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Aircraft Inceptor Trim Apparatus

Abstract

An apparatus for adjusting aircraft inceptor trim includes an inceptor centring device mechanically coupled to a control shaft that rotates in response to inceptor inputs. The inceptor centring device includes an inceptor centring spring preloaded with a preload force to provide a first biasing force to bias the control shaft to an inceptor neutral position. The apparatus has a trim mechanism, mechanically coupled to the inceptor centring device, and includes a trim locking device having a locked state and an unlocked state. A resistance force of the trim mechanism with the trim locking device in the unlocked state is less than the preload force, such that when the trim mechanism is in the unlocked state, actuation of the inceptor adjusts the position of the inceptor centring device to alter the degree of trim.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of European Patent Application No. 24305210.7 filed Feb. 8, 2024, the disclosure of which is incorporated herein by reference in its entirety.

FIELD

[0002] This disclosure relates to an apparatus for adjusting aircraft inceptor trim. This disclosure further relates to a system comprising an apparatus for adjusting aircraft inceptor trim.

BACKGROUND

[0003] Inceptor units in aircraft having a trim function, include a Trim Actuator (TA) comprising electrical motors with control electronics driving a non-reversible mechanical chain linked to an inceptor centring spring.

[0004] The pilot adjusts the trim using a trim rotary switch, instructing the TA to move the inceptor neutral position to the desired trim position.

[0005] Further, when autopilot is in control of the aircraft, the TA can also be used to back-drive the inceptor such that the inceptor position corresponds to the trim orders being sent by the autopilot to the control surface.

[0006] In many cases, inceptor back-driving is not required and, in these situations, commonly used inceptor trim systems are overly complex.

SUMMARY

[0007] According to this disclosure, there is provided an apparatus for adjusting aircraft inceptor trim. The apparatus includes: an inceptor centring device, configured to be mechanically coupled to a control shaft. The control shaft rotates in response to control inputs provided at the inceptor, the inceptor centring device comprises an inceptor centring spring, and the inceptor centring spring is preloaded with a preload force. The inceptor centring spring is configured to provide a first biasing force to bias the control shaft to an inceptor neutral position. The system also includes a trim mechanism mechanically coupled to the inceptor centring device and comprising a trim locking device having an unlocked state in which the trim locking device is configured to allow adjustment of the position of the inceptor centring device; and a locked state in which the trim locking device is configured to maintain the adjusted position of the inceptor centring device. A resistance force of the trim mechanism with the trim locking device in the unlocked state is less than the preload force, such that when the trim mechanism is in the unlocked state, actuation of the inceptor results in adjustment of the position of the inceptor centring device to alter the inceptor neutral position and hence the degree of aircraft inceptor trim.

[0008] It will be understood that the term ‘inceptor’ includes all aircraft input devices which a pilot may use to instruct control of the aircraft. In particular, where used herein, the term ‘inceptor’ includes pedals (e.g. rudder pedals) used to control the yaw axis of an aircraft and control columns/yokes used to control the pitch and roll axes of an aircraft.

[0009] It will be understood that when the trim locking device is in the locked state, actuation of the inceptor results in the spring being deformed according to the inceptor actuation whilst the trim mechanism is stationary (increasing the force exerted by the spring).

[0010] It will be understood that where used herein, the term ‘inceptor neutral position’ refers to the position which is adopted by the inceptor when there is no input load on the inceptor (i.e. no force exerted on the inceptor by a pilot or autopilot).

[0011] It will further be understood that, where used herein, ‘trim neutral position’ refers to the position in which the degree of trim is substantially equal to **0**, i.e. the position in which the inceptor neutral position (i.e. no input load on the inceptor) corresponds to a control surface neutral position.

