Jan. 8, 1952 A. W. FISCHER ET AL 2,581,476

GYROPRECESSING MEANS

Filed May 3, 1945 5 Sheets-Sheet 1

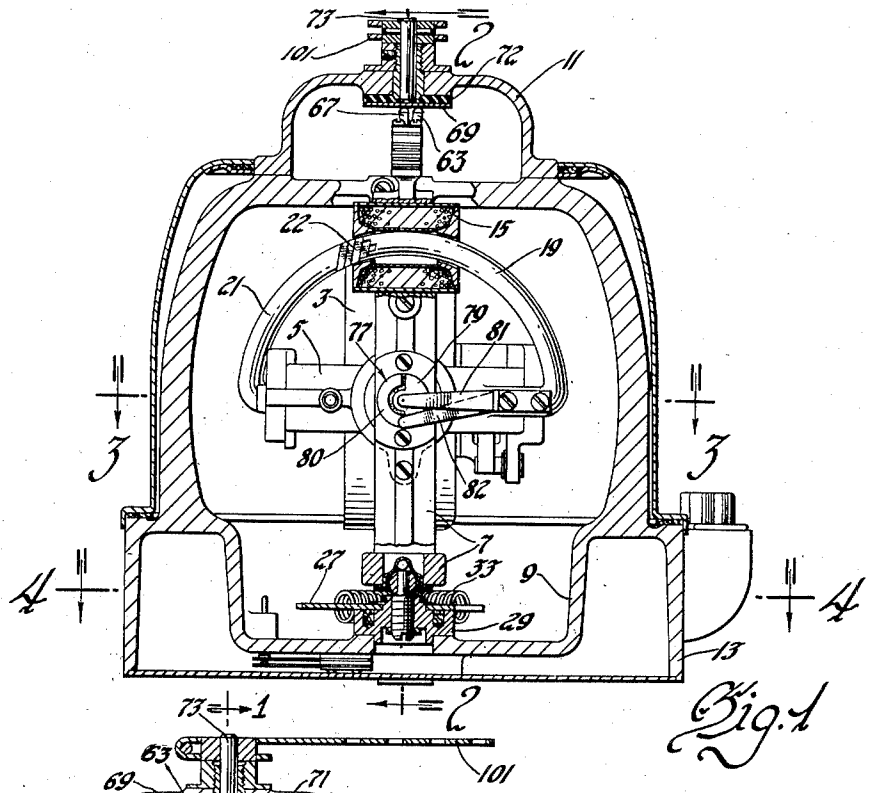


Fig. 1

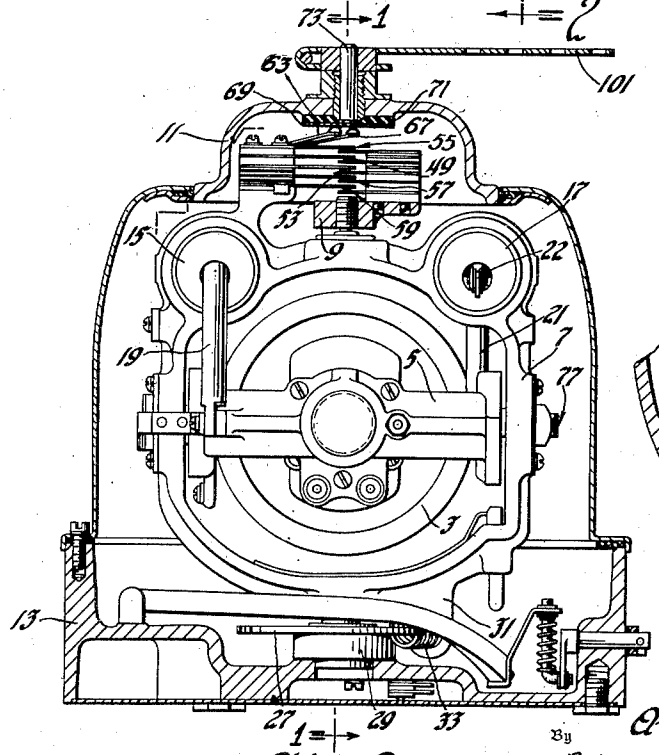


Fig. 2

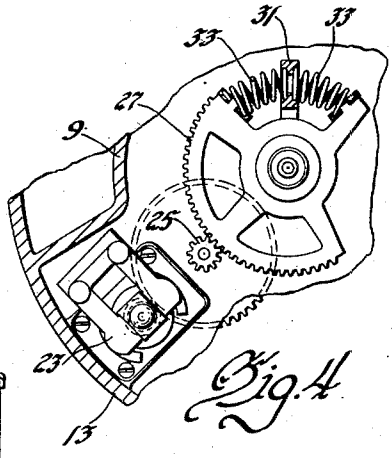


Fig. 4

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Jan. 8, 1952 A. W. FISCHER ET AL 2,581,476

