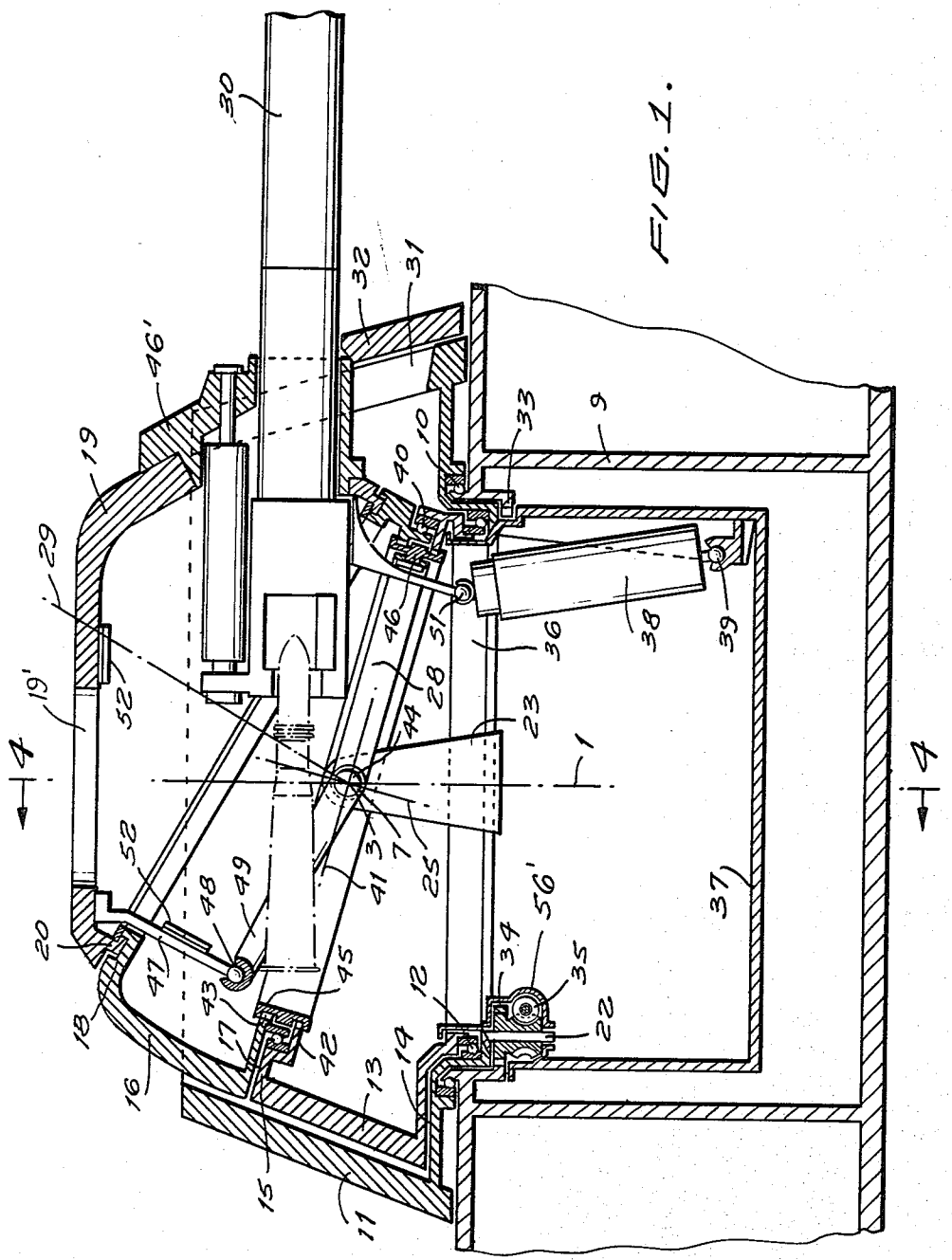
July 5, 1955 R. E. WABNITZ 2,712,271

ADJUSTABLE SUPPORT APPARATUS

Filed June 8, 1953 5 Sheets-Sheet 1

FIG. 1.



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ADJUSTABLE SUPPORT APPARATUS

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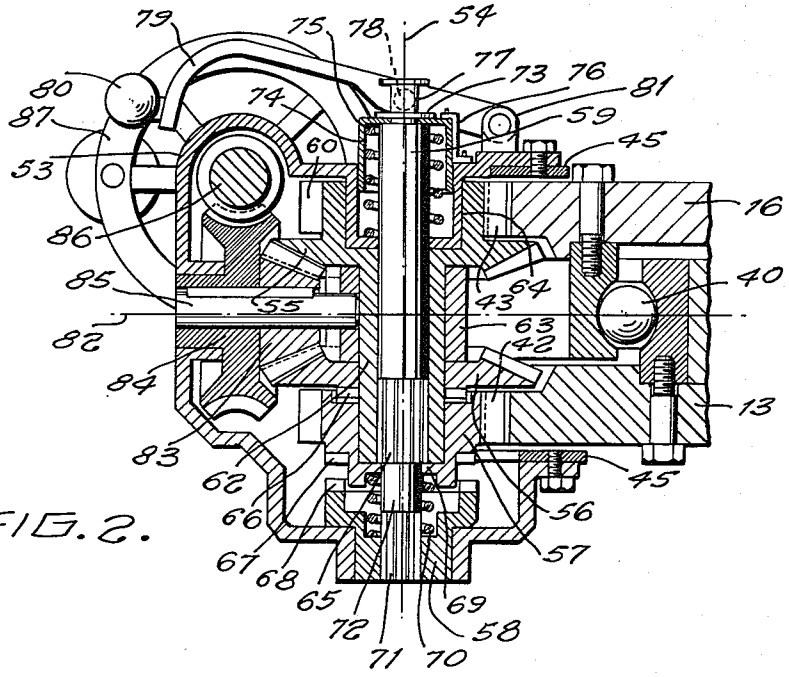


FIG. 2.

