Airborne refueling (also referred to interchangeably herein as air refueling, in-flight refueling, air to air refueling (AAR), aerial refueling, tanking, and the like) refers to the process of transferring fuel from a tanker aircraft to a receiver aircraft during flight.

Two types of airborne refueling systems are currently in use for refueling airborne
10 military aircraft:

- the so-called “hose and drogue” system, used by the US Navy and many non-US air forces;
- the so-called “boom and receptacle” or “flying boom” system, used by the US Air Force, and also used by Israel, Turkey and the Netherlands.

15 In the hose and drogue system, the refueling aircraft is provided with one or more non-rigid refueling lines, at the end of each of which there is a drogue which functions as a stabilizer and includes a receptacle, while the receiver aircraft is fitted with a probe that is configured for engaging with the receptacle. In use, the drogue is not actively controlled, but rather aligns itself freely in the airflow aft of the tanker. The pilot of the
20 receiver aircraft controls the flight path thereof to ensure engaging contact between the probe and the receptacle. Thereafter, the receiver aircraft is refueled via the refueling line and probe.

In the conventional boom and receptacle system, the tanker includes a so-called “flying boom”, which is a rigid tube that telescopes outwardly and is gimbaled to the rear
25 of the tanker aircraft, and is otherwise retracted towards the tanker fuselage when not in

- 2 -

use. The boom carries a fuel line and comprises a fuel transfer nozzle at the end thereof, and the boom is equipped with adjustable flight control surfaces. Once the tanker and receiver aircraft are in close proximity and flying in formation, with the receiver aircraft at a position behind the tanker within an air refueling envelope (i.e., safe limits of travel

5 for the boom with respect to the receiver aircraft and within which contact between the receiving aircraft and the boom is safe), a dedicated operator in the tanker controls the position of the boom via the control surfaces, and inserts the end of the boom including the nozzle into a receptacle provided on an upper part of the receiving aircraft, ensuring proper mating between the nozzle and receptacle, after which fuel transfer can begin.

10 During refueling, and while the boom is engaged with the receptacle, the pilot of the receiver aircraft must continue to fly within the air refueling envelope, and if the receiver aircraft approaches these limits the operator in the tanker requires the receiver aircraft pilot to correct the position thereof, and if necessary the boom is disconnected to prevent accidents. All current tankers of this type carry a single boom and can refuel a single

15 receiver aircraft of this type at a time.

In addition, there are some tankers that comprise a flying boom system and at least one hose and drogue system as well, and are commonly known as Multi-Point Refueling Systems (MPRS). In some cases a hose and drogue system is provided at the aircraft tail, and thus only this system or the flying boom system may be used at any one time. In other

20 cases, two under-wing hose and drogue pods, known as Wing Air Refueling Pods (WARPs), can be provided, one under each wing, in addition to the flying boom system.

By way of general background, WO 2013/102903 and WO 2013/102906 to the present Assignee disclose a variety of refueling devices, systems and methods for use in in-flight refueling. In one example one such device is towed by a tanker aircraft via a fuel

25 hose at least during in-flight refueling, and has a boom member with a boom axis. The boom member enables fuel to be transferred from the fuel hose to a receiver aircraft along the boom axis during in-flight refueling. The device maintains a desired non-zero angular disposition between the boom axis and a forward direction at least when the refueling device is towed by the tanker aircraft in the forward direction via the fuel hose.

30 Also by way of general background, US 7,562,847 discloses an autonomous in-flight refueling hose end unit including a first end configured to be coupled to a fuel hose of a tanker aircraft. and a second end configured to be coupled to receiver aircraft and

- 3 -

adjustable control surfaces, and a flight control computer autonomously controls the control surfaces to fly the refueling hose end into contact with the receiver aircraft.

Also by way of general background, in GB 2,237,251 an in-flight refueling apparatus mountable on a tanker aircraft has a probe receptor coupled with a fuel line and
5 is arranged to be deployed outboard of the aircraft, and can be provided on a drogue or a boom. In one mode, the apparatus is arranged to provide a parameter which is representative of the deviation of the path of the receptor from a predetermined initial path for actuating control means for changing automatically the position of the receptor relative to the initial path. In another mode, a parameter which is representative of the
10 relative angular position of the receptor with respect to the probe of an approaching refueling aircraft for actuating control means for changing automatically the relative angular position to achieve alignment of receptor and probe.

Acknowledgement of the above references herein is not to be inferred as meaning that these are in any way relevant to the patentability of the presently disclosed subject
15 matter.

GENERAL DESCRIPTION

According to a first aspect of the presently disclosed subject matter there is provided a boom member configured for enabling in-flight refueling of a receiver aircraft,
20 the boom member comprising a first boom member portion, a second boom member portion, and a connect/disconnect mechanism:

the first boom member portion including a first boom lumen, a first boom axis, and a fuel receiving end, the fuel receiving end configured for receiving fuel from a fuel source and for enabling delivering fuel via the first boom lumen;

25 the second boom member portion including a second boom lumen, a second boom axis, and a fuel delivery end, the fuel delivery end comprising a fuel delivery nozzle configured for selectively engaging with a fuel receptacle of the receiver aircraft;

the connect/disconnect mechanism being configured for:

- selectively enabling the first boom member portion to be connected with
30 respect to the second boom member portion to provide a connected

- 4 -

configuration, such that free fluid communication is provided between the first boom lumen and the second boom lumen; and

- selectively enabling actively disconnecting the first boom member portion with respect to the second boom member portion to provide a disconnected configuration responsive to receiving a disconnection activation signal.

For example, said connect/disconnect mechanism has a normally said connected configuration, and wherein said connect/disconnect mechanism is electrically actuated via said disconnection activation signal to provide said disconnected configuration.

10 Additionally or alternatively, for example, said connect/disconnect mechanism comprises a mechanical coupling arrangement and an electrically actuatable locking mechanism, wherein the mechanical coupling arrangement comprises a first coupling element affixed to the first boom element, a second coupling element affixed to the second boom element, and wherein the electrically actuatable locking mechanism is configured for
15 selectively locking together the first coupling element with respect to the second coupling element in said connected configuration when the electrically actuatable locking mechanism deactivated, and for selectively unlocking the first coupling element with respect to the second coupling element in said disconnected configuration when the electrically actuatable locking mechanism is electrically activated via said disconnection
20 activation signal. For example, the first coupling element comprises a first cylindrical flange and the second coupling element comprises a second cylindrical flange, wherein in the connected configuration the first cylindrical flange and the second cylindrical flange are co-axial with respect to said second boom axis, and in sealing engagement with respect to one another. Additionally or alternatively, for example, the electrically actuatable
25 locking mechanism further comprises a plurality of locking elements and is configured for:

- enabling said locking elements to lock together the first cylindrical flange and the second cylindrical flange in said connected configuration when the first cylindrical flange and the second cylindrical flange are in a first relative
30 position with respect to one another; and
- enabling said locking elements to unlock the first cylindrical flange and the second cylindrical flange in said connected configuration when the first

- 5 -

cylindrical flange and the second cylindrical flange are in a second relative position with respect to one another.

For example, said locking elements are in the form of a plurality of balls, each ball having a nominally identical respective ball diameter, and wherein said first cylindrical
5 flange comprises a first outer surface and a first inner surface, radially spaced from one another by a first flange thickness, and wherein said first cylindrical flange comprises a plurality of ball chambers in circumferentially arranged relationship therewith, each said ball chamber accommodating one said ball, wherein said first cylindrical flange further comprises a through-opening to said first inner surface to allow only a part of each
10 corresponding ball accommodated in the respective said ball chamber to project out of the respective said through-opening, wherein said radial thickness is less than each said ball diameter, and wherein said coupling system further comprises a collar movably mounted with respect to the first cylindrical flange and in overlying relationship with the first outer surface, the collar comprising a plurality of recesses corresponding to said
15 plurality of ball chambers, and wherein said collar is movable between a locking position and an unlocking position, wherein in the locking position the collar locks the balls in a projecting position with respect to each respective said opening, and wherein in said unlocking position the collar enables the balls to recess into the respective ball chambers away from the respective projecting positions.

20 For example, in said unlocking position said recesses are in radial alignment with respect to said ball chambers, and wherein in said locking position said recesses are radially non-aligned with respect to said ball chambers.

Additionally or alternatively, for example, each said recess is sized such as to enable a respective said ball to be radially displaced thereinto and away from the
25 respective projecting position.

Additionally or alternatively, for example, said second cylindrical flange comprises a second outer surface comprising a plurality of locking grooves in circumferentially arranged relationship therewith, such that in said locking position each said ball projects away from each respective said opening in a respective said projecting
30 position and into a locking configuration with a respect said locking groove, such as to

- 6 -

prevent relative movement between said first cylindrical flange and said second cylindrical flange.

Additionally or alternatively, for example, said collar comprises a mechanical stop, and said electrically actuatable locking mechanism comprises a release solenoid arrangement configured for selectively cooperating with the mechanical stop, such that in the absence of said disconnection activation signal the release solenoid arrangement prevents movement of the collar from the locking position, and such that in response to said disconnection activation signal the release solenoid arrangement allows movement of the collar from the locking position to the unlocking position. For example, said release solenoid arrangement comprises a solenoid and a piston element reciprocable between a first position, corresponding to said locking position, and a second position, corresponding to said unlocking position, responsive to said solenoid being energized via said disconnection activation signal, the piston element comprising a retaining pin configured for selectively cooperating with said mechanical stop, and a biasing spring configured for biasing the piston element into the second position

Additionally or alternatively, for example, said collar is biased into the unlocking position. For example, the boom member comprises a torsion spring mounted at one longitudinal end thereof to said first cylindrical flange and at another longitudinal end thereof to said collar, and configured for biasing the collar into the unlocking position.

Additionally or alternatively, for example, the collar is rotatably mounted with respect to the first cylindrical flange about a reference axis, between a first angular position corresponding to said locking position and a second angular position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

Alternatively, for example, the collar is axially mounted with respect to the first cylindrical flange along a reference axis, between a first axial position corresponding to said locking position and a second axial position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

Alternatively, for example, the collar is axially and rotatably mounted with respect to the first cylindrical flange with respect to a reference axis, between a first axial/angular

- 7 -

position corresponding to said locking position and a second axial/angular position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

Additionally or alternatively, for example, at least an aft part of the first boom member portion, and at least a forward part of the second boom member portion are rectilinear and co-axial with respect to one another. For example, the second boom member portion comprises a fore part connected to the aft part via an elbow portion; alternatively, for example, the second boom member portion is rectilinear.