GYROPRECESSING MEANS

Filed May 3, 1945 5 Sheets-Sheet 2

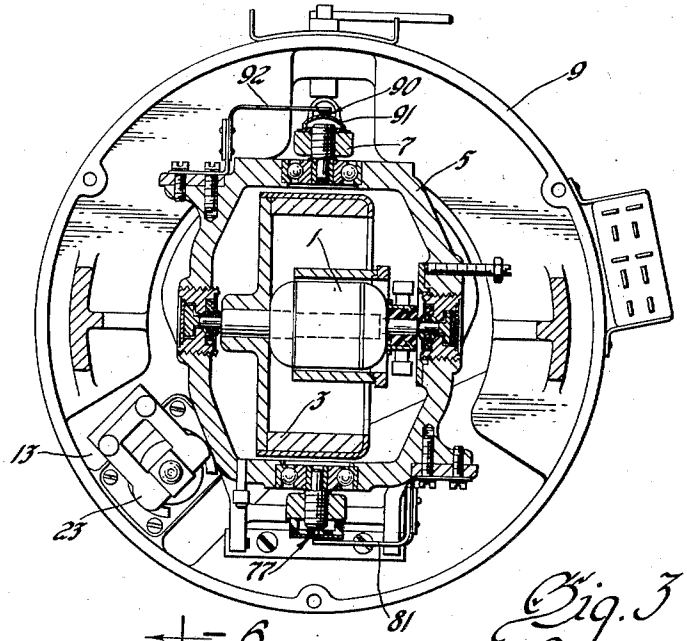


Fig. 3

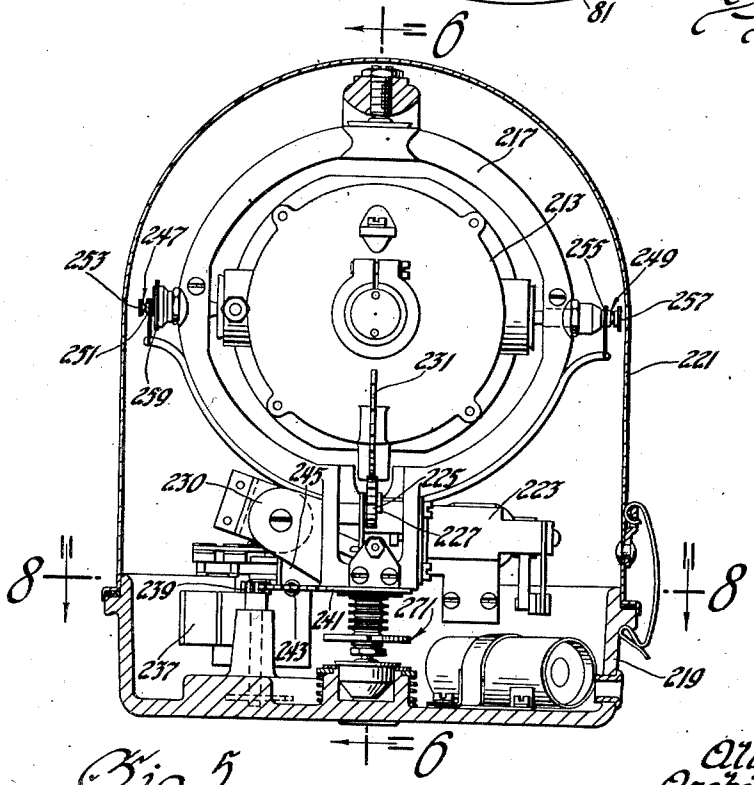


Fig. 5

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Jan. 8, 1952 A. W. FISCHER ET AL 2,581,476