[0012] As such, the trim neutral position is fixed, whereas the inceptor neutral position depends on the current degree of trim.
[0013] It will be understood that a spring is an object which can be deformed by a force, and returns to its original shape after the force is removed.
[0014] It will be understood that since the spring is preloaded with a preload force (the inceptor centring preload force), the spring has already been deformed to the preload force and so any force that is applied to the spring, which is lower than the preload force, will not act to deform the spring (i.e. the spring will act as a rigid element).
[0015] The resistance force of the trim mechanism is a resisting force which resists movement of the inceptor centring device away from the trim neutral position. The resistance force of the trim mechanism may comprise forces resulting from friction present in bearings and/or pivots. The resistance force of the trim mechanism may comprise damping forces resulting from damping devices.
[0016] In examples, the inceptor centring device comprises a first part which is configured to be mechanically coupled to the control shaft, a second part which is mechanically coupled to the trim mechanism, wherein the first and second parts are each mechanically coupled to the inceptor centring spring, and wherein the second part is moveable relative to the first part.
[0017] In examples, the trim mechanism comprises a trim centring device which is configured to provide a second biasing force to bias the inceptor centring device towards a trim-neutral position, wherein the resistance force includes the second biasing force (i.e. the resistance force comprises the second biasing force, and may further comprise forces resulting from friction present in bearings and/or pivots, and/or damping forces resulting from damping devices.
[0018] The second biasing force may increase as the inceptor centring device rotates further away from the trim-neutral position. In examples, the maximum value of the second biasing force (e.g. when the inceptor centring device is at maximum rotation away from the trim-neutral position) is such that the resistance force is less than the preload force of the inceptor centring device spring.
[0019] In examples, the trim mechanism comprises a damper configured to damp the second biasing force. The damper may be integrated into the trim locking device. In such examples, the trim locking device may be considered a trim locking and damping device.
[0020] In examples, the damper is an electromechanical damper.
[0021] In examples, the trim centring device comprises a spring configured to provide the second biasing force.
[0022] In examples, the trim centring device comprises a tension spring (e.g. a helical tension spring) configured to provide the second biasing force.
[0023] In examples, the trim centring device comprises a compression spring (e.g. a helical compression spring) configured to provide the second biasing force.
[0024] In examples, the trim centring device comprises a lever and a cam surface mechanically coupled to the inceptor centring device.
[0025] In examples, a first end of the tension spring is coupled to a frame (e.g. a fixed frame of the aircraft), a second end of the tension spring is coupled to a first end of the lever, and wherein the lever is configured to pivot about a pivot point such that a second end of the lever moves along the cam surface such that the tension spring is extended when the inceptor centring device is rotated away from the trim neutral position (i.e. the tension spring is extended regardless of whether the current degree of trim is positive or negative (e.g. yaw right trim or yaw left trim, nose up trim or nose down trim, roll right trim or roll left trim)).
[0026] In examples, the second end of the lever comprises a roller configured to roll along the cam surface.
[0027] In examples, the cam surface is a V-shaped (e.g. V-shaped or U-shaped) cam surface.
[0028] In examples, the trim locking device comprises a power-off brake.
[0029] In examples, the inceptor centring device is mechanically coupled to the trim locking device

via one or more gears (i.e. the mechanical coupling is realised via the meshing of one or more gears).
[0030] In examples, the inceptor centring spring is a torsion spring. In such examples, it will be understood that the preload force is a preload torque. In such examples, the adjustment of the position of the inceptor centring device to alter the degree of trim may be via rotation of the entire inceptor centring device (e.g. about the axis of the control shaft).
[0031] In examples, the inceptor centring spring is a helical torsion spring.
[0032] In examples, the inceptor centring device is configured such that the torsion spring is wound more tightly both when the control shaft rotates in the clockwise direction and when the control shaft rotates in the anti-clockwise direction.
[0033] In examples, the inceptor centring device comprises a driving member (e.g. tooth) which is coupled to the control shaft, and a retaining member (e.g. tooth) which is configured to be stationary when the trim locking device is in the locked state, and moveable when the trim locking device is in the unlocked state, wherein the inceptor centring device is configured such that, when the trim locking device is in the locked state, and the control shaft is rotated, the driving member acts on a first end of the torsion spring and the retaining tooth retaining member retains a second end of the torsion spring such that the torsion spring is wound more tightly. When the trim locking device is in the unlocked state, and the control shaft is rotated, the driving member acts on a first end of the torsion spring and the retaining member is allowed to move when acted upon by a second end of the torsion spring such that the entire inceptor centring device is rotated.
[0034] In examples, the inceptor centring device comprises a compression spring (e.g. a helical compression spring). In examples, the inceptor centring device comprises a push-pull rod. In such examples, the adjustment of the position of the inceptor centring device to alter the degree of trim may be via the movement of an anchorage element of the push-pull rod.
[0035] In examples, the inceptor centring spring is a tension spring (e.g. a helical tension spring). In examples, the inceptor centring device comprises a lever and a cam surface mechanically coupled to the control shaft. In such examples, the adjustment of the position of the inceptor centring device to alter the degree of trim may be via the movement of an anchorage element of the tension spring.
[0036] In examples, the trim mechanism comprises one or more trim sensors mechanically coupled to the trim mechanism and configured to detect the trim position.
[0037] According to the present disclosure, there is provided a system comprising an apparatus as disclosed above, a first aircraft inceptor, and one or more inceptor sensors, wherein the first aircraft inceptor, and the one or more inceptor sensors are mechanically coupled to the control shaft.
[0038] It will be understood that the inceptor sensors are configured to send instructions to a fly-by-wire aircraft control system which in turn instructs movement of the aircraft control surfaces.
[0039] In examples, the system comprises an inceptor damper mechanically coupled to the inceptor centring device and configured to damp the first biasing force provided by the inceptor centring device.
[0040] In examples, the system comprises a second aircraft inceptor mechanically coupled to the control shaft. The first inceptor may be a pilot's inceptor while the second inceptor may be a first officer's inceptor.
[0041] In each of the examples described above, the inceptor may be a pair of rudder pedals for controlling the yaw axis of an aircraft. In such examples, the inceptor centring device may be considered to be a pedal centring element.
[0042] In each of the examples described above, the inceptor may be a control column or yoke for controlling the pitch and roll axes of an aircraft. In such examples, the inceptor centring device may be considered to be a column or yoke centring element.
[0043] In each of the examples described above, the inceptor may be a control column or yoke for