Additionally or alternatively, for example, said connect/disconnect mechanism is configured for enabling selective active disconnection between the receiver aircraft and the refueling device in an essentially non-destructive manner, and in which the second boom member portion remains engaged in the receiver aircraft after such disconnection.

Additionally or alternatively, for example, said connect/disconnect mechanism is configured for enabling selective active disconnection between the receiver aircraft and the refueling device in-flight.

Additionally or alternatively, for example, said connect/disconnect mechanism is configured for enabling reversible disconnection between the receiver aircraft and the refueling device.

According to a second aspect of the presently disclosed subject matter there is provided a refueling device for use in in-flight refueling operation, comprising:

- (a) a body configured for being towed by a tanker aircraft in a forward direction via a fuel hose at least during in-flight refueling operation, the body having a body longitudinal axis;
- (b) spatial control system configured for selectively providing stability and control to the refueling device;
- (c) a boom member as defined herein regarding aforementioned first aspect of the presently disclosed subject matter, the boom member being carried by the body.

- 8 -

For example, the boom member is reversibly pivotable with respect to the body, between a boom stowed position and a boom deployed position, wherein in the boom stowed position the refueling nozzle is closer to the body than in the boom deployed position, and wherein in the boom deployed position engagement with the fuel receptacle
5 of the receiver aircraft is possible. Alternatively, for example, said boom member is in fixed spatial relationship with respect to the body.

Additionally or alternatively, for example, said spatial control system is further configured for selectively providing control moments in at least one of pitch, yaw and roll wherein to enable the refueling device to be flown while towed by the tanker aircraft
10 in said forward direction via said fuel hose.

Additionally or alternatively, for example, said spatial control system comprises selectively controllable aerodynamic control system. For example, said selectively controllable aerodynamic control system comprises a forward set of aerodynamic control surfaces mounted to said body, and an aft set of aerodynamic control surfaces mounted
15 to said body in longitudinally aft spaced relationship with respect to said forward set of aerodynamic control surfaces. For example, said forward set of aerodynamic control surfaces comprises a canard configuration, and said aft set of aerodynamic control surfaces comprises one or more wing elements. Additionally or alternatively, for example, said aft set of aerodynamic control surfaces comprises an H-wing configuration,
20 comprising two vertical wing stabilizers, one each on either side of a respective wing. Additionally or alternatively, for example, said forward set of aerodynamic control surfaces comprises an H-canard configuration, comprising two vertical canard stabilizers, one each on either side of a respective canard.

Additionally or alternatively, for example, said spatial control system is
25 configured for enabling the refueling device to be steered in one, or two, or three degrees of freedom in translation, and in one, or two, or three degrees of freedom in rotation, independently of the tanker aircraft or of the refueling aircraft.

Additionally or alternatively, for example, said body further comprises a longitudinal displacement control system, different from the spatial control system.

Additionally or alternatively, for example, the refueling device further comprises a force generating arrangement configured for selectively generating a force along said second boom axis in a direction towards said fuel delivery nozzle. For example, said force generating arrangement is configured for selectively generating said force along said
5 second boom axis in a direction towards said fuel delivery nozzle responsive to said fuel delivery nozzle being in predetermined proximity to the fuel receptacle of the receiver aircraft wherein to force said fuel delivery nozzle into engagement with the fuel receptacle.

Additionally or alternatively, for example, said body comprising a fuel delivery
10 lumen configured for fluid communication with said fuel hose and said boom member at least during the in-flight refueling operation, wherein said body comprises a coupling having a hose interface configured for connecting said lumen to the fuel hose, said coupling configured for allowing relative rotation between the hose and said body in at least one degree of freedom while maintaining said fuel communication.

15 Additionally or alternatively, for example, the refueling device further comprises a data acquisition system configured for providing spatial data relating to a relative spatial disposition between said fuel delivery nozzle and said fuel receptacle, to enable selectively controlling the refueling device to provide automatic or autonomous or manual engagement of the fuel delivery nozzle to the fuel receptacle of the receiver
20 aircraft.

Additionally or alternatively, for example, the refueling device further comprises a suitable controller for controlling operation thereof.

According to a third aspect of the presently disclosed subject matter there is provided a refueling system comprising a refueling fuel reservoir connected to a refueling
25 device via a hose, the refueling device being as defined herein regarding the aforementioned second aspect of the presently disclosed subject matter.

According to a fourth aspect of the presently disclosed subject matter there is provided a tanker aircraft comprising at least one refueling system as defined herein regarding the aforementioned third aspect of the presently disclosed subject matter.

- 10 -

According to a fifth aspect of the presently disclosed subject matter there is provided a method for in-flight refueling, comprising:

- providing a tanker aircraft as defined herein regarding the aforementioned fourth aspect of the presently disclosed subject matter;
- 5 - deploying the refueling device aft of the tanker aircraft when airborne;
- engaging the fuel delivery nozzle to a receiver aircraft;
- selectively providing said disconnection activation signal to the boom member to thereby disconnect the first boom member portion with respect to the second boom member portion to provide said disconnected configuration;
- 10 - allowing the receiving aircraft to separate from the respective said body while said delivery nozzle is engaged to said receiver aircraft.

A feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any other
15 desired selective disconnection between the receiver aircraft and the refueling system in cases where it is not possible to disengage the fuel delivery nozzle from the receiver aircraft.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
20 other desired selective disconnection between the receiver aircraft and the refueling system, in which such disconnection is essentially non-destructive while leaving the fuel delivery nozzle engaged with the receiver aircraft.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
25 other desired selective disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out independently of the mechanical loads between the fuel delivery nozzle and the receiver aircraft.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
30 other desired selective disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out under conditions wherein the

- 11 -

mechanical loads between the fuel delivery nozzle and the receiver aircraft are in the order of nominal in-flight refueling loads.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
5 other desired selective disconnection between the receiver aircraft and the refueling system, in which the connect/disconnect mechanism is integrated in the boom member.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any other desired selective disconnection between the receiver aircraft and the refueling
10 system, in which the connect/disconnect mechanism can be assembled, and held in a preloaded position via an engaged locking pin. Typically, setting the preloaded position is carried out only on first installation of the connect/disconnect mechanism.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
15 other desired selective disconnection between the receiver aircraft and the refueling system, in which the connect/disconnect mechanism can have no or little maintenance requirements.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any
20 other desired selective disconnection between the receiver aircraft and the refueling system, in which the connect/disconnect mechanism can be used in failure events, for example including any form of mechanical jam during disengagement of the boom member from the receiver aircraft, and/or for example arising from electrical command malfunction or release malfunction.

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any other desired selective disconnection between the receiver aircraft and the refueling
25 system, in which the connect/disconnect mechanism can be used to essentially by-pass a jammed nozzle by essentially separating the nozzle from the remainder of the boom
30 member.

- 12 -

Another feature of at least one example of the presently disclosed subject matter is that there is provided a refueling device that enables emergency disconnection or any other desired selective disconnection between the receiver aircraft and the refueling system, in which the connect/disconnect mechanism can be operated only by the boom
5 operator.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to better understand the subject matter that is disclosed herein and to exemplify how it may be carried out in practice, embodiments will now be described, by
10 way of non-limiting example only, with reference to the accompanying drawings, in which:

Fig. 1(a) is a front-top isometric view of a refueling device according to of an example of the presently disclosed subject matter, with the boom member in the deployed position; **Fig. 1(b)** is an aft-top isometric view of the refueling device according
15 to the example of Fig. 1(a), with the boom member in the retracted position.

Fig. 2 is a side view of a tanker system according to an example of the presently disclosed subject matter.

Fig. 3 is a transverse partial cross-sectional side view of the boom member of the example of Fig. 1(a).

Fig. 4 is a transverse cross-sectional side view of part of the boom member of the
20 example of Fig. 1(a), in connected configuration.

Fig. 5 is a longitudinal cross-sectional view of the example of Fig. 3 taken along A-A, in locking position.

Fig. 6 is a longitudinal cross-sectional view of the example of Fig. 3 taken along A-A,
25 in unlocking position.

Fig. 7 is a transverse cross-sectional side view of part of the boom member of the example of Fig. 6 taken along B-B, in disconnected configuration.

Fig. 8 is an isometric partial view of the solenoid arrangement of the example of Fig. 3.

- 13 -

Fig. 9(a) is a transverse cross-sectional view of part of the boom member of an alternative variation of the example of Fig. 3, in locking position; **Fig. 9(b)** is a longitudinal cross-sectional view of the example of Fig. 9(a) taken along D-D, in locking position.

- 5 **Fig. 10(a)** is a transverse cross-sectional view of part of the boom member of an alternative variation of the example of Fig. 3, in unlocking position; **Fig. 10(b)** is a longitudinal cross-sectional view of the example of Fig. 10(a) taken along E-E, in unlocking position.

- 10 **Fig. 11** is an isometric partial view of the solenoid arrangement of the example of Fig. 9(a) and Fig. 9(b), in locking position.

Fig. 12 is an isometric partial view of the solenoid arrangement of the example of Fig. 10(a) and Fig. 10(b), in unlocking position.

DETAILED DESCRIPTION

- 15 Referring to Figs. 1(a) and 1(b), a refueling device for use in in-flight refueling operation, according to one example of the presently disclosed subject matter, generally designated **100**, comprises a body **110**, a boom member **130**, and a spatial control system **160**.

- 20 As will become clearer herein, and referring also to Fig. 2, the refueling device **100**, and in particular the body **110** is configured for being towed by a tanker aircraft **12** in a forward direction **A** via a fuel hose **52** at least during in-flight refueling operation.