GYROPRECESSING MEANS

Filed May 3, 1945 5 Sheets-Sheet 3

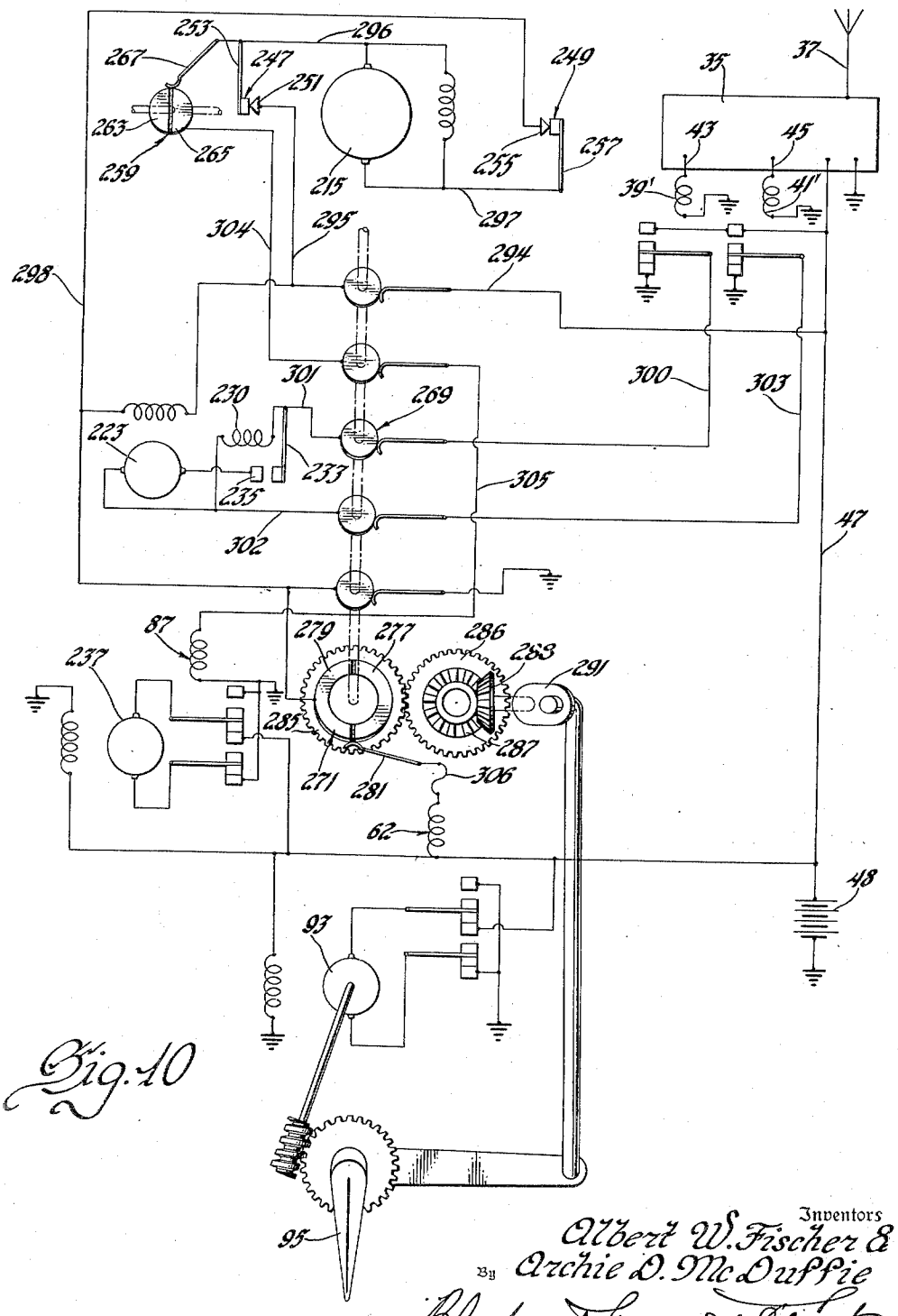


Fig. 10

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GYROPRECESSING MEANS

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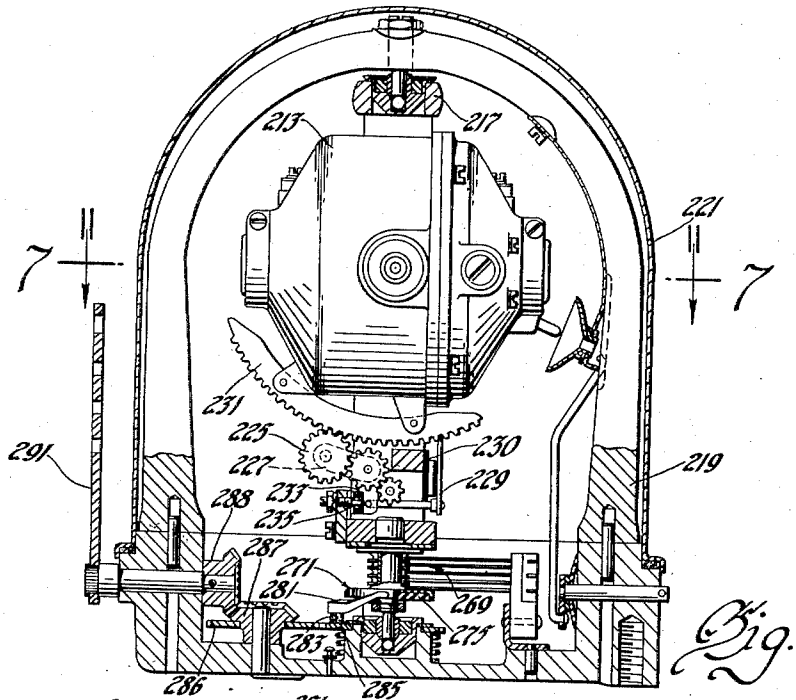


Fig. 6

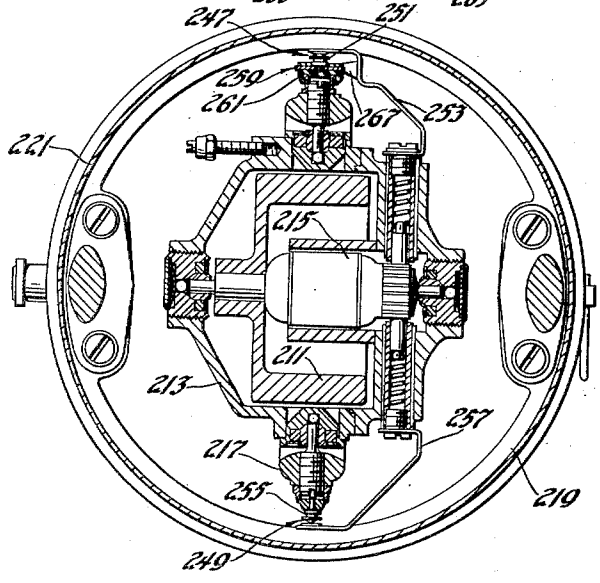


Fig. 7

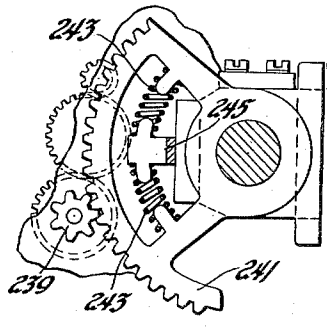


Fig. 8

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GYROPRECESSING MEANS

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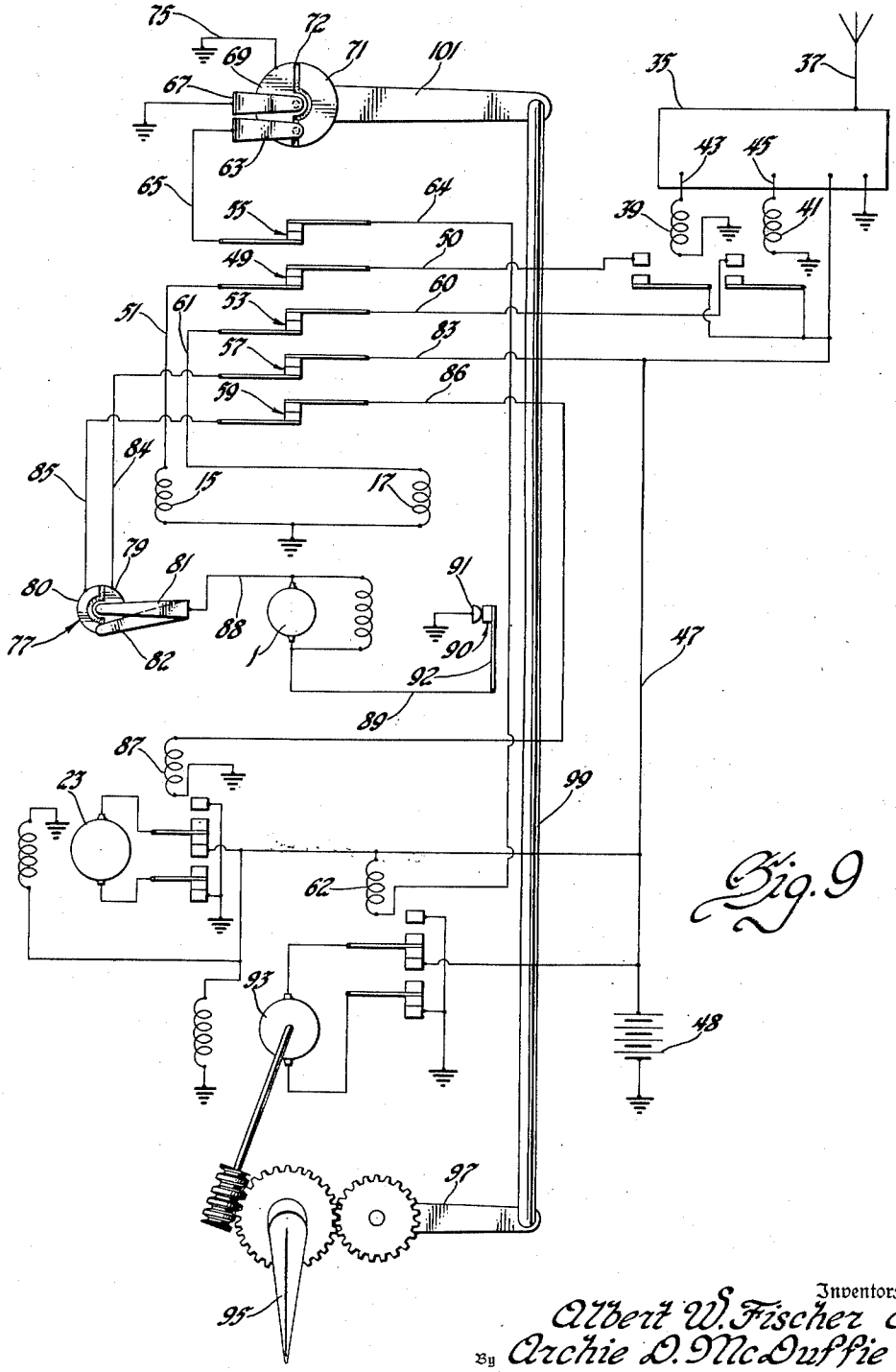


