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This invention relates to steering apparatus which is particularly adapted for use in aircraft having a so-called jet or turbo-jet as its propulsion means. Although the invention is primarily adaptable for use in jet propelled aircraft, it will be understood that its principles are applicable to any form of craft operating in a fluid medium, and having propulsion mechanism operating on a reactive principle with respect to the fluid medium through which the craft is moving. For example, the principle of the invention is applicable whether the fluid medium in which the reactive propulsion mechanism is operating is air or water.

In reaction type propulsion mechanism of the character with which this invention is concerned, such as jet or rocket propelled aircraft, a fluid medium has a high velocity imparted to it by the propulsion mechanism. In producing the high velocity of the fluid medium, a reaction force is created which is effective to impart movement to the craft being propelled by the propulsion mechanism. The fluid medium which has a high velocity imparted to it by the propulsion mechanism in the production of a driving thrust will be the gaseous products of combustion in the case of a rocket, will be gaseous products of combustion and air in the case of a jet or turbo-jet, or will be a mixture of gas and water in the case of a reactive propulsion device operating under water. Regardless of the fluid medium, the relatively high velocity imparted thereto by the propulsion mechanism is employed, in accordance with the principles of this invention, to produce a yawing or steering movement on the craft in which the propulsion mechanism is mounted.

In applying the principles of this invention to reactive propelled craft, this invention has as one of its principal objects the provision of an improved form of control mechanism which will be effective to deflect the fluid medium emerging at high velocity from the propulsion mechanism universally so as to effect both vertical and horizontal steering control efforts in varying amounts.

A further object of the invention is to provide steering control mechanism which will be effective to eliminate the vertical and horizontal control rudders customarily employed for steering craft operating in a fluid medium.

A further object of the invention is to provide control mechanism of the character referred to with control members rigidly mounted at right angles to each other to provide intersecting control surfaces for deflecting engagement with the high velocity fluid medium.

A still further object of the invention is to provide a control mechanism having control members mounted in positions at right angles to each other with a novel form of actuating mechanism by which the angular position of either of the control members with respect to one reference plane may be regulated without changing the angular position of the other of the control members with respect to another reference plane.

Other objects and advantages of the invention will become apparent from the following description.

In the drawings, there is shown a preferred embodiment of the invention. In the drawings:

Fig. 1 is a diagrammatic bottom view of an aircraft provided with steering control mechanism constructed in accordance with the principles of this invention; Fig. 2 is an enlarged and fragmentary perspective view showing and illustrating in detail the structure of the steering control mechanism provided in the craft shown in Fig. 1; Fig. 3 is a plan view of one of the parts of the control mechanism; Fig. 4 is a sectional view taken substantially along the line IV—IV of Fig. 3; Fig. 5 is a plan view of another of the parts of the control mechanism which cooperates with the part illustrated in Fig. 3; Fig. 6 is a sectional view taken substantially along the line VI—VI of Fig. 5; Fig. 7 is a top plan view of the control mechanism illustrating the parts of Figs. 3 and 5 assembled together; Fig. 8 is a view similar to Fig. 7 with the parts illustrated rotated through an angle of 90°; Fig. 9 is an end view looking into the exhaust of the propulsion mechanism and showing the control mechanism of Figs. 7 and 8 mounted in operational position therein; Fig. 10 is a fragmentary view in side elevation of the structure shown in Fig. 9; Fig. 11 is a group view illustrating in top plan and side elevation the structure of one of the mounting pins; and Fig. 12 is a group view illustrating respectively in top plan, side elevation, and end elevation a mounting part employed in connection with the mounting pin shown in Fig. 11.

Referring to Fig. 1 of the drawings, there is shown an aircraft 2 of the jet or turbo-jet type. The craft 2 comprises a body portion 3 having wings 4 projecting laterally from the sides thereof. The propulsion mechanism and its arrangements are illustrated diagrammatically by the dotted lines and includes air scoops 5 through which air for supporting combustion is delivered to an engine 6 of the jet or turbo-jet type. The products of combustion are delivered rearwardly through an exhaust conduit 7, and, as is well-known, the products of combustion travel through the conduit 7 at an extremely high velocity. The conduit 7 is enlarged at its exit end 8 and has steering control mechanism indicated as a whole by the numeral 9 mounted therein. The tail of the body 3 is shaped to conform to the exhaust and the exhaust gas is deflected outward, being dependent upon the craft, the type of propulsion mechanism, and whether the craft is operating in air or submerged in water.

As best shown in Figs. 2 and 9, the control mechanism comprises a pair of discs 12 and 13 which intersect along a common diameter and are rigidly and permanently secured together. In a manner to be described, the angular position of the disc 12 is changed to control movement of the craft in azimuth and the angular position of the disc 13 is changed to control movement of the craft in elevation. In the position of the discs 12 and 13 with respect to the exhaust 8 as shown in Figs. 2 and 9, the craft will move straight ahead without having any steering movement imparted thereto by the discs 12 and 13. As the discs 12 and 13 are moved angularly from the position shown in Figs. 2 and 9, the fluid emerging through the exhaust 8 will be deflected vertically or in an azimuthal direction to effect a corresponding steering control on the craft.