controlling the roll axis of an aircraft. In such examples, the inceptor centring device may be considered to be a column or yoke centring element.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0044] One or more non-limiting examples will now be described, by way of example only, and with reference to the accompanying figures in which:

[0045] FIG. **1** shows an aircraft having control surfaces;

[0046] FIG. **2** shows an exploded view of a system including an apparatus for trimming an aircraft rudder operated by rudder pedals;

[0047] FIG. **3** shows a schematic illustration of an inceptor centring device;

[0048] FIG. **4** shows the inceptor centring device of FIG. **3**, and the trim mechanism of the apparatus;

[0049] FIG. **5** shows a plan view, schematic illustration of the trim centring apparatus;

[0050] FIG. **6** shows a schematic illustration of an alternative inceptor centring device; and

[0051] FIG. **7** shows an exploded view of a variant of the system of FIG. **2**.

DETAILED DESCRIPTION

[0052] FIG. **1** shows an aircraft **100** comprising a plurality of control surfaces **101**. The control surfaces include a rudder **102**, ailerons **103**, and elevators **104**.

[0053] FIG. **2** shows an exploded view of a system **1** which includes an apparatus **2** for trimming an aircraft inceptor. In the illustrated example, the inceptor is a pair of rudder pedals for controlling the yaw axis of an aircraft. The system **1** includes a pair of rudder pedals **3**, a control shaft **5**, an inceptor damper and friction mechanism **7**, and a pair of inceptor sensors **9**.

[0054] It will be understood that whilst the apparatus **2** has been illustrated in relation to rudder pedal trim of a fixed wing aircraft, the novel features disclosed herein are applicable to trim adjustment of any aircraft inceptors, including inceptors of rotary wing aircraft (i.e. helicopters). When applied to rotary aircraft inceptors, the apparatus **2** may be used in the trim of cyclic pitch, collective pitch, and tail rotor pitch.

[0055] The control shaft **5** is mechanically coupled to the rudder pedals **3** by linkages **4** that are configured such that actuation of the rudder pedals **3** results in rotation of the control shaft **5** about its longitudinal axis. Depression of the left pedal results in an anti-clockwise rotation of the control shaft **5**, while depression of the right pedal results in a clockwise rotation of the control shaft **5**.

[0056] An inceptor damper and friction mechanism **7** is mechanically coupled to the control shaft **5** and is configured to resist rotation of the control shaft **5** such that rapid and/or jerky control shaft movements are prevented. The inceptor damper and friction mechanism **7** also damps any oscillations in the rotation of the control shaft **5**. This damper may be an electromagnetic damper, a hydraulic damper, or a friction damper.

[0057] The degree of rotation of the control shaft **5** is detected by inceptor sensors **9**. The inceptor sensors **9** are configured to send instructions to a fly-by-wire aircraft control system (not shown) which in turn instructs movement of the aircraft rudder **102**. It will be understood that in examples, only one inceptor sensor **9** may be provided, but in the illustrated example, two are provided for redundancy. It will be understood that, in examples, the control shaft **5** may be mechanically coupled (e.g. by cable linkages) to the aircraft control surfaces (e.g. the aircraft rudder) such that the control shaft acts directly on the control surface.