Fig. 9

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UNITED STATES PATENT OFFICE

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GYRO PRECESSING MEANS

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Application May 3, 1945, Serial No. 591,796

5 Claims. (Cl. 74—5.47)

1

The present invention generally relates to directional controlling mechanisms and more particularly relates to directional controlling system of the gyroscopic type.

The principal object of the invention is to provide a simple directional control system for an air-borne ship including a gyroscope having simple electromagnetic precessing and erection controlling means by which the direction of the ship may be remotely controlled and which is not subject to errors caused by magnetic leakage from these means or by roll and pitch of the ship.

Two modifications of control means by which the above object is attained and other features thereof will become apparent by reference to the following detailed description and drawings illustrating the systems.

Figures 1 and 2 of the drawings are vertical elevation views taken at right angles to each other, with parts broken away, of one form of gyroscopic directional controlling means; Figure 1 being taken on line 1—1 of Figure 2 and Figure 2 being taken on line 2—2 of Figure 1, with parts broken away.

Figure 3 is a cross-sectional view taken on line 3—3 of Figure 1, with parts broken away.

Figure 4 is a cross-sectional view taken on line 4—4 of Figure 1.

Figures 5 and 6 are vertical elevation views taken at right angles to each other with parts broken away, of another form of gyroscopic controlling means.

Figure 7 is a cross-sectional view taken on line 7—7 of Figure 6 with parts broken away.

Figure 8 is an enlarged cross-sectional view taken on line 8—8 of Figure 5, with parts broken away to show a detail of part of the mechanism to better advantage.

Figures 9 and 10 are schematic views of two control systems and the controlling and control connections between the elements of the systems. The system shown in Figure 9 includes the gyroscopic controlling means shown in Figures 1 to 4 and the system shown in Figure 10 includes the gyroscopic controlling means shown in Figures 5 to 8.

The gyroscopic controlling means shown in Figures 1 to 4 includes an electric driving motor 1 directly connected to a gyroscope rotor 3 supported for rotation about a horizontal axis in an inner gimbal member 5. The inner gimbal member is pivoted on a horizontal axis transverse to the rotor axis in an outer gimbal member 7 which is pivoted about a vertical axis in a gyroscope frame member 9 provided with a removable cap

2

11. The base 13 of the frame 9 is adapted to be mounted on a ship for controlling the direction thereof so that the rotor axis is maintained parallel to the transverse center line of the ship.

Means comprising two ironclad solenoids 15 and 17 and plungers 19 and 21 freely movable therein are provided between the outer and inner gimbals for causing precession of the gyroscope rotor and gimbals about the vertical axis. The solenoids are mounted equidistant and on opposite sides of the vertical axis of the outer gimbal with their axes parallel to the rotor axis and the arcuate plungers are mounted on diagonally opposite corners of the inner gimbal with their free ends freely movable in the solenoids. The free end 22 of each of the plungers is of identical stepped or shaded form, the transverse width of the ends increasing in steps, as best shown in Figure 2, in order to provide constant pull on each by a respective solenoid, when either is energized, and therefore constant torque in either direction between the outer and inner gimbals for a limited range of relative movement between the gimbals.

Means comprising an erection motor 23 secured on the base 13 of the frame for rotating the outer gimbal about its axis is provided for causing erection of the inner gimbal so that the rotor axis is caused to be maintained parallel to the base of the frame 9 at all times. The erection motor is connected by reduction gearing, one gear 25 of which is shown meshing with a sector gear 27 which is rotatable on the outer gimbal lower pivot support 29 about an axis coaxial with that of the outer gimbal, as best illustrated in Figures 1 and 4. A depending lug 31 secured to the lower portion of the outer gimbal extends between adjacent radial projections of the sector gear 27. Each of two identical compression springs 33 is placed between a projection on the sector gear and the adjacent end of the lug 31 to provide a flexible driving connection between the erection motor and the outer gimbal.

Current collecting means are provided between the frame and the gimbal members to connect the above described precession and erection means to control means and to power operated steering mechanism of the ship which is controlled by precession of the gimbals about the vertical axis relative to the frame. These collecting means, the control means and the steering mechanism and the connections therebetween are best shown schematically in Figure 9.

The control means for the gyroscope includes

a radio receiver 35 including suitable filter and amplifier means and an antenna 37 so that when a signal of a certain frequency is received the winding of a relay 39 is energized and when a different frequency signal is received the winding of another relay 41 is energized. One winding terminal of each of these relays is grounded and each of the other terminals is connected by a separate wire to separate output terminals of the receiver. These wires are indicated by the numerals 43 and 45. One input terminal of the receiver is connected to ground and the other input terminal is connected to a positive wire 47 which is connected to the positive terminal of a battery 48 having the negative terminal grounded. The movable contacts of each of the relays 39–41 are also connected to the positive wire 47 and the fixed contact of each is connected to one terminal of each of the precessing solenoids by means of separate current collecting means. The other winding terminals of the solenoids are grounded on the outer gimbal.