- For convenience, and referring again to Figs. 1(a) and 1(b), a roll axis **R**, a pitch axis **P** and a yaw axis **Y** can be conventionally defined with respect to the refueling device **100**. The roll axis **R** is parallel to or co-axial with the longitudinal axis **LAB** of the device **100**;
25 the pitch axis **P** is generally in lateral and orthogonal relationship to the roll axis **R** (i.e., parallel to the horizontal when the body is at a zero roll angle); and yaw axis **Y** is in generally in transverse and orthogonal relationship to the roll axis **R** and the pitch axis **P** (i.e., parallel to the vertical when the body is at a zero pitch angle).

According to an aspect of the presently disclosed subject matter, and referring also to Fig. 3, the boom member **130** is configured for enabling in-flight refueling of a receiver aircraft **20**, the boom member comprising first boom member portion **230**, a second boom member portion **240**, and a connect/disconnect mechanism **300**. According to this aspect of
5 the presently disclosed subject matter, and also as will become clearer herein, the boom member **130** enables selective active disconnection between the receiver aircraft **20** and the refueling device **100** (and thus from the tanker aircraft **12**) in a variety of situations, for example in an emergency for example in which the boom member **130** can become jammed with the receiver aircraft **20**.

10 According to this aspect of the presently disclosed subject matter, the connect/disconnect mechanism **300** is configured for enabling selective active disconnection between the receiver aircraft **20** and the refueling device **100** in an essentially non-destructive manner, and in which the second boom member portion **240** remains engaged in the receiver aircraft **12** after such disconnection. By "essentially non-destructive manner" is
15 meant that at least the first boom member portion **230**, the second boom member portion **240**, and the connect/disconnect mechanism **300** are not damaged *per se* by such disconnection, and in at least in some examples these components can be fully or partially reconnected. For example, some damage to other parts of the refueling system can occur in at least some cases, for example in at least some cases the electrical harness **199** (see Fig. 4
20 and Fig. 7) can be torn during switch disconnection.

According to this aspect of the presently disclosed subject matter, the connect/disconnect mechanism **300** is configured for enabling selective active disconnection between the receiver aircraft **20** and the refueling device **100** in-flight, i.e., while the receiver aircraft **20** and the refueling device **100** are both airborne, and in which the second boom
25 member portion **240** remains engaged in the airborne receiver aircraft **12** after such disconnection.

Furthermore, according to this aspect of the presently disclosed subject matter, the connect/disconnect mechanism **300** is configured for enabling reversible disconnection between the receiver aircraft **20** and the refueling device **100**, thereby enabling the same or
30 another said second boom member portion **240** to be subsequently re-connected to the remainder of the boom member **130**, for example by ground crews.

Without being bound to theory, it is to be noted that particularly in the context of the towable refueling device **100**, such a refueling device **100** can have a mass that is significantly less than the mass of the receiver aircraft **20**, and thus in undesired situations in which for example regular disengagement of the boom member **130** from the receiver aircraft is compromised, simply applying sharp maneuvers to the receiver aircraft **20** can be considered in at least some cases to have low probability of success in terms of disengaging the boom member **130** from the receiver aircraft **20**.

The boom member **130** is carried by the body **110**, and in particular the boom member **130** is mounted to the body **110** via the first boom member portion **230**

10 The boom member **130** comprises a fuel delivery nozzle **135**, the fuel delivery nozzle **135** being configured for selectively engaging with a fuel receptacle **22** (Fig. 1(a)) in the receiver aircraft **20** to enable fuel to be transferred from the fuel hose **52** to the receiver aircraft **20** along during the in-flight refueling operation. The nozzle **135** thus can comprise any conventional design of such nozzles, which are well known in the art, or indeed can
15 comprise any other current or future design of such an in-flight refueling nozzle.

Furthermore, the spatial control system **160** is configured for selectively providing stability and control to the refueling device **100**.

The boom member **130** comprises a boom member lumen **131** for providing fluid communication between the fuel delivery nozzle **135** and the fuel delivery lumen **120**.

20 While in at least this example, the boom member **130** is configured as an elbowed boom, in alternative variations of this example the boom member can instead be configured as a rectilinear boom member having a single rectilinear boom axis therethrough, or as a partially curved boom member. In any case, at least an aft part **239** of the first boom member portion **230**, and at least a forward part **249** of the second boom member portion **240**, are
25 rectilinear and co-axial with respect to one another.

Thus, in at least this example, the second boom member portion **240**, including the forward part **249**, is rectilinear and includes a second boom lumen **241**, a second boom axis **BA2**, and a fuel delivery end **244**, the fuel delivery end comprising the fuel delivery nozzle **135**, which as discussed above is configured for selectively engaging with a fuel
30 receptacle **22** of the receiver aircraft **20**.

Also in at least this example, the first boom member portion **230** includes a fore part **233** connected to the aft part **239** via elbow portion **238**. The first boom member portion **230** includes a first boom lumen **231**, and a fuel receiving end **234**, the fuel receiving end **234** being configured for receiving fuel from a fuel source, in at least this example from the
5 tanker aircraft via the fuel delivery lumen **120** and for enabling delivering fuel to the second boom member portion **240** via the first boom lumen **231**.

The first boom member portion **230**, in particular the aft part **239**, includes a first boom axis **BA1**, which at least in this example is parallel, and in particular co-axial, with second boom axis **BA2**. The fore part **233** has a third boom axis **BA3**, that is at an elbow
10 angle λ with respect to the first boom axis **BA1**.

While in at least this example, the first boom member portion **230** and the second boom member portion **240** are each configured as rectilinear, rigid and generally tubular components, in alternative variations of this example, part of the first boom member portion, for example the fore part **233** and/or the elbow portion **238** can be configured as a non-
15 rectilinear and/or non-rigid and/or non-tubular component. For example, in such alternative variations of this example, the fore part **233** and/or the elbow portion **238** can be configured as a flexible hose connected to the aft portion **239** for example.

Elbow angle λ can be defined on a plane, typically a plane parallel to the plane including the yaw axis **Y** and the roll axis **R** of the device **100**. In at least this example λ is
20 any suitable angle in the range between 60° and 120° .

In at least this example, the boom member **130** is pivotably mounted to the body **110** via the first boom member portion **132**, at hinge axis **C**. Thus, and referring in particular to Fig. 1(a) and Fig. 1(b), the boom member **130** is pivotable between a boom retracted position **RP** and a boom deployed position **DP**, wherein in the retracted position **RP** the fuel delivery
25 nozzle **135** is located closer with respect to the body **110** than in the deployed position **DP**.

Furthermore, in at least this example, in the deployed position **DP** the second boom axis **BA2** is at a first angular disposition with respect to the body longitudinal axis **LAB**, while in the retracted position **RP** the aft boom axis **BA2** is at a second angular disposition with respect to the body longitudinal axis **LAB**, wherein the first angular disposition is
30 different from the second angular disposition.

- 17 -

In any case, in general the boom member **130** is in the deployed position **DP** at least during in-flight refueling operation of the device **100**.

A suitable actuation mechanism (not shown) is provided for controllably pivoting the boom member **130** between the stowed or retracted position **RP** and the deployed
5 position **DP**.

As will become clearer herein, the connect/disconnect mechanism **300** is configured for:

- selectively enabling the first boom member portion **230** to be connected with respect to the second boom member portion **240** to provide a connected
10 configuration **CC**, such that free fluid communication is provided between the first boom lumen **231** and the second boom lumen **241**; and
- selectively enabling active disconnection of the first boom member portion **231** with respect to the second boom member portion **241** to provide a disconnected configuration **DC** responsive to receiving a disconnection activation signal **DAS**.

15 In the connected configuration **CC**, the first boom lumen **231** and the second boom lumen **241** together form the boom lumen **131**. This enables fuel to be provided to the receiver aircraft **20**, when engaged to the fuel delivery nozzle **135**, in the normal manner.

On the other hand, in the disconnected configuration **DC** the second boom member portion **230** is fully detached from (and thus no longer physically connected
20 directly to) the first boom member portion **240**, such that the receiver aircraft **20**, with the second boom portion **240** still engaged thereto, is fully disconnected from the remainder of the refueling device **100**, and can then fly independently thereof.

Thus, the connect/disconnect mechanism **300** has a normally connected configuration **CC**, and in at least this example the connect/disconnect mechanism **300** is
25 electrically actuated via the aforesaid disconnection activation signal **DAS** to provide the disconnected configuration **DC**.

Referring also to Fig. 4 and Fig. 7, in at least this example the connect/disconnect mechanism **300** comprises a mechanical coupling arrangement **400** and an electrically actuable locking mechanism **500**.

The mechanical coupling arrangement **400** comprises a first coupling element **410** affixed to the first boom element **230**, and a second coupling element **420** affixed to the second boom element **240**.

The first coupling element **410** is affixed to the first boom element **230** at an aft end **232** thereof, and the second coupling element **420** affixed to the second boom element **240** at a forward end **244** thereof

The first coupling element **410** comprises a first cylindrical flange **415** and the second coupling element **420** comprises a second cylindrical flange **425**. In the connected configuration the first cylindrical flange **415** and the second cylindrical flange **425** are co-axial with respect to the second boom axis **BA2**, and in sealing engagement with respect to one another, for example via sealing rings **490**.

The first cylindrical flange **415** comprises a first outer surface **414** and a first inner surface **416**, radially spaced from one another by a first flange thickness **t1**.

The second cylindrical flange **425** comprises a second outer surface **424** and a second inner surface **426**, radially spaced from one another by a second flange thickness **t2**. The second inner surface **426** defines part of the second boom lumen **241**.

Referring also to Fig. 5 and Fig. 6, the electrically actuatable locking mechanism **500** is configured for selectively and reversibly locking together the first coupling element **410** with respect to the second coupling element **420** in the connected configuration **CC** when the electrically actuatable locking mechanism **500** deactivated, and for selectively unlocking the first coupling element **410** with respect to the second coupling element **420** in the disconnected configuration **DC** when the electrically actuatable locking mechanism **500** is electrically activated via the disconnection activation signal **DAS**.

The electrically actuatable locking mechanism **500** comprises a plurality of locking elements. In at least this example, the elements are in the form of three balls **510**, but in alternative variations of this example the locking elements can include a plurality of balls, for example more than three balls, or alternatively any other suitable locking elements.