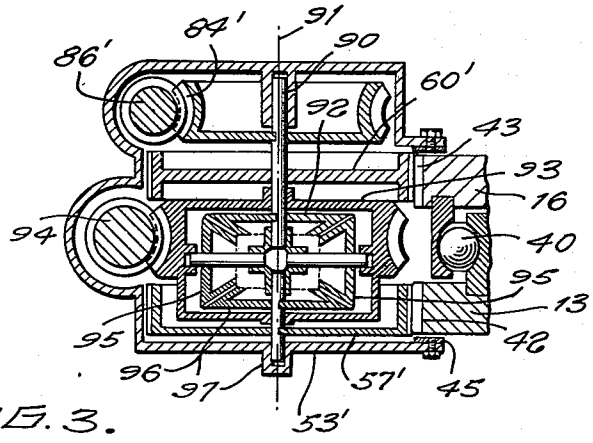


FIG. 3.

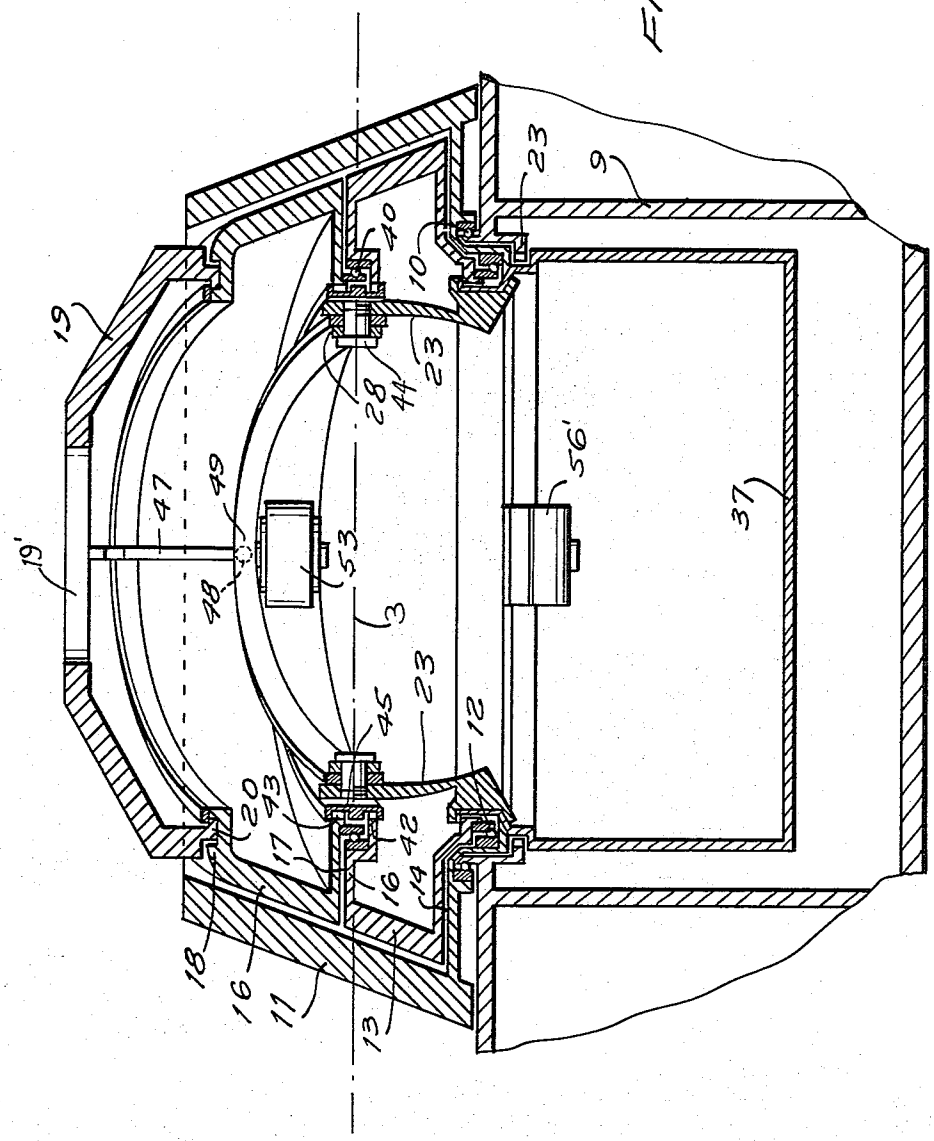
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ADJUSTABLE SUPPORT APPARATUS

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FIG. 4.