The structure of the discs 12 and 13 and their mounting by which the angular position of one may be changed without changing the angular position of the other will be best understood by referring to Figs. 3 through 6.

In Figs. 3 and 4, to which reference is now made, the disc 12 and its mounting ring 14 are shown. As illustrated, the disc 12 comprises a solid circular plate 15 having semi-hexagonally shaped plates 16 projecting from opposite sides thereof. The ring 14 comprises a ring 17 of the same thickness as the plate 15 and side rings 18 having an inner diameter smaller than the inner diameter of the ring 17. The ring 17 and plates 18 cooperate to provide an annular groove 19 in which
the outer edge of the circular plate or disc 15 is receivable. In this manner, ring-shaped structure 14 provides an annular mounting for the disc 12 in which the disc 12 may rotate with respect to the ring 18. Figs. 5 and 6 show the disc 13 as comprised of two substantially semi-circular plates 20 mounted in a ring-shaped structure 21 similar to the ring-shaped structure 14 in which the disc 12 is mounted. The mounting ring 21 comprises a ring 22 of the same thickness as the plates 20 and side discs 23 cooperating therewith to provide an annular groove 24 in which the circular edges of the plates 20 are receivable and in which the plates 20 may rotate in union. The facing edges 25 of the plates 20 are spaced apart a distance equal to the thickness of the plate 15. In addition, the edges 25 have central indentations 26 in which the plates 16 are snugly receivable to keep the discs 12 against rotation with respect to the disc 13. The ends of the surfaces 25 are provided with angularly shaped recesses 27 to provide a space for the reception of the mounting rings 14.

The structure is assembled by first constructing the disc 12 as shown in Figs. 3 and 4. The next step is to place the semi-circular plates 20 on opposite sides of the plate 15 with the semi-octagonal shaped plates 16 fitted snugly in the recesses 26. The parts 16 and 20 may be secured together against movement relative to each other as by welding. When thus mounted in position, the facing surfaces 25—25 and 27—27 of the plates 20 will have abutting engagement with opposite surfaces of the plate 15 and ring 14. With the plates 20 thus secured in position with respect to the disc 15, the mounting ring 21 may then be applied to the sides of the ring-shaped structure 14, to provide a rotatable mounting for the disc 13 which in effect is comprised of the plates 20.

When the parts 12 and 13 are assembled into a unit as described above, the control unit of Fig. 9 is attained. In the unit as shown here, it will be noted that the entire structure is rotatable within the ring 21. In other words, the ring 21 may be rotated about the disc 13 in a plane perpendicular to the axis of the ring 21 without imparting movement to either disc 12 or 13. The ring 14 may be rotated similarly through the spaces provided by the indentations 27—27 without imparting movement to the disc 12.

The unit shown in Figs. 7 and 8 is mounted in position with respect to the exhaust 8 as shown in Fig. 9. This is accomplished by securing a pair of similar mounting parts 30 to each of the rings 14 and 21 at diametrically opposite points thereof. Each of the mounting parts 30 has a groove 31, as shown in Fig. 12, having a V-shape in transverse cross-section, and is situated with a matching cut of the ring 14 or 21 to which it is to be secured. The surfaces 32 defining the groove 31 have an inclination corresponding to the outer edges of the lateral surfaces 18 or 23 against which they are to abut. The parts 30 are placed in position on the rings 14 and 21 and are rigidly secured thereto as by welding.

The outer end of each mounting part 30 is provided with a threaded opening 33 having a collar 34 thereabout. The opening 33 is provided for the reception of the end of an actuating stud or pin 35 having threads at its end 36 for threaded engagement in the opening 33 to secure the pin in position. The outer end 37 is square in shape for connection to an operating member (not shown).

In mounting the unit in position, it is placed in the position as shown in Fig. 9 with each of the members 30 positioned centrally of one of the arms 11. Each of the arms 11 and associated structure shown in section at the right of Fig. 9, immediately opposite the mounting part 30. With the mounting parts 30 in position, a bearing plate 41 is provided. This plate is shaped to fit the inner surface of the arm 11 to prevent movement of the mounting part 30 outwardly through the slot 40. Each of the plates 41 has a groove 42, through which the end of a pin 35 may be passed, and the pins are inserted through such opening and rotated to provide a threaded connection with the part 30. A bearing 42 is then slipped over the pin 35 and the forming 43 is placed over the bearing 42. The housing 43 has abutting engagement with the bearing 42 to hold it against the bearing plate 41. Openings 44 with springs 45 therein for centering the bearings 42 are provided in the housing 49. Plugs 46 provide remov-

able closures for the openings 44 by which access may be had to the springs 45. The housings 43 are secured to the outer surface of the arms 11 as by welding and serve to mount the steering control unit in position on the exhaust 8. With the unit thus positioned, it is ready for operation and may be actuated by the controls (not shown) connected to the ends of the studs or pins 35.