The first cylindrical flange **415** comprises a plurality of ball chambers **520** in circumferentially arranged relationship therewith, i.e., with respect to the first boom axis

BA1. Each ball chamber **520** is open at an outer radial part thereof, each ball chamber **520** is configured for accommodating one ball **510**, and each ball chamber **520** comprises a through-opening **419** made through the first cylindrical flange from the ball chamber **520** to the first inner surface **416**. Each through-opening **419** is shaped and sized such
5 that, with a ball **510** accommodated in the respective ball chamber **520**, part of the ball **510** is able to project out of the respective through-opening **419**.

The electrically actuatable locking mechanism **500** further comprises a collar **550** movably mounted with respect to the first cylindrical flange **415** and in overlying relationship with the first outer surface **414**.

10 The collar **550** comprises a plurality of recesses **555** corresponding to the plurality of ball chambers **520** circumferentially arranged relationship therewith, i.e., with respect to the first boom axis **BA1**. Thus in at least this example the collar **550** comprises three recesses **555**. The recesses **555** are radially spaced outwardly from the collar inner surface **551** with respect to the second boom axis **BA2** by a collar recess spacing **CRS**. In at least
15 this example, the recesses **555** are circumferentially spaced with respect to the collar **550**, and furthermore also extend circumferentially, as best seen in Fig. 5 and Fig. 6.

In yet other alternative variations of this example the collar can be rotatably and axially mounted with respect to the first cylindrical flange **415**, i.e., for allowing rotational and axial movement along the second boom axis **BA2**; for example, when these
20 movements are concurrent, the collar **550** can move helically with respect to the first cylindrical flange **415**. In such examples, the corresponding recesses can be spaced circumferentially from one another and extend helically, for example.

In at least this example, and referring in particular to Fig. 5, each ball **510** has a nominally identical respective ball diameter **BD**, and the first radial thickness **t1** is less
25 than each ball diameter **BD**, by an amount not less than collar recess spacing **CRS**. Thus, when each ball **510** is accommodated in the respective ball chamber **520** and radially aligned with the respective recess **555**, the balls **510** do not project past the first inner surface **416** via the respective through-openings **419**. On the other hand, when each ball **510** is accommodated in the respective ball chamber **520** and radially non-aligned with
30 the respective recess **555**, the balls **510** are in abutment with the collar inner surface **551** and thus project past the first inner surface **416** via the respective through-openings **419**.

The collar **550** is movable between a locking position **LP** and an unlocking position **UP**. In at least this example, the collar **550** is exclusively rotatable (or pivotable) between the locking position **LP** and the unlocking position **UP**, about the second boom axis **BA2**. However, and as will become clearer herein, in alternative variations of this example, the collar can be exclusively translatable between the locking position **LP** and the unlocking position **UP**, for example in a direction parallel to the second boom axis **BA2**. In yet other alternative variations of this example, the collar can be rotatable and translatable between the locking position **LP** and the unlocking position **UP**, for example respectively about and in a direction parallel to the second boom axis **BA2**.

10 In at least this example, in the locking position **LP**, and referring in particular to Fig. 5, the recesses **555** are in circumferentially non-aligned with respect ball chambers **520**, and in particular with the respective balls **510**, and the collar **550** thus locks the balls **510** in a projecting position with respect to each respective through-opening **419**.

In the unlocking position **UP**, and referring in particular to Fig. 6, the recesses **555**
15 are in circumferential alignment with respect ball chambers **520**, and in particular with the respective balls **510**, and the collar **550** enables the balls **510** to recess into the respective ball chambers **520** and partially into the respective recesses **555**, and thus enables the balls **510** to move away radially from the respective projecting positions.

Referring in particular to Fig. 5 and Fig. 7, the second cylindrical flange **425**, in
20 particular the second outer surface **424** thereof, comprises a plurality of locking grooves **429**. The locking grooves **429** are in circumferentially arranged relationship with respect to the second outer surface **424**, such that in the aforesaid locking position each ball **510** projects away from each respective through-opening **419** radially towards the second boom axis **BA2** in a respective projecting position and into a locking configuration with
25 a respective locking groove **429**, such as to prevent relative movement (axial or rotational) between the first cylindrical flange **415** and the second cylindrical flange **425**.

Referring also to Fig. 8, the collar **550** comprises a mechanical stop **558** (also referred to interchangeably herein as a detent), and the electrically actuable locking mechanism **500** comprises a release solenoid arrangement **530**. The release solenoid
30 arrangement **530** is configured for selectively cooperating with the mechanical stop **558**, such that in the absence of the aforesaid disconnection activation signal **DAS** the release

solenoid arrangement **530** prevents movement of the collar **550** from the locking position, and such that in response to the disconnection activation signal **DAS** the release solenoid arrangement **530** allows movement of the collar **550** from the locking position **LP** to the unlocking position **UP**.

5 The release solenoid arrangement **530** comprises a solenoid **532** and a piston element **534** that is mounted for reciprocable movement with respect to the solenoid **532** between a first position, corresponding to the locking position **LP**, and a second position, corresponding to the unlocking position **UP**, responsive to the solenoid **532** being energized via the disconnection activation signal **DAS**.

10 The piston element **534** comprises a retaining pin **538** configured for selectively cooperating with the mechanical stop **558**, and a biasing spring **539** configured for biasing the piston element **534** into the first position.

In at least this example, the collar **550** is biased into the unlocking position **UP**. For this purpose, the release solenoid arrangement **530** comprises a torsion spring **531**
15 mounted at one longitudinal end thereof to the first cylindrical flange **415** and at another longitudinal end thereof to the collar **550**. The torsion spring **531** is preloaded for biasing the collar **550** into the unlocking position **UP**.

In at least this example, the collar **550** comprises a final stop **559** configured for ensuring that the collar **550** stops rotating at the unlocking position **UP** after the release
20 solenoid arrangement **530** is activated by the disconnection activation signal **DAS**.

As disclosed above, in at least this example the collar **550** is rotatably mounted with respect to the first cylindrical flange **415** about the second boom axis **BA2**. Furthermore, in at least this example the collar **550** is rotatable with respect to the first cylindrical flange **415** about the second boom axis **BA2** between a first angular position,
25 corresponding to the aforesaid locking position **LP**, and a second angular position, corresponding to the aforesaid unlocking position **UP**. For example, the angular displacement between the first angular position and the second angular position can be about 30°.

The connect/disconnect mechanism **300** further comprises a control line **390**
30 operatively connecting the release solenoid arrangement **530** to a controller.

- 22 -

For example, the control line **390** can be in the form of an electrical cable, configured for selectively transmitting the disconnection activation signal **DAS** from the controller to the release solenoid arrangement **530**, in particular to the solenoid **532**. The disconnection activation signal **DAS** in such an example is an electrical current sufficient
5 to energize the solenoid **532** sufficiently to cause the piston element **534** together with the retaining pin **538** to be axially moved to a position no longer abutting the mechanical stop **558**, and thereby releasing the collar **550**. In such an example the controller can be a human operator, for example, and the control line **390** comprises an electrical switch to enable selectively closing an electrical circuit to thereby energize the solenoid **532**. In the
10 absence of the retaining pin **538** being in abutting contact with the mechanical stop **558**, the torsion spring **531** is free to rotate the collar **550** from the locking position **LP** to the unlocking position **UP**.

Thus, the connect/disconnect mechanism **300** can be assembled, and held in a preloaded position via the engaged retaining pin **538**.

15 It is to be noted that in at least this example, the release solenoid arrangement **530** is in a normally unpowered configuration corresponding to the locking position **LP**, and the disconnection activation signal **DAS** powers the release solenoid arrangement **530** sufficiently to enable the electrically actuatable locking mechanism **500** to transit to the unlocking position **UP**.

20 Alternatively, the control line **390** is also operatively connected to a communications module (not shown) configured for receiving a command signal from a controller, for example a human operator, and further configured for generating the disconnection activation signal **DAS** in the form of an electrical current sufficient for energizing the solenoid **532**. The communication module can comprise, for example a
25 controller, for example comprising a micro-computer or electronic circuitry, configured for receiving such a command signal and for generating the disconnection activation signal **DAS** in response to receiving the command signal. For example, such a command signal can be in the form of a digital or analog signal, and can be input directly into the communications module via wiring or via wireless connection.

30 In such cases, for example, the controller can be a human operator in the tanker aircraft **12**.

It is to be noted that the connect/disconnect mechanism **300** is configured for supporting mechanical loads up to a maximum threshold load limit, at least in a direction parallel or co-axial with the second boom axis **BA2**, during refueling operations, in which the fuel delivery nozzle **135** is engaged with the receiver aircraft **20**. For example, such a maximum threshold load limit can be more than ten times the magnitude of the nominal mechanical loads expected during standard in-flight refueling. For example, while in some examples such a nominal load can be about 200 lbf, the corresponding maximum threshold load limit can be for example 2700 lbf. In any case, if the maximum threshold load limit is exceeded, this will result in the first coupling element **410** being forcefully separated from the second coupling element **420**, with the probability that parts of the connect/disconnect mechanism **300** becoming damaged in the process.

It is further to be noted that the connect/disconnect mechanism **300** enables emergency disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out independently of the mechanical loads between the fuel delivery nozzle and the receiver aircraft.

It is further to be noted that the connect/disconnect mechanism **300** enables emergency disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out under conditions wherein the mechanical loads between the fuel delivery nozzle and the receiver aircraft are in the order of nominal in-flight refueling loads. By "nominal in-flight refueling loads" is meant the magnitude of the nominal mechanical loads expected during standard in-flight refueling; for example, in some examples such a nominal in-flight refueling loads can be about 200 lbf.

Thus, while in this example the collar **550** is rotatably mounted with respect to the first cylindrical flange **415** about a reference axis, wherein such a reference axis is co-axial with the second boom axis **BA2**, in alternative variations of this example the collar can instead be mounted axially with respect to the first cylindrical flange, i.e., for allowing axial movement along the second boom axis **BA2**. In such examples, the corresponding recesses can be spaced circumferentially from one another and extend axially, for example.

For example, and referring to Figs. 9(a) to 12, in such an alternative variation of the example of Fig. 3, the respective connect/disconnect mechanism, generally designated

with reference numeral **300'** in these figures, comprises a corresponding mechanical coupling arrangement **400'** and a corresponding electrically actuatable locking mechanism **500'**.