[0058] It will be understood that where used herein, the term ‘pedal neutral position’ corresponds to the term ‘inceptor neutral position’ and refers to the position which is adopted by the rudder pedals **3** (inceptor) when there is no input load on the pedals (i.e. no force exerted on the pedals by a pilot or autopilot).

[0059] It will further be understood that, where used herein, 'trim neutral position' refers to the position in which the degree of rudder trim =**0**. i.e. when the pedal neutral position corresponds to no left or right rudder.

[0060] As such, the trim neutral position is fixed, whereas the pedal neutral position depends on the current degree of rudder trim.

[0061] It will be understood that the apparatus **2** may be compatible with a plurality of different systems, and so features of the apparatus **2** discussed below should not be construed as being limited to the specific system **1** shown in FIG. **1**.

[0062] The apparatus **2** comprises an inceptor centring device **11**, and a trim mechanism **13** which includes a trim gear sector **15**, a trim locking and damping device **16**, and a trim centring device **17**. The trim mechanism may also comprise one or more trim sensors **19**. Operation of the individual elements of the apparatus **2** will be discussed below in relation to FIGS. **3-5**.

[0063] FIG. **3** shows a schematic illustration of the inceptor centring device **11**. The inceptor centring device **11** comprises a helical torsion spring **21**, an upper cup **23**, a lower cup **25**, a driving tooth **27**, a retaining tooth **29**, and an anchorage element **31**. The upper and lower cups **23**, **25** each at least partially surround the torsion spring **21** and are free to rotate around the control shaft **5**.

[0064] A first end of the torsion spring **21** is coupled to the upper cup **23** at a first connection point. A second end of the torsion spring **21** is coupled to the lower cup **25** at a second connection point. Each of the upper and lower cups **23**, **25** comprise respective driving surfaces **33**, **35**.

[0065] Both the driving tooth **27** and the retaining tooth **29** are sandwiched between the driving surfaces **33**, **35**. Further, each of the driving surfaces **33**, **35** overlap with both of the driving tooth **27** and the retaining tooth **29** such that both driving surfaces **33**, **35** can be acted upon by the driving tooth **27** and the retaining tooth **29**.

[0066] The driving tooth **27** is rigidly coupled to the control shaft **5**. The retaining tooth **29** is rigidly coupled to the anchorage element **31** which is rigidly coupled to the trim gear sector **15**. As such, the retaining tooth **29** is only allowed to move when the trim locking and damping device **16** is in an unlocked state. When the trim locking and damping device **16** is in a locked state, the anchorage element **31**, and thus the retaining tooth **29** are fixed in position.

[0067] When a left-hand rudder input is received, the control shaft **5** rotates anti-clockwise. This rotation also moves the rigidly connected driving tooth **27** in an anti-clockwise direction (to the right in the reference frame of FIG. **3**). As a result, the driving tooth **27** acts on the driving surface **33** of the upper cup **23**, and hence pulls on the first end of the torsion spring **21** via the first connection point.

[0068] The second end of the torsion spring **21** acts on the lower cup **25** via second connection point **32**, and so the driving surface **35** of the lower cup **25** acts on the retaining tooth **29**. Since the retaining tooth **29** is fixed in position, the rotation of the control shaft **5** acts to wind the torsion spring **21** more tightly, winding the spring up on itself. When pressure on the left-hand rudder pedal is released, the torsion spring **21** unwinds, acting to move the driving tooth **27** back in line with the retaining tooth **29**, moving the control shaft **5** and the rudder pedals **3** back to the pedal neutral position.

[0069] When a right-hand rudder input is received, the control shaft **5** rotates clockwise. This rotation also moves the rigidly connected driving tooth **27** in a clockwise direction (to the left in the reference frame of FIG. **3**). As a result, the driving tooth **27** acts on the driving surface **35** of the lower cup **25**, and hence pulls on the second end of the torsion spring **21** via the second connection point.

[0070] The first end of the torsion spring **21** acts on the upper cup **23** via the first connection point, and so the driving surface **33** of the upper cup **23** acts on the retaining tooth **29**. Since the retaining tooth **29** is fixed in position, the rotation of the control shaft **5** acts to wind the torsion spring **21** more tightly, winding the torsion spring **21** up on itself. When pressure on the right-hand rudder pedal is released, the torsion spring **21** unwinds, acting to move the driving tooth **27** back in line with the retaining tooth **29**, moving the control shaft **5** and the rudder pedals **3** back to a pedal neutral position.