One of these current collecting means is indicated generally at 49. This current collecting means includes two spring fingers, provided with engaging contacts located on the axis of the outer gimbal, and connected in series between the fixed contact of the relay 39 and one winding terminal of precessing solenoid 15 by wires 50 and 51. The other terminal of the winding is grounded on the outer gimbal. One of these spring fingers is secured on an insulator carried by the frame 9 and the other finger is secured to an insulator carried by the outer gimbal 7. Other identical current collecting means mounted in identical manner are indicated generally at 53, 55, 57 and 59.

The current collecting means 53 is connected in series between the fixed contact of the relay 41 and one winding terminal of the precessing solenoid 17 by wires 60 and 61. The other winding terminal of the solenoid 17 is also grounded on the outer gimbal.

The current collecting means 55 is connected in series with the winding of a reversing relay 62 between the positive wire 47 and a spring finger 63 by wires 64 and 65. The finger 63 and another spring finger 67 are each secured by an insulator to the outer gimbal and these fingers cooperate with contact disks 69 and 71 secured to a disk insulator 72 carried on the lower end of a shaft 73 which is supported for rotation in the frame cap 11 about a vertical axis coaxial with that of the outer gimbal axis. The finger 63 is positioned to engage either the contact disk 69 or the contact disk 71 or adjacent ends of both contact disks upon relative movement between the outer gimbal and shaft 73 and the finger 67 is grounded on the outer gimbal and is positioned to bear on the contact disk 69 at a point coaxial with the outer gimbal vertical axis. The contact disk 69 is grounded to the frame cap 11 by a flexible wire 75.

The current collecting means 57 and 59 are connected in series with another current collecting means generally indicated at 77. The current collecting means 77 comprises contact disks 79 and 80 secured to an insulator disk which is supported on the outer gimbal in coaxial relation with the inner gimbal axis and two spring fingers 81 and 82 bearing thereon which are secured to an insulator carried by the inner gimbal. The finger 81 bears on the contact disk 79 at a point on the axis of the inner gimbal and the current collecting means 57 is connected between the

positive wire 47 and the contact disk 79 by the wires 83 and 84. The other spring finger 82 is adapted to bear on either or on the adjacent ends of the contact disks 79 and 80. The current collecting means 59 is connected in series by wires 85 and 86 between the contact disk 80 and one winding terminal of another reversing relay 87, having the other terminal grounded. Both of the spring fingers 81 and 82 are connected by a wire 88 to a terminal of the rotor motor 1, the other terminal of which is connected to ground through a wire 89 and another current collecting means indicated generally at 90. This means includes a contact 91 on the outer gimbal and a spring finger 92 grounded on the inner gimbal and bearing on the contact 91 at a point located on the horizontal axis of the inner gimbal.

The reversing relay 62 controls reversal of an electric steering motor 93 which is operably connected by irreversible gearing to the rudder 95 of the ship. An arm 97 is geared to the rudder and is connected by a link 99 to an arm 101 secured to the shaft 73 and the arms and link serve as a follow-up linkage. The field winding of the steering motor is connected between the positive wire 47 and ground and the armature is connected across the two movable contacts of the relay 62 which normally contact the central and lower fixed relay contacts and are moved upwardly into contact with the central and upper fixed relay contacts when the winding of the relay is energized. The fixed central relay contact is connected to the positive wire 47 and the other two fixed relay contacts are grounded so that with the movable contacts in the normal position the motor is energized for rotation in one direction and when the relay winding is energized and the armature contacts are moved upwardly the motor is energized for rotation in the opposite direction of rotation.

The reversing relay 87 is of similar form to the steering motor reversing relay 62 and serves to reverse the rotation of the erection motor 23. The field winding of the erection motor is connected between the positive conductor 47 and ground, the armature is connected across the movable contacts of the relay 87 which normally contact the central and lower fixed relay contacts and are moved upwardly into contact with the central and upper fixed relay contacts to cause reversal of the erection motor when the relay winding is energized as the central fixed contact is connected to the positive wire 47 and the other fixed contacts are grounded in the same manner as the reversing relay 62 for the steering motor 93.

The operation of the above described control system and gyroscopic directional control means is as follows:

With the gyroscope rotor 3 driven by the motor 1 about a horizontal axis transverse to the longitudinal center line of the ship corresponding to the course setting any slight movement of the ship to the right of the course causes the shaft 73 and disk contacts 69 and 71 to turn clockwise with reference to the outer gimbal, due to the linkage connection between the shaft and rudder 95. This causes the contact disk 71 to move into contact with the spring finger 63 carried by the outer gimbal to disconnect the steering reversing relay winding from ground to cause the relay contacts to fall to their normal position. This causes the steering motor 93 to be energized for rotation in proper direction to cause clockwise rotation of the rudder to cause the ship to turn

left back on course and this causes the shaft 73 and the contact disks to be rotated counterclockwise until the grounded contact disk 69 moves into contact with the finger 63 to complete an energizing circuit comprising the current collecting means 55 and wires 47, 64 and 65 for the winding of the relay 62. This causes the movable contacts to be moved upwardly and cause reversal of the steering motor and the direction of rotation of the shaft 73 and contact disks thereon. The ship is accordingly caused to follow the course setting by slight alternate right and left turns of the ship about the course setting. In other words the ship is caused to hunt about the course setting as determined by the gyroscope. Should the ship tend to roll about its longitudinal center line and the pivot axis of the inner gimbal the disk contact 79 or the disk contact 80 mounted on the outer gimbal, depending upon the direction of roll, will be moved into contact with the spring finger 82 on the inner gimbal. Movement of the contact disk 79 clockwise into contact with the finger 82 opens the circuit connection comprising the wires 85 and 86 to the winding of the erection motor reversing relay 87 to cause the erection motor 23 to apply torque in the proper direction to the outer gimbal about its vertical axis to cause the inner gimbal to rotate so that the rotor axis is maintained parallel to the transverse center line of the ship. This causes the grounded disk contact 80 on the outer gimbel to contact the spring finger 82 on the inner gimbal to cause re-establishment of the circuit connection through the winding of the relay 87 comprising current collecting means 57 and 59 and wires 47, 83, 84, 85 and 86. This causes upward movement of the movable contacts of the relay 87 and reversal of the erection motor 23 and reverse torque to be applied to the outer gimbal so that the rotor axis is moved back parallel to the transverse axis of the ship. With this arrangement the axis of the rotor is caused to hunt slightly about the transverse center line of the ship at all times.