The mechanical coupling arrangement **400'** comprises a first coupling element
5 **410'** affixed to the first boom element **230**, and a second coupling element **420'** affixed to the second boom element **240**.

The first coupling element **410'** is affixed to the first boom element **230** at an aft end **232** thereof, and the second coupling element **420'** affixed to the second boom element **240** at a forward end **244** thereof.

10 The first coupling element **410'** comprises a first cylindrical flange **415'** and the second coupling element **420'** comprises a second cylindrical flange **425'**. In the connected configuration the first cylindrical flange **415'** and the second cylindrical flange **425'** are co-axial with respect to the second boom axis **BA2**, and in sealing engagement with respect to one another, for example via sealing rings **490'**.

15 The first cylindrical flange **415'** comprises a first outer surface **414'** and a first inner surface **416'**, radially spaced from one another by a first flange thickness **t1'**.

The second cylindrical flange **425'** comprises a second outer surface **424'** and a second inner surface **426'**, radially spaced from one another by a second flange thickness **t2'**. The second inner surface **426'** defines part of the second boom lumen **241**.

20 The electrically actuatable locking mechanism **500'** is configured for selectively and reversibly locking together the first coupling element **410'** with respect to the second coupling element **420'** in the respective connected configuration **CC** when the respective electrically actuatable locking mechanism **500'** deactivated, and for selectively unlocking the first coupling element **410'** with respect to the second coupling element **420'** in the
25 disconnected configuration **DC** when the electrically actuatable locking mechanism **500'** is electrically activated via the disconnection activation signal **DAS** carried by the control line **390**.

The electrically actuatable locking mechanism **500'** comprises a plurality of locking elements. In at least this example, the elements are in the form of three balls **510'**, but in

alternative variations of this example the locking elements can include a plurality of balls, for example more than three balls, or alternatively any other suitable locking elements.

The first cylindrical flange **415'** comprises a plurality of ball chambers **520'** in circumferentially arranged relationship therewith, i.e., with respect to the first boom axis **BA1**. Each ball chamber **520'** is open at an outer radial part thereof, each ball chamber **520'** is configured for accommodating one ball **510'**, and each ball chamber **520'** comprises a through-opening **419'** made through the first cylindrical flange from the ball chamber **520'** to the first inner surface **416'**. Each through-opening **419'** is shaped and sized such that, with a ball **510'** accommodated in the respective ball chamber **520'**, part of the ball **510'** is able to project out of the respective through-opening **419'**.

The electrically actuatable locking mechanism **500'** further comprises a collar **550'** movably mounted with respect to the first cylindrical flange **415** and in overlying relationship with the first outer surface **414'**. In particular, collar **550'** is movable axially with respect to the first cylindrical flange **415'**, i.e., parallel to the first boom axis **BA1**.

The collar **550'** comprises a plurality of recesses **555'** corresponding to the plurality of ball chambers **520'** circumferentially arranged relationship therewith, i.e., with respect to the first boom axis **BA1**. Thus in at least this example the collar **550** comprises three recesses **555'**. The recesses **555'** are radially spaced outwardly from the collar inner surface **551'** with respect to the second boom axis **BA2** by a collar recess spacing **CRS'**. In at least this example, the recesses **555'** are circumferentially spaced with respect to the collar **550'**, and furthermore also extend axially, as best seen in Fig. 9(a) and Fig. 10(a).

In at least this example, and referring in particular to Fig. 10(b), each ball **510'** has a nominally identical respective ball diameter **BD'**, and the first radial thickness **t1'** is less than each ball diameter **BD'**, by an amount not less than collar recess spacing **CRS'**. Thus, when each ball **510'** is accommodated in the respective ball chamber **520'** and radially aligned with the respective recess **555'**, the balls **510'** do not project past the first inner surface **416'** via the respective through-openings **419'**. On the other hand, when each ball **510'** is accommodated in the respective ball chamber **520'** and radially non-aligned with the respective recess **555'**, the balls **510'** are in abutment with the collar inner surface **551'** and thus project past the first inner surface **416'** via the respective through-openings **419'**.

The collar **550'** is movable between a locking position **LP** and an unlocking position **UP**. In at least this example, the collar **550'** is exclusively translatable (i.e., not rotatable or pivotable) between the locking position **LP** and the unlocking position **UP**, about the second boom axis **BA2**.

5 In at least this example, in the locking position **LP**, and referring in particular to Fig. 9(a), the recesses **555'** are in axially non-aligned with respect ball chambers **520'**, and in particular with the respective balls **510'**, and the collar **550'** thus locks the balls **510'** in a projecting position with respect to each respective through-opening **419'**.

10 In the unlocking position **UP**, and referring in particular to Fig. 10(a), the recesses **555'** are in axial alignment with respect ball chambers **520'**, and in particular with the respective balls **510'**, and the collar **550'** enables the balls **510'** to recess into the respective ball chambers **520'** and partially into the respective recesses **555'**, and thus enables the balls **510'** to move away radially from the respective projecting positions.

Referring in particular to Fig. 9(a) and Fig. 9(b), the second cylindrical flange **425'**, in particular the second outer surface **424'** thereof, comprises a plurality of locking grooves **429'**. The locking grooves **429'** are in circumferentially arranged relationship with respect to the second outer surface **424'**, such that in the aforesaid locking position each ball **510'** projects away from each respective through-opening **419'** radially towards the second boom axis **BA2** in a respective projecting position and into a locking configuration with a respective locking groove **429'**, such as to prevent relative movement (axial or rotational) between the first cylindrical flange **415'** and the second cylindrical flange **425'**.

Referring in particular to Fig. 9(b), Fig. 10(b), Fig. 11 and Fig. 12, the collar **550'** comprises a mechanical stop **558'** (also referred to interchangeably herein as a detent), and the electrically actuable locking mechanism **500'** comprises a release solenoid arrangement **530'**. The release solenoid arrangement **530'** is configured for selectively cooperating with the mechanical stop **558'**, such that in the absence of the aforesaid disconnection activation signal **DAS** the release solenoid arrangement **530'** prevents movement of the collar **550'** from the locking position, and such that in response to the disconnection activation signal **DAS** the release solenoid arrangement **530'** allows movement of the collar **550'** from the locking position **LP** to the unlocking position **UP**.

The release solenoid arrangement **530'** comprises a solenoid **532'** and an arm element **534'** that is mounted for pivotal movement with respect to the solenoid **532'** between a first position, corresponding to the locking position **LP**, and a second position, corresponding to the unlocking position **UP**, responsive to the solenoid **532'** being energized via the disconnection activation signal **DAS**.

The arm element **534'** is configured for selectively cooperating with the mechanical stop **558'**, and a biasing spring **539'** configured for biasing the arm element **534'** into the first position.

In at least this example, the collar **550'** is biased into the unlocking position **UP**. For this purpose, the release solenoid arrangement **530'** comprises a linear spring **531'** mounted at one longitudinal end thereof to the first cylindrical flange **415'** and at another longitudinal end thereof to the collar **550'**. The linear spring **531'** is preloaded for axially biasing the collar **550'** into the unlocking position **UP**.

In at least this example, the collar **550'** comprises a final axial stop **559'** configured for ensuring that the collar **550'** stops axial translation at the unlocking position **UP** after the release solenoid arrangement **530'** is activated by the disconnection activation signal **DAS**.

Thus, in this example in which the collar is mounted with respect to the first cylindrical flange along a reference axis (for example wherein said reference axis is co-axial with said second boom axis), the collar **550'** is axially movable with respect to the first cylindrical flange **415'** about the second boom axis **BA2** between a first axial position (Fig. 9(a)) corresponding to the locking position **LP**, and a second axial position (Fig. 10(a)) corresponding to the unlocking position **UP**.

Also in at least this example, the connect/disconnect mechanism **300'** further comprises a control line **390'** operatively connecting the release solenoid arrangement **530'** to a controller.

For example, the control line **390'** can be in the form of an electrical cable, configured for selectively transmitting the disconnection activation signal **DAS** from the controller to the release solenoid arrangement **530'**, in particular to the solenoid **532'**. The disconnection activation signal **DAS** in such an example is an electrical current sufficient

- 28 -

to energize the solenoid **532'** sufficiently to apply a resisting torque to the arm element **534'**, to thereby cause the arm element **534'** to be pivoted to a circumferential position no longer abutting the mechanical stop **558'**, and thereby releasing the collar **550'**. In such an example the controller can be a human operator, for example, and the control line **390'** comprises an electrical switch to enable selectively closing an electrical circuit to thereby energize the solenoid **532'**. In the absence of the arm element **534'** being in abutting contact with the mechanical stop **558'**, the linear spring **531'** is free to axially push the collar **550'** along the first boom axis **BA1** from the locking position **LP** to the unlocking position **UP**.

10 Thus, the connect/disconnect mechanism **300'** can be assembled, and held in a preloaded position via the engaged arm element **534'**.

It is to be noted that in at least this example, the release solenoid arrangement **530'** is in a normally unpowered configuration corresponding to the locking position **LP**, and the disconnection activation signal **DAS** powers the release solenoid arrangement **530'** sufficiently to enable the electrically actuatable locking mechanism **500'** to transit to the unlocking position **UP**.

Alternatively, the control line **390'** is also operatively connected to a communications module (not shown) configured for receiving a command signal from a controller, for example a human operator, and further configured for generating the disconnection activation signal **DAS** in the form of an electrical current sufficient for energizing the solenoid **532'**. The communication module can comprise, for example a controller, for example comprising a micro-computer or electronic circuitry, configured for receiving such a command signal and for generating the disconnection activation signal **DAS** in response to receiving the command signal. For example, such a command signal can be in the form of a digital or analog signal, and can be input directly into the communications module via wiring or via wireless connection.

In such cases, for example, the controller can be a human operator, for example in the tanker aircraft **12**.