The vertically spaced ends 37, as viewed in Fig. 9, provide a control 50 by which rotational movement of the horizontal plate 12 and azimuthal movement of the vertical plate 12 may be controlled. Similarly, the horizontally spaced ends 37, as viewed in Fig. 9, provide a control 51 by which the elevational movement of the plate 12 may be controlled. These controls 50 and 51 are controlled by changing the relative angular positions of one of the discs 12 or 13 with respect to the exhaust 8 without varying the position of the control 50 or 51.

The operation of the structure will be better understood by considering the action that takes place upon rotation of either of the control parts 50 and 51. When the part 50 is rotated, the mounting member 30 and ring 14 are rotated about the axis of the vertical pins 35. This changes the angular position of the vertical plate 12 and the fluid moving through the exhaust conduit 8 is deflected upwardly to the left or right according to the angular direction in which the plate 12 is moved to give the desired steering motion in azimuth. This angular movement or positioning of the horizontal plate 12 is accomplished without changing the angular position of the plate 13. The plate 13 is rotated by the angular movement of the plate 12 without any change in its angular position, the plate 13 being permitted by its rotatable mounting in the ring 21.

In a similar manner, rotation of the controls 51 is effective to change the angular position of the horizontal plate 13 without changing the angular position of the vertical plate 12. When the controls 51 are rotated, the ring 21 and plate 13 rotate about the axis of the horizontal pins 35 to change the angular position of the plate 13 to deflect the fluid flowing through the conduit 8 vertically to impart a steering movement in elevation to the craft. The rotation of the plate 13 causes a rotation of the vertical plate 12 in its mounting ring 11 without changing its angular position.

When one of the plates 12 or 13 is out of its neutral position, as shown in Fig. 9, rotation of the other of such plates causes its moving through the conduit 8 to shift slightly. The shifting movement of the actuating pins 35 is provided for by the resilient mounting of such pins in the blocks 43, such mounting being carried by the bearings 42 carrying the pins 35. It will be noted that the openings in the housings 43 through which the pins 35 project are elongated as at 52 to provide for shifting movement of the pins 35.

Provision of the actuating parts. It will be apparent that the control unit of this invention provides improved structure for utilizing the velocity of a fluid stream for controlling the movement of the aircraft and the like. Attention is particularly directed to the fact that the steering control is effected by two plates which intersect each other centrally thereof and extend at right angles to each other. It will also be noted that the mounting of the plates 12 and 13 in the exhaust 8 enables the independent or simultaneous adjustment of their respective angular positions relative to the exhaust 8 so as to effect selected or combined steering controls in elevation and azimuth.

While I have illustrated and described one specific embodiment of my invention, it will be understood that this is merely by way of illustration, and that various changes and modifications may be made therein within the contemplation of my invention and under the scope of the following claims.

I claim:

1. A steering apparatus for craft moving in a fluid medium comprising a conduit through which fluid is discharged at relatively high velocity into said fluid medium, and a control device comprising a pair of discs connected together along a common axis by a common shaft to rotate as a unit, each of said discs having an elongated member mounted in said conduit for deflecting the fluid passing therethrough to thereby steer the craft through said fluid medium.

2. A steering apparatus for craft moving in a fluid medium comprising a conduit through which fluid is discharged at relatively high velocity into said fluid medium,
5 a control device comprising a pair of discs connected together along a common diameter and at right angles to each other, and means mounting said device for limited universal movement in said conduit to different angular positions with respect thereto to vary the angular deflection of the fluid being discharged therefrom and to thereby steer the movement of the craft through said fluid medium.

3. Steering apparatus for craft moving in a fluid medium comprising a conduit through which fluid is discharged at relatively high velocity into said fluid medium, a control device comprising a pair of discs connected together along a common diameter and at right angles to each other, and means mounting said device for limited universal movement in said conduit comprising a pair of rings respectively mounted adjacent an end of said conduit for rotational movement about an axis extending transversely thereof, the axes about which said rings rotate intersecting with each other, each of said discs being mounted for rotational movement in one of said rings.

4. The invention claimed in claim 3 characterized by each of said rings having a pair of diametrically opposed pivots providing a rotational mounting therefor in said conduit.

5. The invention claimed in claim 3 characterized by each of said rings having a pair of diametrically opposed pivots providing a rotational mounting therefor in said conduit, and a housing supporting each of said pivots for limited movement with respect to said conduit.

6. The combination with the discharge conduit of a reactive type motor, of a steering apparatus comprising a pair of discs connected together along a common diameter and at right angles to each other, and means mounting said discs adjacent the discharge end of said conduit comprising a pair of rings respectively mounted for rotation about an axis extending transversely thereof, the axes about which said rings rotate intersecting with each other, each of said rings including structure mounting one of said discs for rotation therein.

7. Steering apparatus for craft moving in a fluid medium comprising a conduit through which fluid is discharged at relatively high velocity into said fluid medium, and a steering control unit at the discharge end of said conduit comprising a first annulus mounted for rotation about a diameter thereof extending vertically of said conduit, a second annulus mounted for rotation about a diameter thereof extending horizontally of said conduit, and a pair of discs connected together along a common diameter and at right angles to each other, said annuli respectively including parts engageable with the periphery of and mounting one of said discs for rotation about the rotational axis of the annulus mounting the other of said discs.

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