If it is desired to change the course setting of the ship while in fight a signal of given frequency is transmitted and this signal is picked up by the antenna 37 of the radio receiver to cause energization of the winding of either of the relays 39 or 41 and closure of the contacts of either relay to cause energization of either the precessing solenoid winding 15 or 17. Energization of the solenoid winding 15 through the closed contacts of the relay 39, the current collecting means 49 and wires 47, 50 and 51 applies pull between the winding and its plunger 19 and torque is applied between the inner and outer gimbals in proper direction to cause precession of the outer gimbal counterclockwise about the vertical axis to cause the spring finger 63 to move into contact with the contact disk 71 to cause the steering motor to cause the ship to turn left to the new course setting about which it hunts in the previously described manner. Conversely energization of the solenoid winding 17 in response to a received radio signal of a different frequency through the closed contacts of the relay 41, current collecting means 53 and wires 60 and 61 causes pull to be applied between the winding and its plunger and torque to be applied between the outer and inner gimbals in the reverse direction. This causes clockwise precession of the outer gimbal about the vertical axis and the finger 63 to move into contact with the grounded contact disk 69 to cause the ship to turn right to the new course setting about which it hunts as previously described.

It will be evident from the above that when either of the precessing windings 15—17 is energized, pull is applied to one of the plungers 19—21 and torque in either direction is applied directly between the inner and outer gimbals to cause the outer gimbal to precess about its vertical axis in either direction. Precession of the outer gimbal in either direction causes the lug 31 thereon to exert torque on and compress either of the springs 33 between the lug 31 and one portion of the sector gear 27 of the train of gears operable by the erection motor 23 secured to the gyro frame 13. Compression of either of the springs 33 causes a slight tilting of the inner gimbal with respect to the outer gimbal in either direction and tilting of the rotor axis. This causes the contact finger 82 on the inner gimbal to move into contact with either of the contacts 79 or 80 on the outer gimbal to cause energization and rotation of the erection motor in either direction necessary to relieve the compression of either of the springs 33 due to the precession of the outer gimbal so that the sector gear 27 is maintained in the same relative angular position with respect to the lug 31 of the outer gimbal and equal compression is maintained on the springs 33 and the inner gimbal is accordingly rotated in proper direction by this operation of the erection motor to cause the rotor axis to be moved back to its original position, parallel to the transverse center line of the ship, about which it is continuously caused to hunt by reason of the contacts 79—80—82 controlling energization and reversal of the erection motor 23 as previously explained.

The shaded ends 22 of the plungers provide constant torque in either direction between the outer and inner gimbals for the slight movement in either direction of the inner gimbal by the erection motor with reference to the outer gimbal to maintain the rotor axis parallel to the transverse center line of the ship.

During precession of the gyroscope in either direction about the vertical axis any banking or rolling of the ship requires the application of torque by the erection motor in the proper direction to the outer gimbal about its vertical axis, depending upon the direction of rotor rotation about its spin axis, to maintain the spin axis parallel to the transverse center line of the ship.

The other modification of directional control system shown in Figure 10 and the gyroscopic control means included therein is shown in Figures 5 to 7.

The gyroscopic control means comprises a rotor 211 which is rotatable about a horizontal axis in a rotor housing serving as an inner gimbal member 213 by an electric motor 215. The inner gimbal is pivoted about a horizontal axis, transverse to the rotor axis in an outer gimbal member 217 which is pivoted about a vertical axis in a frame 219 of the gyroscope. The frame 219 is adapted to be mounted in a ship with the base parallel to the transverse center line of the ship. The frame is enclosed in a removable housing cap 221.

A precession motor 223 is mounted on the outer gimbal and is connected by reduction gearing also carried on the outer gimbal member as best shown in Figures 5 and 6. One gear 225 of this gear reduction is rotatable in one arm of a bell crank 227 which is pivoted on the outer gimbal. The

other arm of the bell crank is linked to an armature 229 of an electromagnet 230 which is also supported on the outer gimbal so that upon energization of the electromagnet winding the gear 225 is moved into mesh with a sector gear 231 secured to the inner gimbal, as illustrated in Figure 6. When the gear 225 is engaged with the sector gear 231 a contact 233 secured on an insulator on the bell crank 227 is moved into contact with another contact 235 secured on an insulator on the outer gimbal to control energization of the precession motor 223 after engagement of the gear 225 with the sector gear 231.

An erection motor 237 is mounted on the base of the frame and is connected by reduction gearing on the base of the frame, one gear 239 of which meshes with a sector gear 241 rotatably mounted on the lower pivot of the outer gimbal, as best shown in Figures 5 and 8. Springs 243 are placed between adjacent spokes of the sector gear 241, the inner ends of which bear on a lug 245 on the outer gimbal extending downwardly between the spokes of the sector gear 241.

Current collecting and controlling means are provided between the frame and the outer and inner gimbals to control energization of the rotor motor and to control reversal of precession and erection motors and to control reversal of power operated steering mechanism of the ship. These current collecting means, motors and ship steering mechanism together with the electrical connections therebetween are shown in Figures 5 and 6 and schematically in Figure 10.