It is to be noted that the connect/disconnect mechanism **300'** is configured for supporting mechanical loads up to a maximum threshold load limit, at least in a direction

- 29 -

parallel or co-axial with the second boom axis **BA2**, during refueling operations, in which the fuel delivery nozzle **135** is engaged with the receiver aircraft **20**. For example, such a maximum threshold load limit can be more than ten times the magnitude of the nominal mechanical loads expected during standard in-flight refueling. For example, while in
5 some examples such a nominal load can be about 200 lbf, the corresponding maximum threshold load limit can be for example 2700 lbf. In any case, if the maximum threshold load limit is exceeded, this will result in the first coupling element **410'** being forcefully separated from the second coupling element **420'**, with the probability that parts of the connect/disconnect mechanism **300'** becoming damaged in the process.

10 It is further to be noted that the connect/disconnect mechanism **300'** enables emergency disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out independently of the mechanical loads between the fuel delivery nozzle and the receiver aircraft.

It is further to be noted that the connect/disconnect mechanism **300'** enables
15 emergency disconnection between the receiver aircraft and the refueling system, in which such disconnection can be carried out under conditions wherein the mechanical loads between the fuel delivery nozzle and the receiver aircraft are in the order of nominal in-flight refueling loads. By "nominal in-flight refueling loads" is meant the magnitude of the nominal mechanical loads expected during standard in-flight refueling; for example,
20 in some examples such a nominal in-flight refueling loads can be about 200 lbf.

In yet other alternative variations of the above examples, and in which the collar is axially and rotatably mounted with respect to the first cylindrical flange **415** with respect to a reference axis (for example wherein said reference axis is co-axial with said second boom axis **BA2**), the collar **550** is axially and rotatably movable with respect to
25 the first cylindrical flange **415** with respect to the second boom axis **BA2** between a first axial/angular position corresponding to the locking position **LP** and a second axial/angular position corresponding to the unlocking position **UP**.

The refueling device **100** further comprises an electrical harness **199** (see for example Fig. 4 and Fig. 7), for controlling operation of the fuel delivery nozzle **135**, and
30 is operatively connected to the second boom member portion **240**. The electrical harness **199** in at least this example also incorporates the respective control line **390** or the

- 30 -

respective control line **390'** for controlling operation of the respective connect/disconnect mechanism **300'** or the respective connect/disconnect mechanism **300'** (via the release solenoid arrangement **530'**).

Referring again to Fig. 2, a tanker system **10**, according to one example of the
5 presently disclosed subject matter, comprises the tanker aircraft **12** including one or more in-flight refueling systems **50**. As will become clearer herein, each refueling system **50** comprises a refueling device **100**.

In at least this example, the tanker aircraft **12** has three such in-flight refueling systems **50**, one in-flight refueling system **50** carried by the port wing **14**, another in-flight
10 refueling system **50** carried by the starboard wing, and a third in-flight refueling system **50** located in the rear portion of the fuselage **15**, and the tanker aircraft **12** is configured for in-flight concurrent refueling of up to three receiver aircraft **20**. Thus, in at least this example, one in-flight refueling system **50** is centrally-located and mounted with respect to the rear fuselage of the tanker aircraft **12**, and each of the other two in-flight refueling systems **50** is
15 comprised in a respective pod **51** that is attached to the underside of the respective wing. In alternative variations of this example the tanker aircraft **12** can have at least one, or two, or more than three in-flight refueling systems **50**, arranged in any suitable configuration with respect to the tanker aircraft **12**.

By way of non-limiting example, such a tanker aircraft **12** can be a suitably equipped
20 Boeing 767, Boeing 747, or Airbus 330, and each receiver aircraft **20** can include any suitable aircraft, for example any one of suitably equipped F-15, or F-16, or F-35, or B1, or B2 stealth bomber, or other suitably equipped fighter, bomber or other aircraft. Alternatively, and also by way of non-limiting example, the tanker aircraft can be an unmanned aerial vehicle (UAV), and/or at least one of the receiver aircraft can be a UAV.

Also by way of non-limiting example, a refueling flight envelope for use with such
25 a tanker system **10** can include a forward speed of between about 220 knots and about 320 knots (typically about 280 knots), and an altitude of between 500ft and between about 30,000ft to about 40,000ft, and in general typically not below about 10,000ft, in which refueling can take place between the tanker aircraft **12** and each receiver aircraft **20**, flying
30 in formation, depending on the operating limits of the tanker aircraft and of the receiver aircraft, as well as other factors.

- 31 -

In at least this example, and referring again to Figs. 1(a) and 1(b), each in-flight refueling system **50** comprises an elongate, non-rigid, fuel delivery hose **52**, reversibly extendible from the tanker aircraft **12**. A first end (not shown) of the hose **52** is connected to a refueling fuel tank (not shown) carried by the tanker aircraft **12**. For example, such a
5 refueling fuel tank can be an internal fuel tank of the tanker aircraft **12**, for example the tanker aircraft's own fuel tanks, or a special fuel reservoir mounted internally in the tanker aircraft **12**, for example in the fuselage, or externally (for example carried in fuel pods).

The hose **52** is flexible and can be retracted into a roll up drum (not shown), suitably provided in the tanker aircraft **12**, and selectively deployed therefrom when required.

10 The second (aft) end **54** of hose **52** is operatively connected to a respective refueling device **100** that is towed in a forward direction **A** by the tanker aircraft **12** via hose **52** when the hose **52** is extended and the tanker aircraft **12** is in flight.

Thus, and referring again to Figs. 1(a) and 1(b), the refueling device according to a first example of the presently disclosed subject matter, generally designated **100**, is
15 configured for use with respect to an in-flight refueling system, for example at least one of the in-flight refueling systems **50** of the example of the tanker system **10** illustrated Fig. 2.

Refueling device **100** is affixed to the end **54** of hose **52** and comprises body **110**, which at least in this example is in the form of a generally elongate fuselage, and comprises longitudinal axis **LAB**. While in at least this example the body **110** comprises a general oval
20 or elliptical cross section, in alternative variations of this example the body **110** can have any other suitable cross-sectional shape, for example circular cross-section, polygonal cross-section, super-elliptical cross-section, and so on.

The body **110** comprises a fuel delivery lumen **120** and carries boom member **130** in fluid communication with fuel delivery lumen **120**.

25 The body **110** comprises a coupling **140** at forward end **114** thereof. The coupling **140** comprises a hose interface configured for connecting the lumen **120** to the hose **52**, and thereby to the tanker aircraft **12**. The coupling **140** can be configured for allowing relative rotation between the body **110** and the hose **52** while maintaining fluid communication between the lumen **120** and the hose **52** and thus the refueling tank. In
30 this example, the coupling **140** is in the form of a universal joint or the like (also referred

- 32 -

to as a universal coupling, a Cardan joint, a Hardy-Spicer joint or a Hooke's joint, and so on), and is thus configured for allowing relative rotation between the body **110** and the hose **52** in three degrees of freedom.

In alternative variations of this example and in other examples, the coupling can instead be configured for allowing relative rotation between the body **110** and the hose **52** in one degree of freedom, or in two degrees of freedom. In yet other alternative variations of this example the coupling **140** can be omitted and replaced with a fixed coupling that is configured to maintain a fixed relative spatial disposition between the body **110** and the hose **52**.

Referring again to Fig. 1(a), the body **110** has a neutral point **NP**. In at least this example, at least during refueling operation the fuel delivery nozzle **135** is longitudinally forward of the neutral point **NP** by a longitudinal spacing **LS**. As is well known in the art the neutral point of an air vehicle is the position at which the center of gravity needs to be located to provide the aircraft with neutral stability. In practice conventionally, the center of gravity of many conventional air vehicles is often not located at the neutral point, and the distance between the two is referred to as the static margin. The static margin is "positive" if the center of gravity is located forward of the neutral point, providing the aircraft with positive stability, or "negative" if the center of gravity is located aft of the neutral point, providing the aircraft with negative stability. In at least this example, the device **100** is configured with positive stability, and the neutral point **NP** thereof is located aft of the center of gravity **CG**.

It is also to be noted that in practice, the fuel delivery nozzle **135** is spaced below the underside **115** of the body **110** by a transverse spacing to provide sufficient clearance with respect to the receiver aircraft **20**, and thereby minimize risk of collision between the receiver aircraft **20** and the body **110**.

While in at least this example, the boom member **130** is configured as an elbowed boom, in alternative variations of this example the boom member **130** is configured as a rectilinear boom or as a curved boom.

In the stowed or boom retracted position (Fig. 1(b)), boom member **130** is pivoted about axis **C** into a position where the fuel delivery nozzle **135** is closest to the lower side

- 33 -

of body **110**. In the boom deployed position, boom member **130** is variably pivoted about pivot axis **C** in a downward direction to provide a desired orientation with respect to the fuel receptacle of the receiver aircraft **20**.

In any case, in general the boom member **130** is in the boom deployed position **DP**
5 at least during in-flight refueling operation of the device **100**.

A suitable actuation mechanism (not shown) is provided for controllably pivoting the boom member **130** between the stowed or boom retracted position **RP** and the boom deployed position **DP**.

The refueling device **100**, in particular the boom member **130**, nozzle **135** and
10 lumen **120** can be sized to allow suitable fuel flow rates for refueling a wide range of receiver aircraft. By way of non-limiting example, relative high fuel flow rates (for example up to 1000 US gallons/6,500 lb. per minute) can be provided for refueling operations of large aircraft (for example transport aircraft, bombers, etc.), while for fighter aircraft that cannot accept fuel at the maximum flow rate of the refueling device
15 **100**, the refueling pressure can be correspondingly reduced. Alternatively, the refueling device **100**, in particular the boom member **130**, nozzle **135**, lumen **131** and lumen **120** can be sized to allow suitable fuel flow rates for refueling a narrow range of receiver aircraft., for example only fighter aircraft or only larger aircraft (for example about 400 US gallons/2,600 lb. per minute).

20 The spatial control system **160** is configured for controlling a spatial disposition of the refueling device **100** when towed aft of the tanker aircraft **12** via the hose **52**, and enables the refueling device **100** to be steered and/or to adopt any desired stable spatial disposition while being towed at the end **54** of hose **52**.