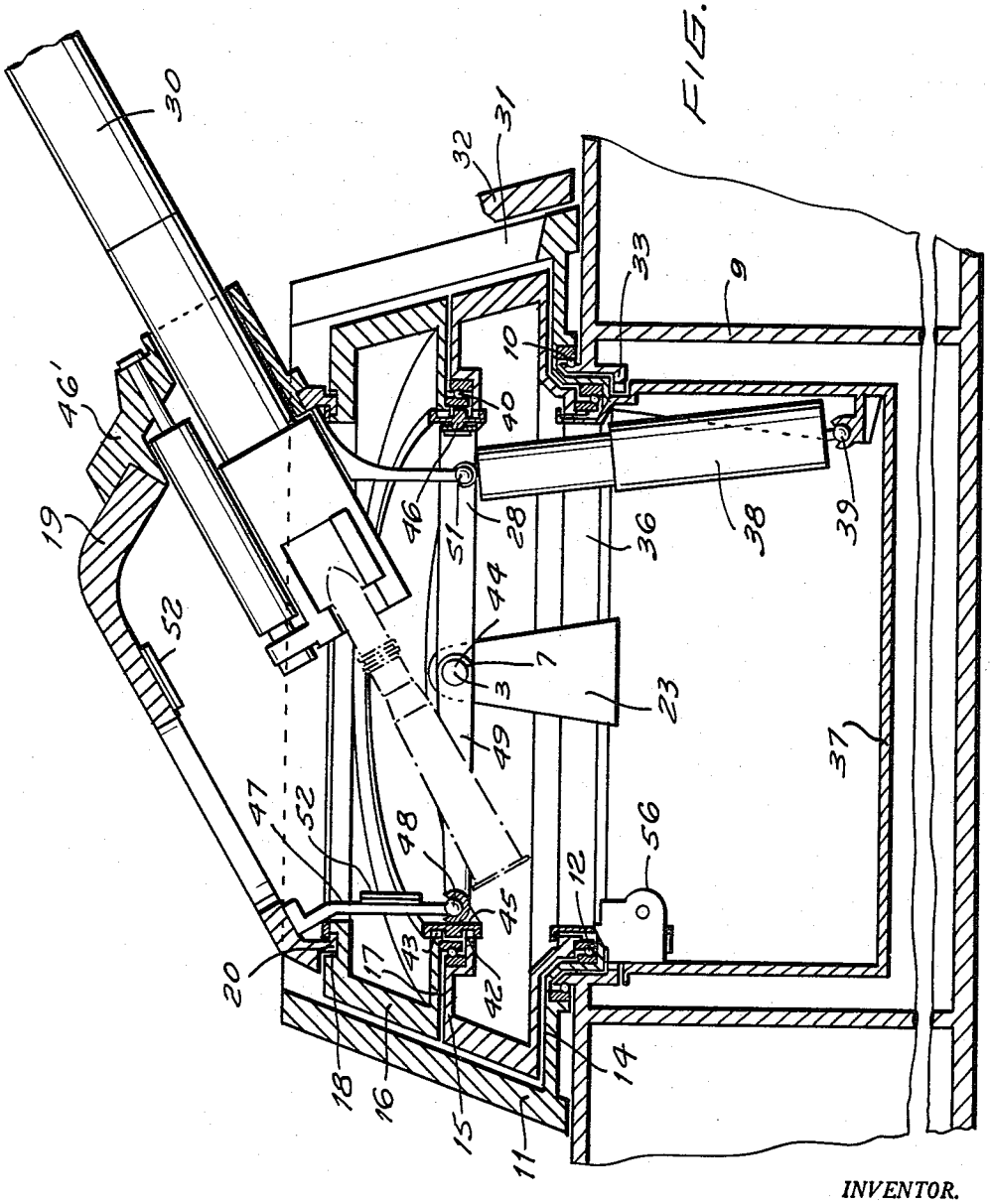
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ADJUSTABLE SUPPORT APPARATUS

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FIG. 5.



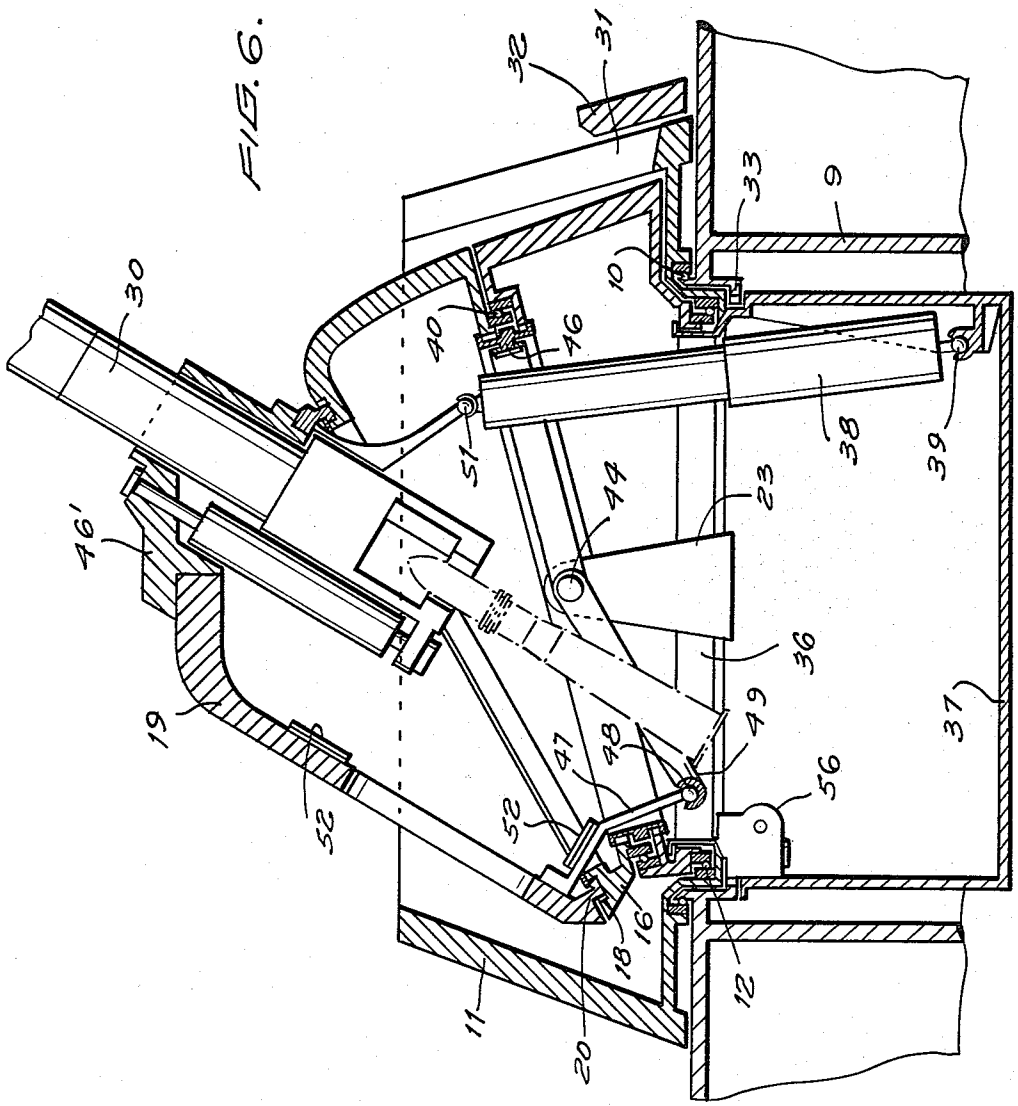
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ADJUSTABLE SUPPORT APPARATUS