[0071] Using the above described arrangement, the torsion spring **21** is wound more tightly both when the control shaft **5** rotates in the clockwise and anti-clockwise directions.

[0072] Since both the driving surface **33** of the upper cup **23**, and the driving surface **35** of the lower cup **25** each overlap with the driving tooth **27** and the retaining tooth **29**, the torsion spring **21** cannot unwind any further than the point at which both driving surfaces **33**, **35** are in contact with both the driving tooth **27** and retaining tooth **29**. As such, the torsion spring **21** can be preloaded with a preload torque, and the preload torque can be set by setting the thickness of the driving tooth **27** and retaining tooth **29**. In examples, the inceptor centring device may include a mechanism for adjusting the preload torque.

[0073] By preloading (pre-torquing) the torsion spring **21**, the inceptor centring device **11** is arranged such that any torque which is applied to the torsion spring **21** via the driving tooth **27** or retaining tooth **29** which is less than the preload torque will not wind the spring **21**. As such, when the trim locking device **16** is unlocked, an applied torque which is lower than the pre-load torque will rotate the entire inceptor centring device **11** without winding the torsion spring **21**, since the torsion spring **21** will act as a rigid element.

[0074] FIG. **4** shows an exploded perspective view of the apparatus **2** for trimming an aircraft inceptor. As explained above, the apparatus **2** comprises an inceptor centring device **11**, and a trim mechanism **13** which includes a trim gear sector **15**, a trim locking and damping device **16**, and a trim centring device **17**. The trim mechanism **13** shown in FIG. **4** also comprises trim sensors **19**. The inceptor centring device **11** shown in FIG. **4** is the inceptor centring device **11** illustrated in FIG. **3**.

[0075] The anchorage element **31** is rigidly coupled to the trim gear sector **15**. The trim gear sector **15** comprises teeth **38**, and a body **39** which surrounds the control shaft **5**. The body **39**, and hence the trim gear sector **15** is free to rotate around the control shaft. The trim gear sector is mechanically coupled to the trim locking and damping device **16**. The trim locking and damping device **16** comprises a drive shaft **40** having teeth **42**.

[0076] In the example illustrated in FIG. **4** the trim gear sector **15** and the trim locking and damping device **16** are coupled via an intermediate gear **41**. In the illustrated example, the intermediate gear **41** is a compound spur gear comprising first teeth **43** and second teeth **45**. The teeth **38** of the trim gear sector **15** engage with the first teeth **43**, and the second teeth **45** engage with the teeth **42** on the drive shaft **40** of the trim locking and damping device **16**. It will be understood that in different configurations, the teeth **38** on the trim gear sector **15** could engage directly with the teeth **42** on the drive shaft **40**, or the body **39** could engage with the drive shaft **40**, or the body **39** and the drive shaft **40** could be integrally formed.

[0077] The trim locking and damping device **16** comprises a power off brake (POB) **47** and a damper **49**. In the illustrated example, the damper is an electromagnetic damper **49** but in other examples the damper **49** may be any suitable damper, such as a hydraulic damper, or a friction damper.

[0078] When no power is being provided to the POB **47**, the drive shaft **40** is locked in place, as such, the trim gear sector **15**, and anchorage element **31** of the inceptor centring device **11** are locked in place. When power is provided to the POB **47**, it is unlocked, and so the drive shaft **40**, trim gear sector **15**, and anchorage element **31** of the inceptor centring device **11** are free to move, but this movement is damped (via the drive shaft **40**) by the electromagnetic damper **49**.

[0079] The trim centring device **17** is coupled to the body **39** of the trim gear sector **15** and is configured to bias the trim mechanism **13** towards a trim-neutral position. The trim centring device **17** is described in detail in relation to FIG. **7**.