In particular, and referring to Fig. 1(a), spatial control system **160** is configured
25 for selectively and controllably providing a non-zero angular disposition, between the second boom axis **BA2** of the boom member **130** and the forward direction **A**, and enables this angular disposition to be selectively maintained between the second boom axis **BA2** and the forward direction **A** at least for a part of the time when the refueling device **100** is being towed by the tanker aircraft **12** via hose **52**, in particular during the engagement
30 operation of the fuel device **100** to the receiver aircraft **20** and during refueling thereof.

- 34 -

The spatial control system **160** is also configured for providing stability to the refueling device **100**, while tethered to and towed by the tanker aircraft **12** via the hose **52**, and while the second boom axis **BA2** is at any desired pitch and/or yaw and/or roll angle to provide the aforesaid angular disposition.

5 In particular, this angular disposition is such as to provide a design angle θ_{des} that is within a particular angular range which corresponds to the design relative angular position of the boom member **130** (in particular the design relative angular position of the second boom axis **BA2**) with respect to the receiver aircraft **20**. Thus, at the design angle the second boom axis **BA2** is in an engagement enabling orientation with respect to the
10 receiver aircraft **20**, and in particular with respect to the fuel receptacle **22**.

In at least one non-limiting example, the design angle can be about 30° , and operation of the refueling device **100** to adopt this angle automatically renders it compatible for use with existing receiver aircraft **20**, in which the fuel receptacles **22** are configured for receiving and engaging with a nozzle at the end of a boom where the boom
15 is at about 30° to the longitudinal axis of the receiver aircraft, without the need for modifying the configuration of the fuel receptacle thereof.

In at least this example, the spatial control system **160** comprises a selectively controllable aerodynamic control system **170**, comprising a forward set **172** of aerodynamic control surfaces **173** mounted to body **110** at a forward portion thereof, and an aft set **174** of
20 aerodynamic control surfaces **175** mounted to the body **110** at an aft portion thereof. The aft set **174** is thus in aft spaced relationship with respect to the forward set **172**, and the center of gravity **CG** of the body **110** is disposed longitudinally intermediate the aft set **174** and the forward set **172**, noting that the actual longitudinal position of the center of gravity **CG** can shift between two extreme longitudinal positions according to, *inter alia*, whether the boom
25 member **135** is extended or retracted, and whether fuel is present in the refueling device **100** or absent therefrom.

It is to be noted that at least in this example, the center of gravity **CG** is forward of the neutral point **NP**.

In at least this example, the forward set **172** of aerodynamic control surfaces **173** is
30 in the form of a H-canard arrangement at a forward part of the body **110**, and similarly the

- 35 -

aft set **174** of control surfaces **175** is in the form of a H-tail arrangement. However, other arrangements are also possible for selectively controllable aerodynamic control system **170** and/or for the body **110**. Alternatively, for example the forward set **172** of aerodynamic control surfaces **173** and/or the aft set **174** of aerodynamic control surfaces **175** can optionally be blended with the body **100** to provide a blended body configuration. In yet other alternative variations of this example, for example, one of the forward set **172** of aerodynamic control surfaces **173** and/or the aft set **174** of aerodynamic control surfaces **175** can be omitted, and the other one of forward set **172** of aerodynamic control surfaces **173** and/or the aft set **174** of aerodynamic control surfaces **175** can be formed as a flying wing configuration, incorporating therein the functions of body **110**, which can then be omitted. In yet other alternative variations of this example, for example, the forward set **172** of aerodynamic control surfaces **173** and/or the aft set **174** of aerodynamic control surfaces **175** can both be omitted, and the body **110** can be formed as a lifting body, integrally providing the functions of the aerodynamic control system **170**. In yet other alternative variations of this example, for example, the aerodynamic control system **170** can be replaced with or supplemented by reaction control thrusters.

Optionally, the device **100** can comprises a longitudinal displacement control system **200** (Fig. 2), different from the spatial control system **160**, which can be operated to selectively provide longitudinal displacements to the refueling device **100**, and/or can be operated as an aerodynamic stabilizer arrangement.

Further optionally, the device **100** can comprises a force generating arrangement (not shown) configured for selectively generating a force along said second boom axis in a direction towards said fuel delivery nozzle. For example, such a force generating arrangement is configured for selectively generating said force along the second boom axis **BA2** in a direction towards the fuel delivery nozzle **135** responsive to the fuel delivery nozzle **135** being in predetermined proximity to the fuel receptacle **22** of the receiver aircraft **20** wherein to force the fuel delivery nozzle **135** into engagement with the fuel receptacle **22**.

Further optionally, the refueling device **100** further comprises a data acquisition system (not shown) configured for providing spatial data relating to a relative spatial disposition between the fuel delivery nozzle **135** and the fuel receptacle **22**, to enable

- 36 -

selectively controlling the refueling device **100** to provide automatic or autonomous or manual engagement of the fuel delivery nozzle **135** to the fuel receptacle **22** of the receiver aircraft **20**.

Further optionally, the refueling device **100** further comprises a suitable device
5 controller (not shown) for controlling operation of the refueling device **100**. For example such a device controller can be in the form of a suitable computer or computing device.

The boom member **130**, the refueling device **100**, and the tanker system **10** can be used for example as follows, according to aspects of the presently disclosed subject matter.

10 With the tanker system **10** airborne, one refueling device is deployed aft of the tanker aircraft and towed via the hose **52**.

The receiver aircraft **12** approaches the deployed refueling device **100** and the fuel delivery nozzle **135** is engaged with respect to the receiver aircraft, enabling in-flight refueling to proceed in the normal manner. For example, the fuel delivery nozzle **135** and
15 fuel receptacle **22** are engaged and locked via locking latches, which are typically provided in the receiver aircraft **20**.

When refueling is complete, or when the pilot of the receiver aircraft **20** otherwise wishes to disengage from the refueling device **100**, release of the locking latches is commanded via an electrical signal. The electrical command signal can come from the
20 refueling device **100** itself in an automated manner (for example responsive to determining directly or indirectly that the receiver aircraft fuel tanks are full, or after a predetermined time after commencement of fuel flow to the receiver aircraft). Alternatively, electrical command signal can come from the operator of the refueling system of the tanker system **10**. Alternatively, electrical command signal can come from
25 the pilot of the receiver aircraft **20**.

In normative situations, at the end of refueling the fuel delivery nozzle disengages from the refueling device **100**, which is then retracted by the tanker aircraft.

In certain circumstances there can arise a nozzle disconnect failure, in which it is not possible to disconnect the fuel delivery nozzle **135** from the receiver aircraft **20**. For

- 37 -

example, a mechanical jam can occur preventing disengagement, or there is an electrical command malfunction that prevents the fuel delivery nozzle **135** from being released from the fuel receptacle.

In such a nozzle disconnect failure situation, a potentially catastrophic flight
5 condition can be created since, in the absence of the presently disclosed subject matter, the receiver aircraft is now permanently mechanically connected to the delivery system **10** via the trapped fuel delivery nozzle **135**.

On the other hand, and according to an aspect of the presently disclosed subject matter, the operator in the refueling system **10** can, in such circumstances selectively
10 provide the disconnection activation signal **DAS** to the boom member **130**, in particular to the connect/disconnect mechanism **300**, to thereby disconnect the first boom member portion **230** with respect to the second boom member portion **240** to thereby provide the disconnected configuration, in which the fuel delivery nozzle together with the second boom member **240** remain engaged with the receiver aircraft, but are now disconnected
15 from the remainder of the boom element **130** and the fuel system **10**.

Alternatively, the disconnection activation signal **DAS** can be provided to the boom member **130**, in particular to the respective connect/disconnect mechanism **300** or to the respective connect/disconnect mechanism **300'**, via a separate channel. For example, such a separate channel can be via the receiver aircraft pilot, ground station, and
20 so on.

In this manner, the receiving aircraft is no longer mechanically connected to the refueling system **10**, and is thus allowed to separate from the respective refueling device **10** while said delivery nozzle is engaged to the receiver aircraft.

The refueling process is terminated with disconnection of the respective
25 connect/disconnect mechanism **300** or the respective connect/disconnect mechanism **300**, and the refueling device **100** can be stowed back into the tanker aircraft.

- 38 -

In the method claims that follow, alphanumeric characters and Roman numerals used to designate claim steps are provided for convenience only and do not imply any particular order of performing the steps.

Finally, it should be noted that the word “comprising” as used throughout the
5 appended claims is to be interpreted to mean “including but not limited to”.

While there has been shown and disclosed examples in accordance with the presently disclosed subject matter, it will be appreciated that many changes may be made therein without departing from the scope of the presently disclosed subject matter as set out in the claims.

CLAIMS:

1. Boom member configured for enabling in-flight refueling of a receiver aircraft, the boom member comprising a first boom member portion, a second boom member portion, and a connect/disconnect mechanism:
- 5 the first boom member portion including a first boom lumen, a first boom axis, and a fuel receiving end, the fuel receiving end configured for receiving fuel from a fuel source and for enabling delivering fuel via the first boom lumen;
- the second boom member portion including a second boom lumen, a second boom axis, and a fuel delivery end, the fuel delivery end comprising a fuel delivery nozzle
- 10 configured for selectively engaging with a fuel receptacle of the receiver aircraft;
- the connect/disconnect mechanism being configured for:
- selectively enabling the first boom member portion to be connected with respect to the second boom member portion to provide a connected configuration, such that free fluid communication is provided between the first boom lumen and the second boom lumen; and
 - 15 - selectively enabling actively disconnecting the first boom member portion with respect to the second boom member portion to provide a disconnected configuration responsive to receiving a disconnection activation signal.
- 20 2. The boom member according to claim 1, wherein said connect/disconnect mechanism has a normally said connected configuration, and wherein said connect/disconnect mechanism is electrically actuated via said disconnection activation signal to provide said disconnected configuration.
3. The boom member according to any one of claims 1 to 2, wherein said
- 25 connect/disconnect mechanism comprises a mechanical coupling arrangement and an electrically actuatable locking mechanism, wherein the mechanical coupling arrangement comprises a first coupling element affixed to the first boom element, a second coupling element affixed to the second boom element, and wherein the electrically actuatable locking mechanism is configured for selectively locking together the first coupling element with
- 30 respect to the second coupling element in said connected configuration when the electrically actuatable locking mechanism deactivated, and for selectively unlocking the first coupling element with respect to the second coupling element in said disconnected

configuration when the electrically actuatable locking mechanism is electrically activated via said disconnection activation signal.