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FIG. 6.



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ADJUSTABLE SUPPORT APPARATUS

Richard E. Wabnitz, Brussels, Belgium

Application June 8, 1953, Serial No. 360,134

Claims priority, application Switzerland May 7, 1949

12 Claims. (Cl. 89—41)

The present invention relates to an adjustable support apparatus for locating an article carried by the apparatus at a predetermined position in space.

This application is a continuation-in-part of copending application Serial No. 160,432, filed May 6, 1950, and entitled "Universal Adjusting and Positioning Device etc."

Apparatus of the above type is particularly useful in ordnance equipment, mounted on sea, land or air vehicles or even in stationary installations, for properly locating a weapon in space. Known structures of this type are exceedingly complicated and involved, requiring a considerable amount of gears, levers, drive apparatus and the like which are subject to very large stresses and which take up a considerable amount of space so that little room is left for personnel and for supplies such as ammunition and the like.

One of the objects of the present invention is to overcome the above drawbacks by providing a support apparatus which is capable of accurately positioning an article in space while leaving a considerable amount of room for personnel and supplies.

A further object of the present invention is to provide an adjustable support apparatus with an adjusting means which is of an exceedingly simple and rugged construction and which at the same time is capable of functioning properly for a long period of time.

Another object of the present invention is to provide an adjustable support apparatus which gives a wide range of movement to the articles supported and which is capable of carrying out the adjustments very rapidly either by hand or by suitable motors or the like which may be automatically operated.

With the above objects in view the present invention mainly consists of an adjustable support apparatus which includes a frame having a first positioning means mounted thereon for turning movement about a first predetermined axis. A second positioning means is mounted on the first positioning means for movement about a second predetermined axis inclined to and intersecting the first predetermined axis at a predetermined point. A carrier, for carrying an article to be positioned by the apparatus, is itself carried by the second positioning means and is connected to the frame so as to be stationary therewith, and a connecting means interconnects the carrier with the second positioning means for movement with respect to each other about a third axis which is inclined to the first and second axes and which intersects the same at the above-mentioned predetermined point.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a partly sectional, partly diagrammatic, side

elevational view illustrating the apparatus of the invention as applied to a gun turret;

Fig. 2 is a fragmentary, partly sectional elevational view on an enlarged scale, as compared to Figs. 1 and 4, of a turning means for operating the mechanism which adjusts the position of the article carried by the apparatus of Fig. 1, the section of Fig. 2 being taken in a plane normal to the plane of Fig. 4 and passing centrally through the latter;

Fig. 3 is a diagrammatic illustration of a different embodiment of the apparatus of Fig. 2;

Fig. 4 is a sectional view taken along line 4—4 of Fig. 1 in the direction of the arrows, part of the structure of Fig. 4 being omitted from Fig. 1 in the interest of clarity;

Fig. 5 is a view corresponding to Fig. 1 but showing the gun of Fig. 1 raised from its lowest position shown in Fig. 1 to a position midway between this lowest position and its maximum elevation; and

Fig. 6 is a view corresponding to Fig. 1 but showing the structure in the position where the gun is at maximum elevation.

Referring now to the drawings and in particular to Fig. 1 thereof, it will be seen that the apparatus of the invention includes a mounting means 9 which may be a part of a stationary installation or a part of a land, sea or air vehicle. This mounting means 9 is provided with a top wall having a circular opening passing therethrough and carrying the inner race ring of the ball bearing 10.