[0080] FIG. **5** shows a plan view of the trim centring device **17**. The trim centring device **17** comprises a cam element **51**, a lever **53**, and a coil spring **55**. The cam element **51** is rigidly coupled to the body **39** of the trim gear sector **15** such that the trim gear sector **15** and the cam element **51** both rotate about the control shaft **5** together. In some examples, the cam element **51** may be unitarily formed with the body **39** of the trim gear sector **15**. The cam element **51** comprises a V shaped cam surface **57**. The lever **53** comprises a pivot point **59** at which the lever **53** is pivotally mounted to a fixed frame, and a first arm **61**, and a second arm **63** which each extend away from the pivot point **59** and each have respective distal ends **65**, **66**. The distal end **65** of the first arm is pivotally connected to a first end **69** of the coil spring **55**. A second end **71** of the coil spring **55** is fixedly mounted to a fixed frame. At the distal end **66** of the second arm **63**, a roller **67** is provided which is in contact with the cam surface **57**. In the illustrated example, the first arm **61** and the second arm **63** are curved. In examples, the coil spring **55** could be replaced with a torsion spring disposed around pivot point **59**. In examples, the trim centring device may not comprise a lever and cam surface, and may be implemented as a torsion spring connected between body **39** and a fixed frame of the aircraft. The illustrated cam surface arrangement is preferable to such alternatives since the gradient of the cam surface can be tuned within a compact design.

[0081] The V-shaped cam surface **57** is configured such that when the cam element **51** rotates in either a clockwise, or anti-clockwise direction, the roller **67** rolls along the cam surface **57**, away from the pit **73** of the V, and the distal end **66** of the second arm **63** is urged in the direction of arrow A shown in FIG. **5**. The lever **53** therefore pivots around pivot point **59**, and so the distal end **65** of the first arm **61** moves in the direction of arrow B, extending the coil spring **55**. As such, the coil spring **55** acts to bias the trim centring device **17** to the position in which the roller **67** is seated in the pit **73** of the V-shaped cam surface **57**. The trim centring device **17** is configured such that this position corresponds to the trim neutral position.

[0082] The overall operation of the system **1** will now be explained.

[0083] When the pilot desires to trim the inceptor (in the illustrated example, the rudder pedals) they will unlock the trim mechanism **13**. This can be done via, for example, a trim unlock button in the cockpit. Upon receipt of a trim unlock instruction, power is provided to the POB **47** unlocking the drive shaft **40**, and hence allowing the trim gear sector **15**, and anchorage element **31** of the inceptor centring device **11** to move. In this unlocked state, the inceptor centring device **11** is biased towards the trim neutral position by the trim centring device **17**, as explained above.

[0084] To trim the aircraft rudder **102** (control surface **101**), the pilot moves the rudder pedals **3** (inceptor) to the desired position. The apparatus **2** is configured such that the pre-load of the inceptor centring spring **21** is greater than the total maximum force which is resisting rotation of the inceptor centring device **11** across the full range of pedal (inceptor) movement. This force is made up of the damping force from the damper **49**, the biasing force generated by the trim centring device **17**, as well as general frictional forces (from bearings and linkages).

[0085] As a result of the pre-load of the torsion spring **21**, the pre-load force must be exceeded before the torsion spring **21** of the inceptor centring device **11** is wound more tightly. As such, when the trim mechanism **13** is unlocked, movement of the rudder pedals **3** (inceptor) acts to rotate the entire inceptor centring device **11**, rather than winding the torsion spring **21**. When the pilot is happy with the level of trim, they will re-lock the trim mechanism **13**, for example, using a trim lock button in the cockpit. Upon receipt of a trim lock instruction, power is cut to the POB **47**, locking the drive shaft **40**, and hence preventing the trim gear sector **15**, and anchorage element **31** of the inceptor centring device **11** from moving. The system is now locked in trim. In the trim-locked state, movement of the rudder pedals **3** will rotate the control shaft **5** and wind up the torsion spring **21** as explained in relation to FIG. **3**.

[0086] An advantage of this configuration is that, since the inceptor centring device **11** is rotated without winding the torsion spring **21**, the inceptor (e.g. rudder pedal) feel (i.e. the force required to depress either the left or right rudder pedal, force required to tilt the control column etc) around the inceptor neutral position is transferred to the trimmed position since, regardless of the trim position, the torsion spring is unwound (other than the pre-load) in the inceptor neutral position.