4. The boom member according to claim 3, wherein the first coupling element comprises a first cylindrical flange and the second coupling element comprises a second
5 cylindrical flange, wherein in the connected configuration the first cylindrical flange and the second cylindrical flange are co-axial with respect to said second boom axis, and in sealing engagement with respect to one another.

5. The boom member according to any one of claims 3 to 4, wherein the electrically actuatable locking mechanism further comprises a plurality of locking elements and is
10 configured for:

- enabling said locking elements to lock together the first cylindrical flange and the second cylindrical flange in said connected configuration when the first cylindrical flange and the second cylindrical flange are in a first relative position with respect to one another; and
- 15 - enabling said locking elements to unlock the first cylindrical flange and the second cylindrical flange in said connected configuration when the first cylindrical flange and the second cylindrical flange are in a second relative position with respect to one another.

6. The boom member according to claim 5, said locking elements are in the form of
20 a plurality of balls, each ball having a nominally identical respective ball diameter, and wherein said first cylindrical flange comprises a first outer surface and a first inner surface, radially spaced from one another by a first flange thickness, and wherein said first cylindrical flange comprises a plurality of ball chambers in circumferentially arranged relationship therewith, each said ball chamber accommodating one said ball,
25 wherein said first cylindrical flange further comprises a through-opening to said first inner surface to allow only a part of each corresponding ball accommodated in the respective said ball chamber to project out of the respective said through-opening, wherein said radial thickness is less than each said ball diameter, and wherein said coupling system further comprises a collar movably mounted with respect to the first cylindrical flange
30 and in overlying relationship with the first outer surface, the collar comprising a plurality of recesses corresponding to said plurality of ball chambers, and wherein said collar is movable between a locking position and an unlocking position, wherein in the locking position the collar locks the balls in a projecting position with respect to each respective

said opening, and wherein in said unlocking position the collar enables the balls to recess into the respective ball chambers away from the respective projecting positions.

7. The boom member according to claim 6, wherein in said unlocking position said recesses are in radial alignment with respect to said ball chambers, and wherein in said
5 locking position said recesses are radially non-aligned with respect to said ball chambers.

8. The boom member according to any one of claims 6 to 7, wherein each said recess is sized such as to enable a respective said ball to be radially displaced thereinto and away from the respective projecting position.

9. The boom member according to any one of claims 6 to 8, wherein said second
10 cylindrical flange comprises a second outer surface comprising a plurality of locking grooves in circumferentially arranged relationship therewith, such that in said locking position each said ball projects away from each respective said opening in a respective said projecting position and into a locking configuration with a respect said locking groove, such as to prevent relative movement between said first cylindrical flange and
15 said second cylindrical flange.

10. The boom member according to any one of claims 6 to 9, wherein said collar comprises a mechanical stop, and said electrically actuable locking mechanism comprises a release solenoid arrangement configured for selectively cooperating with the mechanical stop, such that in the absence of said disconnection activation signal the
20 release solenoid arrangement prevents movement of the collar from the locking position, and such that in response to said disconnection activation signal the release solenoid arrangement allows movement of the collar from the locking position to the unlocking position.

11. The boom member according to claim 10, wherein said release solenoid
25 arrangement comprises a solenoid and a piston element reciprocable between a first position, corresponding to said locking position, and a second position, corresponding to said unlocking position, responsive to said solenoid being energized via said disconnection activation signal, the piston element comprising a retaining pin configured for selectively cooperating with said mechanical stop, and a biasing spring configured for
30 biasing the piston element into the second position

12. The boom member according to any one of claims 6 to 11, wherein said collar is biased into the unlocking position.

13. The boom member according to claim 12, comprising a torsion spring mounted at one longitudinal end thereof to said first cylindrical flange and at another longitudinal end thereof to said collar, and configured for biasing the collar into the unlocking position.

14. The boom member according to any one of claims 6 to 13, wherein the collar is
5 rotatably mounted with respect to the first cylindrical flange about a reference axis, between a first angular position corresponding to said locking position and a second angular position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

15. The boom member according to any one of claims 6 to 13, wherein the collar is
10 axially mounted with respect to the first cylindrical flange along a reference axis, between a first axial position corresponding to said locking position and a second axial position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

16. The boom member according to any one of claims 6 to 13, wherein the collar is
15 axially and rotatably mounted with respect to the first cylindrical flange with respect to a reference axis, between a first axial/angular position corresponding to said locking position and a second axial/angular position corresponding to said unlocking position, wherein said reference axis is co-axial with said second boom axis.

17. The boom member according to any one of claims 1 to 16, wherein at least an aft
20 part of the first boom member portion, and at least a forward part of the second boom member portion are rectilinear and co-axial with respect to one another.

18. The boom member according to claim 17, wherein the second boom member portion comprises a fore part connected to the aft part via an elbow portion.

19. The boom member according to claim 17, wherein the second boom member
25 portion is rectilinear.

20. The boom member according to any one of claims 1 to 19, wherein said connect/disconnect mechanism is configured for enabling selective active disconnection between the receiver aircraft and the refueling device in an essentially non-destructive manner, and in which the second boom member portion remains engaged in the receiver
30 aircraft after such disconnection.

- 43 -

21. The boom member according to any one of claims 1 to 20, wherein said connect/disconnect mechanism is configured for enabling selective active disconnection between the receiver aircraft and the refueling device in-flight.

22. The boom member according to any one of claims 1 to 21, wherein said
5 connect/disconnect mechanism is configured for enabling reversible disconnection between the receiver aircraft and the refueling device.

23. A refueling device for use in in-flight refueling operation, comprising:

- (a) a body configured for being towed by a tanker aircraft in a forward direction via a fuel hose at least during in-flight refueling operation, the
10 body having a body longitudinal axis;
- (b) spatial control system configured for selectively providing stability and control to the refueling device;
- (c) a boom member as defined in any one of claims 1 to 22, the boom member being carried by the body.

15

24. The refueling device according to claim 23, wherein the boom member is reversibly pivotable with respect to the body, between a boom stowed position and a boom deployed position, wherein in the boom stowed position the refueling nozzle is closer to the body than in the boom deployed position, and wherein in the boom deployed
20 position engagement with the fuel receptacle of the receiver aircraft is possible.

25. The refueling device according to claim 23, wherein said boom member is in fixed spatial relationship with respect to the body.

26. The refueling device according to any one of claims 23 to 25, wherein said spatial control system is further configured for selectively providing control moments in at least
25 one of pitch, yaw and roll wherein to enable the refueling device to be flown while towed by the tanker aircraft in said forward direction via said fuel hose.

27. The refueling device according to any one of claims 23 26 27, wherein said spatial control system comprises selectively controllable aerodynamic control system.

28. The refueling device according to claim 27, wherein said selectively controllable
30 aerodynamic control system comprises a forward set of aerodynamic control surfaces mounted to said body, and an aft set of aerodynamic control surfaces mounted to said

body in longitudinally aft spaced relationship with respect to said forward set of aerodynamic control surfaces.

29. The refueling device according to claim 28, wherein said forward set of aerodynamic control surfaces comprises a canard configuration, and said aft set of
5 aerodynamic control surfaces comprises one or more wing elements.

30. The refueling device according to claim 28 or claim 29, wherein said aft set of aerodynamic control surfaces comprises an H-wing configuration, comprising two vertical wing stabilizers, one each on either side of a respective wing.

31. The refueling device according to any one of claims 28 to 30, wherein said
10 forward set of aerodynamic control surfaces comprises an H-canard configuration, comprising two vertical canard stabilizers, one each on either side of a respective canard.

32. The refueling device according to any one of claims 23 to 31, wherein said spatial control system is configured for enabling the refueling device to be steered in one, or two, or three degrees of freedom in translation, and in one, or two, or three degrees of freedom
15 in rotation, independently of the tanker aircraft or of the refueling aircraft.

33. The refueling device according to any one of claims 23 to 32, wherein said body further comprises a longitudinal displacement control system, different from the spatial control system.

34. The refueling device according to any one of claims 23 to 33, further comprising
20 a force generating arrangement configured for selectively generating a force along said second boom axis in a direction towards said fuel delivery nozzle.

35. The refueling device according to claim 34, wherein said force generating arrangement is configured for selectively generating said force along said second boom axis in a direction towards said fuel delivery nozzle responsive to said fuel delivery nozzle
25 being in predetermined proximity to the fuel receptacle of the receiver aircraft wherein to force said fuel delivery nozzle into engagement with the fuel receptacle.

36. The refueling device according to any one of claims 23 to 35, said body comprising a fuel delivery lumen configured for fluid communication with said fuel hose and said boom member at least during the in-flight refueling operation, wherein said body
30 comprises a coupling having a hose interface configured for connecting said lumen to the fuel hose, said coupling configured for allowing relative rotation between the hose and said body in at least one degree of freedom while maintaining said fuel communication.

- 45 -

37. The refueling device according to any one of claims 23 to 36, further comprising a data acquisition system configured for providing spatial data relating to a relative spatial disposition between said fuel delivery nozzle and said fuel receptacle, to enable selectively controlling the refueling device to provide automatic or autonomous or
5 manual engagement of the fuel delivery nozzle to the fuel receptacle of the receiver aircraft.

38. The refueling device according to any one of claims 23 to 37, further comprising a suitable controller for controlling operation thereof.

39. A refueling system comprising a refueling fuel reservoir connected to a refueling
10 device via a hose, the refueling device being as defined in any one of claims 23 to 38.

40. A tanker aircraft comprising at least one refueling system as defined in claim 39.

41. A method for in-flight refueling, comprising:
- providing a tanker aircraft as defined in claim 40;
- deploying the refueling device aft of the tanker aircraft when airborne;
15 - engaging the fuel delivery nozzle to a receiver aircraft;
- selectively providing said disconnection activation signal to the boom member to thereby disconnect the first boom member portion with respect to the second boom member portion to provide said disconnected configuration;
- allowing the receiving aircraft to separate from the respective said body while said
20 delivery nozzle is engaged to said receiver aircraft.