An annular frame having an open top extends through the opening in the top wall of mounting means 9 downwardly into the latter, this frame including the annular member 11 which at its underside carries the outer race ring of ball bearing 10 and which has a lower inner face portion to which the outer race ring of a ball bearing 12 is fixed. This annular member 11 is provided with an outer wall made of a heavy armor plate so as to be explosion and bullet proof and thereby protect the personnel and equipment in the interior of the turret illustrated in Fig. 1, this outer wall being conical, as shown, or cylindrical if desired.

An annular wall 36 is fixed adjacent its top edge to the inner bottom edge of the member 11 and extends about the bearing 12 to protect the latter from foreign matter, this annular wall 36 being fixed at its bottom peripheral edge to a floor 37 on which personnel may stand and on which supplies such as ammunition and the like may be located. The opening in the top wall of the mounting means 9 as well as the substantially cylindrical side wall 36 and member 11 are all located about a common vertical axis 1.

A turning means is provided to turn the parts 11, 36, 37 about the axis 1 with respect to the mounting means 9, this turning means taking the form of a housing 56' (Figs. 1 and 4) fixed to the inner side of the wall 36 and housing a worm 35 adapted to be rotated by any suitable hand wheel, motor or the like, not shown. A vertically extending shaft which is turnable in this housing carries a worm wheel meshing with the worm 35 and a pinion 34 fixed to the worm wheel for turning movement therewith about the axis of shaft 22 and meshing with the inner teeth of the ring gear 33 which is fixed to the underside of the top wall of mounting means 9 about the opening in this top wall. Thus, when the motor or the like, which may be reversible, is operated, the pinion 39 turns and rides around the stationary ring gear 33 to turn the frame 11, 36, 37 about the axis 1.

A first positioning means in the form of a wedge member 13 is mounted through the medium of bearing 12 on the annular member 11 for movement about the vertical axis 1, this wedge member 13 being annular and hollow and forming part of a sphere. The inner race ring of bearing 12 is fixed to the bottom of the wedge member 13,

and this wedge member 13 also has a bottom planar end face 14 which is located in a plane normal to the turning axis 1 and which is slidable with respect to the member 11. The top face 15 of member 13 is located in a plane which is inclined to the axis 1 at an angle other than a right angle and which is parallel to the plane 41 in which the bearing 40 is located, this bearing 40 having its outer race ring fixed to the top of the annular wedge member 13.

A second positioning means in the form of a second annular wedge member 16 forming part of a hollow sphere is carried by the wedge member 13 for movement about a second axis 25 intersecting the axis 1 at the point 7 and being normal to the top face 15 of wedge member 13. The second wedge member 16 has a bottom face 17 also located in a plane normal to axis 25 and adapted to slidably engage the top face 15 of wedge member 13, the inner race ring of bearing 40 being fixed to the underface of wedge member 16. This wedge member 16 has a top face 18 which is inclined to the axis 25 at an angle other than a right angle and which is normal to the axis 29 which intersects the axes 1 and 25 at the point 7.

A carrier 19, for carrying an article such as the gun 30 or the like and in the particular example illustrated forming a turret dome, is carried by the top wedge member 16, the bearing 20 interconnecting wedge member 16 and carrier 19 for movement with respect to each other about the axis 29. Figs. 1, 5 and 6 show in dot-dash lines a diagrammatic illustration of a projectile in position to be loaded into the gun 30.

The weapon in the form of gun 30 is mounted on standard armor plate 46' which is removably fixed to the turret dome 19, and the plate 46' and weapon 30 extend through an opening 31, formed in the annular member 11, which is large enough to permit raising and lowering of the gun 30 within desired limits, this opening 31 being covered in a known way by the armor plate 32. The use of standard plate 46' and the size of the opening 31 permits the gun carried by the dome 19 to be quickly and easily changed when required.

A pair of plates 23 (Figs. 1 and 4) are fixed to opposite inner faces of the top edge portion of the side wall 36 and extend upwardly into the wedge member 13. Each of these plates 23 carries a pin 44 whose axis is located along the horizontal axis 3 which is normal to the plane in which Fig. 1 is taken as well as to the axis 1 and which also passes through the point 7, the axis 3 extending horizontally across Fig. 4 through the pins 44. A semi-circular member 49 has its opposite free ends turnably mounted on the pins 44 so that this member 49 is turnable about the axis 3, and, as is evident from Fig. 1, the diameter of member 49 is substantially smaller than that of the wedge members 13 and 16 so that this member 49 may freely turn about the axis 3 upwardly into the wedge member 16 or downwardly into the wedge member 13. Midway between its opposite free ends, the semi-circular member 49 forms the socket of a ball and socket joint 48, the ball of which forms the bottom free end of a bar 47 which is fixed to the underside of the turret dome 19. It is apparent that this arrangement prevents turning movement of the turret dome 19 and frame 11, 36, 37 with respect to each other about the axes 1 or 29. Thus, it is apparent that the parts 47, 48, 49, 44, 23 form a means interconnecting the carrier 19 and frame 11, 36, 37 for movement with respect to each other about the axis 3 and holding the frame and carrier 19 against movement with respect to each other about the axis 1.

The opposite free ends of a second semi-circular member 28 are also respectively turnably carried by the pins 44, this member 28 being connected midway between its ends by a pivot pin 46 to the ring 45 which is located in the plane 41 at the elevation of the top face 15 of wedge member 13 and bottom face 17 of wedge member 16. This ring member 45 has top and bottom flanges which respectively overlap the annular gear 43, formed at the inner periphery of the bottom wall of wedge member 16 or being fixed to the latter, and the annular gear 42, formed at the inner periphery of the top wall of wedge member 13 or being fixed to the latter, this ring 45 and the wedge members 13 and 16 being arranged with respect to each other for free turning movement about the axis 25.