[0087] When the pilot wants to return to the trim-neutral position, they will unlock the trim mechanism **13** in the same way as described above. If the pilot does not exert any pressure on either of the rudder pedals **3** (the inceptor), the inceptor centring device **11**, and hence the pedals **3**, will return to the trim neutral position as a result of the biasing force provided by the trim centring device **17**. The electromagnetic damper **49** ensures that the trim mechanism **13** does not return to the trim neutral position too quickly. This to ensure that the rudder **102** (control surface **101**) does not move too quickly, which could unsettle the stability of the aircraft **100**.
[0088] In the illustrated example, the trim mechanism **13** comprises a pair of trim sensors **19**. These trim sensors **19** can be seen in FIGS. **2** and **4**. As shown in FIG. **4**, the sensors comprise engaging elements **75** having teeth **77**. These teeth **77** engage with corresponding teeth **79** on the trim gear sector bearing **39** such that the rotational position of the trim gear sector **15** can be detected by the sensors **19** and hence the trim position can be determined. The trim sensors **19** are configured to send a signal to a display unit in the cockpit (not shown) in order to inform the pilot of the current trim position. It will be understood that in examples, only one trim sensor **19** may be provided, but in the illustrated example, two are provided for redundancy. It will be understood that the trim sensors may be implemented n different ways. For example, one or more trim sensors may be directly embedded in body **39**.
[0089] Although the inceptor centring device **11** described above comprises a torsion spring **21**, it will be understood that alternative inceptor centring devices may also be suitable for use in the trim mechanism **13**. FIG. **6** shows a schematic illustration of another inceptor centring device **110**. The inceptor centring device **110** comprises a helical compression spring **112**, and a rod **114** which extends coaxially through the compression spring **112**. The inceptor centring device **110** further comprises a first driving element **116** which is adjacent to a first end of the spring **112**, and a second driving element **118** which is adjacent to a second end of the spring **112**. The rod **114** extends through holes **115** and **117** in both the first driving element **116**, and the second driving element **118** respectively, and comprises a first shoulder **122** which is adjacent to the first driving element **116**, and a second shoulder **124** which is adjacent to the second driving element **118**.
[0090] The first and second shoulders **122** and **124** are arranged such that when the rod **114** moves in a first direction, the first shoulder **122** abuts the first driving element **116** which acts to compress the spring **112** against the second driving element **118**, and such that when the rod **114** moves in a second direction, the second shoulder **124** abuts the second driving element **118** which acts to compress the spring **112** against the first driving element **116**.
[0091] The inceptor centring device **110** further comprises a spring housing **119**, and a bellcrank **120**.
[0092] The bellcrank **120** is fixedly coupled to the control shaft **5**, and pivotally coupled to a first end **126** of the rod **114** such that the bellcrank **120** translates rotation of the control shaft **5** into linear movement of the rod **114**.
[0093] When the control shaft **5** rotates in an anti-clockwise direction (moving the bellcrank **120** downwards in the reference frame of FIG. **6**) the rod **114** is pushed downwards. As a result, the first shoulder **122** acts on the first driving element **116**. The second driving element **118** is held in place by the spring housing **119**, and the rod **114** is allowed to move through the hole **117** in the second driving element **118** such that the spring **112** is compressed between the first and second driving elements **116**, **118**.
[0094] When the control shaft **5** rotates in a clockwise direction (moving the bellcrank **120** upwards in the reference frame of FIG. **6**) the rod **114** is pulled upwards. As a result, the second shoulder **124** acts on the second driving element **116**. The first driving element **116** is held in place by the spring housing **119**, and the rod **114** is allowed to move through the hole **115** in the first driving element **116** such that the spring **112** is compressed between the first and second driving elements **116**, **118**.
[0095] The spring housing **119** comprises an anchorage element **126** which, when installed in a

trim mechanism **13** would be coupled to a trim locking device (not shown). In a similar manner to that explained above with relation to the inceptor centring device **11** of FIG. **3**, the compression spring **112** has a pre-load compression force applied to it such that, when the trim locking device is unlocked, and a force lower than the preload force is applied to the rod **114** (and hence the spring **112**), the spring **112** acts as a rigid element and so the position of the entire inceptor centring device **111** will be adjusted, altering the trim.

[0096] FIG. **7** shows an exploded view of a system **201** which is a variant of the system **1**. System **201** may be used in an aircraft having dual controls and includes two inceptors, such as two pairs of rudder pedals, a pilot's pedals **3***a* and a first officer's pedals **3***b*. The system **201** comprises the same components as the system **1**, but two control shafts, a pilot's control shaft **5***a* and a first officer's control shaft **5***b*, are provided, one for each pair of rudder pedals **3***a*, **3***b*. The control shafts **5***a*, **5***b* are mechanically coupled by linkage **81** such that both control shafts **5***a*, **5***b* and both pairs of rudder pedals **3***a*, **3***b* move together and rudder trim adjustment can be performed by either a pilot or a first officer.