Current collecting means generally indicated at 247 and 249 are provided between the outer and inner gimbals on the axis of the latter. The collecting means 247 includes a contact 251 secured on an insulator on one end of the outer gimbal in coaxial relation with the inner gimbal axis and a spring finger 253 secured on a brush holder of the rotor motor 215 and bearing on the contact 251 at a point coaxial with the inner gimbal axis. The current collecting means 249 is similar to that previously described and includes a contact 255 secured on an insulator carried on the other end of the outer gimbal in coaxial relation with the inner gimbal axis and a spring finger 257 secured to the other brush holder of the rotor motor 215 and bearing on the contact 255 at a point coaxial with the inner gimbal axis.

Another current collecting means indicated generally at 259 is provided adjacent the collecting means 247. This means serves as a reversing switch to control reversal of the erection motor and, as best shown in Figures 5, 7 and 10, comprises an insulator disk 261 mounted on the outer gimbal in coaxial relation with the axis of the inner gimbal and having two contacts 263 and 265 of semicircular form secured to the periphery of the disk 261 and a spring contact finger 267 bearing on the adjacent ends of each when the inner gimbal is in the normal horizontal position as shown. The spring contact 267 is secured directly to the spring contact finger 253 of the current collecting means 247.

Other current collecting means indicated generally at 269 and 271 in Figure 6 are provided between the outer gimbal and the frame. The means 269 includes five collecting or slip rings and flexible contact fingers bearing on each. Each of the collector rings are mounted on an insulating bushing on the lower pivot of the outer gimbal and each of the fingers are secured to an insulator on the frame.

The current collecting means 271 serves as a reversing switch to control reversal of the power steering mechanism of the ship. As best shown in Figures 6 and 10 this means comprises an insulator disk 275 secured on the lower pivot of the outer gimbal and provided with semicircular contact disks 277 and 279 on the periphery of the insulator disk. The adjacent ends of these disk contacts are normally contacted by a flexible contact finger 281 secured on an insulator 283 on a gear 285 rotatable on the base of the frame about an axis coaxial with that of the outer gimbal. The gear 285 is connected by gears 286, 287 and 288 on shafts rotatable in the frame and a follow-up lever 291 is secured to one of the shafts.

As best shown in Figure 10 this second modification of gyroscopic control mechanism is also controlled by a radio receiver and it also controls a power operated steering mechanism. The receiver and steering mechanism and the reversing relays for the steering and erection motors are identical to those described for controlling the previously described gyroscopic control mechanism, but relays of different construction are provided to control precession.

The rotor motor 215 is connected between ground on the frame and the positive wire 47 by means of the current collecting means 247 and 249, two of the slip rings of the current collecting means 271 and wires 47, 294, 295, 296, 297 and 298. The positive wire 47 is connected to the positive terminal of the battery 48 having the negative terminal grounded. The field winding of the precession motor 223 is connected between the wires 295 and 298. The winding of the electromagnet 230 is connected between the movable contacts of the relays 39' and 41' through two other of the slip rings of the current collecting means 269 and wires 300, 301, 302 and 303. The movable contact of the electromagnet is connected to the wire 301 and the armature of the precession motor 223 is connected between the fixed contact of the electromagnet and the wire 302. The spring finger 267 of the current collecting means 259 is connected to the wire 296 and the contact disk 265 of this means is connected by means of another slip ring and finger of the current collecting means 271 and wires 304 and 305 to one winding terminal of the motor reversing relay 87 of the erection motor 237. The other terminal of the winding of the relay 87 is grounded. One winding terminal of the steering reversing relay 62 for the steering motor 93 is connected to the positive wire 47 and the other winding terminal of the relay 62 is connected by a flexible conductor 306 to the spring finger 281 of the current collecting means 271. The disk contact 279 of the means 271 is connected to the wire 298 and is accordingly grounded through the lower slip ring and finger. The battery connections to the contacts of the reversing relay 62 and 87 and to the erection and steering motors 237 and 93 are identical to those previously described and shown in Figure 9.

As previously mentioned, the contact arrangement of the relays 39' and 41' is different from the relays 39 and 41, previously described. Each of the relays 39' and 41' are provided with two fixed contacts and a movable contact normally in engagement with the lower fixed contact. The upper fixed contacts are connected to the positive wire 47, the lower fixed contacts are grounded, the movable contacts are separately connected by

separate wires 300 and 303 between two of the current collecting means indicated generally at 269. Each of the relay windings, however, are connected between ground and a separate output terminal of the radio receiver 35 in identical manner to that previously described with reference to the relays 39 and 41 shown in Figure 9.

The operation of this second modification of gyroscopic control means and system in which it is included is as follows: With the rotor rotating about the horizontal axis transverse to the course setting and longitudinal center line of the plane if the ship turns slightly to the left of the course setting the finger 281 of the current collecting means 271 will move out of contact with the contact disk 279 and into contact with the contact disk 277 to break the energizing connection to the winding of the steering motor reversing relay 62 and cause the relay contacts to fall to the position shown. This causes the motor to be energized to cause rotation of the rudder counterclockwise in order to cause the ship to turn right back on the course setting. Counterclockwise movement of the rudder and turning of the ship to the right causes the disk contacts 277 and 279 to be turned counterclockwise by the follow-up gear and linkage connection between the rudder 95 and these contacts until the contact disk 277 moves from under the spring finger 281 and the finger is contacted by the contact disk 279. This causes the establishment of a circuit between the positive wire 47 to ground through the winding of relay 62, the wire 306, finger 281 and disk contact 279 which is connected to ground by the wire 298 and the lower collector ring and finger of the current collecting means 271. The movable contacts of the relay 62 are moved upwardly upon energization of the winding to cause reversal of the steering motor and movement of the rudder clockwise to cause the ship to turn to the left and back on course and this causes clockwise rotation of the contact disks 279 and 277 to again cause reversal of the steering motor. It will be evident that the ship is caused to hunt slightly to the right and left of the course in the same manner as with the previously described gyroscopic controlling means.