A ball and socket joint 39 is carried by the frame 36, 37 and supports a hydraulic piston and cylinder apparatus 38 which engages the ball and socket joint 51 fixed to the turret dome 19. Fluid pressure in the hydraulic apparatus 38 serves to take up stresses between the above-described parts which rest on each other so that these parts are always easy to turn with respect to each other while at the same time sealing the interior of the turret against dirt, gas, and the like.

The turret dome 19 is provided with a suitable opening 19' which may be closed in any known way and through which the personnel and equipment are permitted to enter into the apparatus. The brackets 52, of any suitable construction, are fixed, for example, to the dome 19 and to the bar 47 to carry equipment such as automatic loading devices and/or to carry seats for the personnel.

A self-locking turning means is carried by the ring 45 for turning the wedge members 13 and 16, and two different embodiments of such a turning means are illustrated in Figs. 2 and 3, respectively.

Referring now to Fig. 2, it will be seen that a housing 53 is connected to a part of the ring 45. A worm 86 is turnably mounted in the housing and is adapted to be turned by a hand wheel 87 or through a reversible electric motor or the like. The worm 86 meshes with a worm wheel 84 which is keyed to shaft 85 and which is turnably supported by the housing 53. A bevel gear 83 also is keyed to the shaft 85 so as to rotate therewith and with the worm wheel 84.

A first bevel gear 55, turnably supported in housing 53 for rotation about axis 54, meshes with one side of bevel gear 83, and a second bevel gear 56, also turnable about axis 54, meshes with an opposite side of bevel gear 83. The bevel gear 55 is fixed to or integral with a pinion 60 meshing with the ring gear 43 of wedge member 16, and this bevel gear 55 also has integral therewith or fixed thereto a hollow shaft portion 62 extending downwardly through the bevel gear 56 and forming a bearing for the latter.

The lower end portion of hollow shaft 62 is splined to a portion 65 of shaft 59 whose axis coincides with axis 54, this shaft 59 being slidable along and in the hollow shaft 62. The shaft 59, below splined portion 65 thereof, has a cylindrical portion 72 and a second splined portion 71 which is splined to a clutch member 58 turnably supported by housing 53 for rotation about axis 54 and having clutch teeth 68 on its top face so that clutch member 58 forms one half of a dog clutch transmission.

A second gear 57 meshes with the ring gear 42 of wedge member 13 and is turnable on the outer surface of hollow shaft 62 for rotation about its axis 54. This gear 57 has an underface provided with clutch teeth 67 adapted to mesh with clutch teeth 68, and the top face of gear 57 is provided with clutch teeth which mesh with clutch teeth 66 located at the lower side of bevel gear 56 and being integral therewith. A coil spring 70 is located between and in engagement with clutch member 58 and gear 57 to urge the latter upwardly into mesh with clutch teeth 66 and to urge the clutch member 58 downwardly.

The hollow shaft 62 is turnably carried by bearing 63 of the housing 53 which also determines the distance between bevel gears 55 and 56, and this bevel gear 55 also is turnably supported by the bearing portion 64 of housing 53. The gear 57 is provided with an inwardly extending annular ring portion 69 through which the cylindrical

portion 72 of shaft 59 extends and against which the lower end of splined portion 65 of shaft 59 bears. Thus, this shaft 59, through its splined connections with hollow shaft 62 and clutch member 58 always rotates with hollow shaft 62 and clutch member 58 and at the same time is axially movable along hollow shaft 62 and clutch member 58.

The shaft 59 is provided adjacent its top end with a collar 73 against which an inverted cup-shaped member 74 bears, a coil spring 75 being located about shaft 59 in member 74 and urging the latter and shaft 59 therewith upwardly, this spring 75 also bearing against the outer face of housing 53 in the bearing portion 64 thereof. The top end of shaft 59 is formed with an annular groove 77 in which a pair of rollers 78 are located, these rollers being arranged on opposite sides of axis 54 and being turnably carried by the two arm portions, respectively, of a lever 79 which is pivoted to the exterior of housing 53 at 81, one of the arm portions of lever 79 and one of the rollers 78 being shown in Fig. 2, and a hand grip 80 is fixed to lever 79, as is also shown in Fig. 2.

Fig. 2 also illustrates the ball bearing 40 whose inner race ring is fixed to the wedge member 16 and whose outer race ring is fixed to the wedge member 13. As will be pointed out below, the gear 57 is adapted to move downwardly along axis 54, and the lower flange of ring 45 extends inwardly about the space through which gear 57 moves so as to clear the latter. Also, the housing 53 carries a stop 76 for limiting the upward movement of member 74 and shaft 59.

With the structure of Fig. 2 in the position illustrated the gear 57 is connected by clutch teeth 66 with bevel gear 56 so that the latter transmits its turning motion to this gear 57 which in turn transmits its turning motion to the ring gear 42 and wedge member 13. Upon rotation of worm 86 either by hand wheel 87 or by a reversible motor or the like, the worm wheel 84, bevel gear 83 and shaft 85 rotate about axis 82 and turn the bevel gears 55 and 56 in opposite directions about axis 54, so that the gears 60 and 57 also turn in opposite directions about axis 54 and therefore, through their engagement with ring gears 43 and 42, respectively, turn the wedge members 16 and 13, respectively, in opposite directions. Thus, the turning means of Fig. 2 is capable of rotating the wedge members 13 and 16 simultaneously in opposite directions and at the same rate through the same angles.