[0097] Since the control shafts **5***a*, **5***b* are mechanically coupled, components are shared between the control shafts. In the illustrated example, the inceptor damper and friction mechanism **7** is provided on the first officer's control shaft **5***b*, and the apparatus **2** (including the inceptor centring device **11** and the trim mechanism **13**) is provided on the pilot's control shaft **5***a*. A pair of inceptor sensors **9** are provided on each of the control shafts **5***a*, **5***b* for redundancy.

[0098] It will therefore be seen that the apparatus and system of the present disclosure has been designed to work according to the way in which pilot's typically carry out manual inceptor trim adjustment. As such, in certain applications, such as those where no inceptor back driving is required, the apparatus and system of the present disclosure represents a more simple, mechanical system, due to the absence of motors which has the potential to be both lighter, and more reliable than conventional inceptor trim actuator-based systems. The absence of electronics in the apparatus may also lead to a reduced component cost.

[0099] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0100] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. An apparatus for adjusting aircraft inceptor trim, the apparatus comprising: an inceptor centring device configured to be mechanically coupled to a control shaft; wherein the control shaft rotates in response to control inputs provided at the inceptor; wherein the inceptor centring device comprises an inceptor centring spring; wherein the inceptor centring spring is preloaded with a preload force; and wherein the inceptor centring spring is configured to provide a first biasing force to bias the control shaft to an inceptor neutral position; and a trim mechanism mechanically coupled to the inceptor centring device; wherein the trim mechanism comprises a trim locking device having: an unlocked state in which the trim locking device is configured to allow adjustment of the position of the inceptor centring device; and a locked state in which the trim locking device is configured to maintain the adjusted position of the inceptor centring device; wherein a resistance force of the trim mechanism with the trim locking device in the unlocked state is less than the preload force, such that when the trim mechanism is in the unlocked state, actuation of the inceptor results in adjustment of the position of the inceptor centring device to alter the inceptor neutral position and hence the degree of aircraft inceptor trim.

2. The apparatus as claimed in claim 1, wherein the trim mechanism comprises a trim centring device configured to provide a second biasing force to bias the inceptor centring device towards a trim-neutral position; wherein the resistance force includes the second biasing force.

3. The apparatus as claimed in claim 2, wherein the trim mechanism comprises a damper configured to damp the second biasing force.

4. The apparatus as claimed in claim 2, wherein the trim centring device comprises a tension spring configured to provide the second biasing force.

5. The apparatus as claimed in claim 2, wherein the trim centring device comprises a lever and a cam surface mechanically coupled to the inceptor centring device.

6. The apparatus as claimed in claim 5, wherein the trim centring device comprises a tension spring configured to provide the second biasing force; wherein a first end of the tension spring is coupled to a frame; wherein a second end of the tension spring is coupled to a first end of the lever; and wherein the lever is configured to pivot about a pivot point such that a second end of the lever moves along the cam surface, such that the tension spring is extended when the inceptor centring device is rotated away from the trim neutral position.

7. The apparatus as claimed in claim 5, wherein the cam surface is a V-shaped cam surface.

8. The apparatus as claimed in claim 1, wherein the trim locking device comprises a power-off brake.

9. The apparatus as claimed in claim 1, wherein the inceptor centring spring is a torsion spring.

10. The apparatus as claimed in claim 1, wherein the inceptor centring spring is a helical torsion spring.

11. The apparatus as claimed in claim 10, wherein the inceptor centring device is configured such that the torsion spring is wound more tightly both when the control shaft rotates in the clockwise direction and when the control shaft rotates in the anti-clockwise direction.

12. The apparatus as claimed in claim 11, wherein the inceptor centring device comprises: a driving member which is coupled to the control shaft; and a retaining member which is configured to be stationary when the trim locking device is in the locked state, and moveable when the trim locking device is in the unlocked state; wherein the inceptor centring device is configured such that, when the trim locking device is in the locked state and the control shaft is rotated, the driving member acts on a first end of the torsion spring and the retaining member retains a second end of the torsion spring such that the torsion spring is wound more tightly.

13. The apparatus as claimed in claim 1, wherein the trim mechanism comprises one or more trim sensors configured to detect the trim position.

14. A system comprising: An apparatus for adjusting aircraft inceptor trim as claimed in claim 1; a first aircraft inceptor; and one or more inceptor sensors; wherein the first inceptor and the one or more inceptor sensors, are mechanically coupled to the control shaft.

15. The system as claimed in claim 14, comprising an inceptor damper mechanically coupled to the inceptor centring device; wherein the inceptor damper is configured to damp the first biasing force provided by the inceptor centring device.