The outer gimbal is likewise rotated by the erection motor so that the rotor axis is maintained parallel to the transverse center line of the ship in a similar manner to that previously described. Any tilting movement of the outer gimbal with respect to the vertical axis and transverse to the rotor axis causes either the disk contact 263 or the disk contact 265 of the current collecting means 259 to move into contact wth the contact finger 267 of this means. When the disks contact 263 is in contact with the finger 267 the winding of the reversing relay 87 is deenergized to cause the erection motor 237 to apply torque to the outer gimbal with reference to its axis in proper direction to cause the inner gimbal to turn with respect to the outer gimbal to cause the rotor axis to be maintained parallel to the transverse center line of the ship. If the ship rolls in the opposite direction the disk contact 265 moves into contact with the finger 267 to establish a circuit to the winding of relay 87 through these contacts, and two of the slip rings and fingers of the current collecting means 269 and wires 47, 294, 295, 296, 304 and 305 to ground. This causes the contacts of the relay to be moved upwardly and cause reversal of the erection motor and application of torque to the outer gimbal about its axis in the reverse direction to cause the inner gimbal to move in the opposite direction until the rotor axis is again parallel to the transverse center line of the ship. The rotor axis is accordingly maintained parallel at all times to the frame of the gyroscope and transverse center line of the ship.

Remote steering of the ship is accomplished in similar manner as previously described by means of radio signals of different frequency picked up by the receiver 35 to cause energization of the winding of either of the relays 39' or 41'. This causes upward movement of the movable contact by either relay to cause current flow in one direction or the other through the wires 300, 301, 302 and 303 and the electromagnet 230 to cause the armature thereof to cause engagement of the gear train driven by the precession motor and current flow through the armature thereof in one direction or the other when the contacts operated by the electromagnet are closed. This causes torque to be applied between the inner and outer gimbals in either direction and precession of the rotor and gimbals in opposite directions about the vertical axis. Precession in one direction causes the disk contact 277 of the current collecting means 271 to move into contact with the spring contact 281 of this means to cause deenergization of the winding of the reversing relay 62 which causes rotation of the steering motor 93 and rudder 95 in proper direction to bring the ship back on the new course setting. By reason of the follow-up linkage between the rudder and current collecting means 271 and the turning of the ship the spring contact 281 then contacts the disk contact 279 to cause energization of the winding of the relay 62 through wires 47, 306, 298 and one slip ring and finger of the current collecting means 271 to ground. This causes the direction of rotation of the steering motor and rudder to be reversed to cause turning of the ship in the opposite direction back on the course setting. The ship will accordingly be caused to hunt about the course setting as previously described.

In the two modifications of gyroscopic control devices the electromagnetic means for controlling precession and erection are designed to prevent magnetic leakage therefrom in order to eliminate errors in the operation of the controlling means, and as the erection means acts at all times to maintain the rotor axis parallel to the transverse center line of the ship no errors are introduced due to roll or pitch of the ship. Also the arrangement is such that by causing proper rotation of the rotor the banking of the ship when turning causes the outer gimbal to be turned by the erection motor in the same direction as the outer gimbal was precessed by either the solenoid or motor precessing means.

We claim:

1. A directional gyroscope for controlling steering mechanism comprising a gyroscope rotor supported by gimbals on a frame for normal rotation about a horizontal axis parallel to the base of the frame, resilient driving means including a reversible erection motor for applying torque to the gimbals and rotor in either direction about the vertical axis of the frame when the frame is tilted to maintain the rotor axis parallel to the base of the frame, erection motor reversing control contacts between the gimbals operable by relative movement between the gimbals upon tilting of the frame.

2. A directional gyroscope for controlling steering mechanism comprising a gyroscope rotor sup-

ported by gimbals on a frame for normal rotation about a horizontal axis parallel to the base of the frame, resilient driving means including a reversible erection motor for applying torque to the gimbals and rotor in either direction about the vertical axis of the frame when the frame is tilted to maintain the rotor axis parallel to the base of the frame, erection motor reversing control contacts between the gimbals operable by relative movement between the gimbals upon tilting of the frame, ironclad solenoids, and plungers having shaded poles of stepped form for exerting constant pull and torque between the gimbals in either direction to cause precession of the rotor and gimbals in either direction about the vertical axis of the frame, depending upon which solenoid is energized, and control means for selectively controlling energization of the solenoids.

3. A directional gyroscope comprising a gyroscope rotor supported by inner and outer gimbals for normal rotation about a horizontal axis parallel to the base of a frame, means for applying torque in either direction between the gimbals for causing precession in either direction of the outer gimbal with respect to the frame about a vertical axis, a reversible erection motor on the frame for applying torque in either direction between the outer gimbal and frame, resilient drive means connecting the motor and outer gimbal, and motor reversing control means operable upon relative movement between the gimbals for controlling the erection motor to cause the rotor axis to hunt about a preselected horizontal axis with respect to the frame.

4. A directional control gyroscope having a rotor supported by inner and outer gimbals on a frame for normal rotation about an axis parallel to the base of the frame, precessing means for applying torque between the gimbals in either direction to cause precession of the outer gimbal about a vertical axis with respect to the frame, coaxial connecting means on said frame and said outer gimbal to operate said precessing means and erection means comprising resilient connecting means between the outer gimbal and the frame and additional torque means connected with said resilient connecting means for applying torque in either direction between the outer gimbal and frame with respect to the vertical axis and control means operable upon relative movement of the inner and outer gimbals for controlling said additional torque applying means to maintain the rotor about said horizontal axis parallel to the gyroscope frame.

5. A gyroscopic directional control system for a steering mechanism comprising a frame having a horizontal base, an outer gimbal pivoted about a vertical axis in the frame, an inner gimbal pivoted about a horizontal axis in the outer gimbal, a motor driven gyroscope rotor mounted for rotation in the inner gimbal transverse to the inner gimbal pivot axis, a resilient connection between the frame and outer gimbal, a reversible erection motor to apply torque to the outer gimbal through the resilient connection in order to maintain the axis of the rotor parallel to the base of the frame, electrical precessing means between the gimbals for exerting torque directly therebetween to cause precession of the rotor and gimbals about the vertical axis of the outer gimbal, cooperating, electrical energizing and reversing contacts located on the gimbals in coaxial relation to the axis of the inner gimbal to reverse the erection motor and cooperating, electrical energizing contacts located on the frame and outer gimbal in coaxial relation to the axis of the outer gimbal to energize the erection motor and precessing means.

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