Furthermore, the worm drive 86, 84 is self locking so that the turning means of Fig. 2, when it is not operating, locks wedge members 13 and 16 to each other so as to prevent relative movement thereof, and the housing 53 locks the wedge members through the turning means of Fig. 2 to the ring 45 which is connected by pivot pin 46 to the semi-circular member 28 turnably connected to the pins 44 which are carried by plates 23, respectively, that are fixed to the frame 11, 36, 37, so that when this frame is turned about the axis 1 and the turning means of Fig. 2 is not operated the wedge members 13 and 16 will necessarily turn together with the frame 11, 36, 37 about axis 1.

Since hollow shaft 62 is integral with or fixed to gear 55, this shaft 62 rotates with gear 55 and through the splined connection to portion 65 of shaft 59 rotates the shaft 59 which, through the splined connection 71, rotates the clutch member 58. When the lever 79 is depressed the shaft 59 will be moved downwardly and the springs 75 and 70 will be compressed. The bottom end of splined portion 65 of shaft 59, through its engagement with inner ring portion 69 of gear 57, will move the latter downwardly out of engagement with clutch teeth 66 and will move the clutch teeth 67 and 68 into driving engagement with each other, the gear 57 still meshing with ring gear 42 of wedge member 13. Thus, with the parts of the turning means of Fig. 2 in this latter position, the gear 57 will turn in the same direction as gear 60 about axis 59 so that the wedge members 16 and 13 will rotate in the same direction and at the same rate through the same angles. Therefore, the lever 79 and parts associated therewith form a control means for setting the turning means of Fig. 2 either in the operating position illustrated, where wedge members 13 and 16 will be turned in opposite directions, or in a second operating position where the wedge members 13 and 16 are turned in the same direction. Upon release of lever 79, the springs 70 and 75 automatically return the turning means of Fig. 2 to the position illustrated.

Fig. 3 illustrates an embodiment of a turning means which is different from that of Fig. 2 and which includes a differential mechanism. Referring to Fig. 3, it will be seen that a housing 53' is fixed to the ring 45 in the same way as the housing 53. The ball bearing 40, whose inner race ring is fixed to the top wedge member 16 and whose outer race ring is fixed to the bottom wedge member 13, also is shown in Fig. 3. A worm 86' is turnably supported by the housing 53' and meshes with a worm wheel 84' fixed to the shaft 90 which is turnably supported in housing 53' for rotation about axis 91. The shaft 90 is fixed to a gear 60' meshing with the ring gear 43 of wedge member 16, and this shaft 90 also is fixed to a sun gear 92 of a differential mechanism.

A worm wheel 93 is turnably carried by the shaft 90 for free rotation about axis 91 and meshes with a second worm 94 turnably carried by the housing 53' and adapted to be rotated by hand or a suitable reversible motor. The worm wheel 93 is fixed to and carries a support which is turnable with the worm wheel 93 about axis 91 and which turnably supports a pair of planetary gears 95 of the differential mechanism, these planetary gears being turnable about their own axes which are coincident and normal to axis 91 and also being turnable together with worm wheel 93 about axis 91.

The planetary gears 95 mesh, on the one hand, with the sun gear 92 and, on the other hand, with a second sun gear 96 which is turnable about axis 91, this sun gear 96 being fixed to and carried by a shaft 97 whose axis is coincident with axis 91 and which is mounted for rotation about axis 91 in the housing 53'. Also, this shaft 97 is fixed to and carries the lower gear 57' which meshes with the ring gear 42 of wedge member 13, this gear 57' turning with shaft 97 about axis 91.

The worm drives 86', 84', and 94, 93 are both self-locking so that the worm wheels 84' and 93 can only turn upon turning of the worms 86' and 94, respectively. Thus, if the worm 86' is driven either by hand or a suitable motor, while the worm 94 is not operated, the worm wheel 84' will turn so as to rotate shaft 90 and thereby rotate gear 60' to turn wedge member 16 and also the sun gear 92 will turn with shaft 90. The worm wheel 93, however, will be prevented from turning by worm 94 so that the planetary gears 95 cannot turn about axis 91 and can only turn about their own axes. This rotation of the planetary gears transmits rotation of sun gear 92 to sun gear 96 which turns in a direction opposite to that of sun gear 92. The gear 57' rotates with the sun gear 96 so that with the apparatus of Fig. 3 in the position where worm 94 is idle, gears 60' and 57' will be turned in opposite directions to turn the wedge members 16 and 13, respectively, in opposite directions through equal angles.

If, on the other hand, worm 86' is maintained stationary while worm 94 is rotated, it is apparent that sun gear 92 will be maintained stationary and therefore the planetary gears 95 will turn about axis 91 as well as about their own axes to rotate sun gear 96 about axis 91 and also rotate gear 57' and wedge member 13.

Therefore, if both worms 86' and 94 are turned simultaneously, it is possible to accelerate or decelerate the speed of rotation of gear 57' with respect to gear 60' so that by proper regulation of the speed and direction of rotation of worm 86' and 94 it is possible to turn gears 60' and 57' at the same speed and in the same direction about axis 90 so that the wedge members 13 and 16

may be simultaneously turned in the same direction to produce the same results which are accomplished by the apparatus of Fig. 2. The apparatus of Fig. 3, however, is much more flexible since it will provide any desired relative movement of the wedge members **13** and **16**. Also, the self-locking worm drives of Fig. 3, when they are not operating, lock the wedge members **13** and **16** to each other and through the housing **53'** to the ring **45** so that the turning means of Fig. 3 also causes the wedge members **13** and **16** to turn about axis **1** with the frame **11, 36, 37**.

The above described apparatus is capable of accurately positioning an article, such as gun **30**, in space since it is capable of turning the gun **30** about an axis substantially parallel to its own axis, which corresponds to the roll axis, about the axis **3**, which corresponds to the pitch axis, and about the axis **1** which is normal to these axes, these three axes being normal to each other and forming three ordinates for positioning an article, such as gun **30**, in space.

In order to locate the gun **30** at a desired position with respect to axis **1**, the turning means **33, 34, 35** is operated, either by hand or by motor, to turn the frame **11, 36, 37** on the mounting means **9** about the axis **1**, and the dome **19** is stationary with respect to this frame because of its connection thereto through members **47, 48, 49, 44, 23** so that this dome **19** necessarily turns with frame **11, 36, 37** about axis **1**. Also the gun **30** carried by dome **19** necessarily turns with the latter. The turning means **33, 34, 35** is capable of turning this frame and dome **19** and gun **30** therewith in either direction through 360° about axis **1**, and this turning means may be operated as long as desired to turn the frame **11, 36, 37** and dome **19** and gun **30** therewith as many times as desired about axis **1** without in any way interfering with other parts of the apparatus. As was pointed out above, the turning means of Figs. 2 and 3 lock the wedge members **13** and **16** to each other and to ring **45** which is in turn connected by elements **46, 28, 44, 23** to the frame **11, 36, 37**, so that if the turning means of Figs. 2 or 3 are not operated while the turning means **33, 34, 35** is operated, the wedge members **13** and **16** will turn together with all the rest of the apparatus, except mounting means **9** and ring gear **33**, about the axis **1**.

In order to position the gun **30** about axis **3** so as to regulate the elevation of this gun, the wedge members **13** and **16** are simultaneously turned in opposite directions by the turning means of Fig. 2 or Fig. 3, as described above. The wedge members **13** and **16** are shown in Fig. 1 in the position where they provide the lowest elevation of gun **30** since the apexes of the wedge members **13** and **16** are located beneath the gun **30** directly over each other in the plane which includes the axis **1** and the axis of gun **30**. If it is assumed that the top and bottom faces of each wedge member include therebetween an angle of 30°, it is evident that the top face **18** of wedge member **16** is located in a plane which makes an angle of 60° with the axis of gun **30** when this latter axis is horizontal and the parts are in position shown in Fig. 1. If either the turning means of Fig. 2 or that of Fig. 3 is operated to turn the wedge members **13** and **16** in opposite directions from the position of Fig. 1, it is evident that after each wedge member has turned through 90°, the apexes of the wedge members are 180° apart from each other and located in the plane which includes axes **1** and **3**, and moreover the top face **18** of wedge member **16** will now be located in a plane normal to axis **1** so that the gun **30** has been turned upwardly about axis **3** through 60°. This is a position of the parts shown in Fig. 5. However, inasmuch as the wedge members **13** and **16** shown in the drawings each has an apex angle of approximately 15°, rather than 30°, the gun **30** is shown in Fig. 5 as elevated through 30° from the position of Fig. 1.

Continued turning of wedge members **13** and **16** in opposite directions will bring them to a position (Fig. 6) where their apexes are again located directly over each other but 180° distant from the position shown in Fig. 1. At this point the top face **18** of wedge member **16** is inclined oppositely to the position shown in Fig. 1, and the gun **30** has been turned upwardly through 120° from the position of Fig. 1 about axis **3**. Therefore, with a structure where each wedge member includes between its top and bottom faces an angle of 30°, it is possible to turn the gun **30** about axis **3** through 120°. With the structure of the drawings where the apex angle of the wedge members is 15°, the maximum elevation shown in Fig. 6 is an elevation of 60° from the position shown in Fig. 1 which illustrates the minimum elevation.

Since the dome **19** is stationary with respect to the frame **11, 36, 37** this turning of the wedge members **13** and **16** tilts this dome together with gun **30** about axis **3** but does not cause any rotation of the dome **19** or frame **11, 36, 37** about axis **1**. During this turning of dome **19** and gun **30** about axis **3**, the bar **47** and semi-circular member **49** move downwardly or upwardly about axis **3** through the ring **45**. Also, the ball and socket joint **51** connected to dome **19** moves up and down and a fluid under pressure, such as oil or the like, is automatically supplied to and removed from the hydraulic apparatus **38** so that this apparatus constantly relieves pressure between the several bearing surfaces of the apparatus, the fluid being moved to and from the apparatus **38** at the rate required to exactly compensate for movement of the ball and socket joint **51**. The hydraulic apparatus **38** forms no part of the present invention.

It will be noted that the ball and socket joint **48**, the axis **3** and the ball and socket joint **51** are all located at the same distance from the top face **18** of wedge member **16** and in a plane parallel to a plane in which the top face of wedge member **16** is located.

As was mentioned above, the apparatus of the invention also is capable of positioning the gun **30** about a roll axis substantially parallel with the axis of this gun. In order to accomplish this result, the turning means of either Fig. 2 or Fig. 3 is operated so as to simultaneously turn both wedge members **16** and **13** in the same direction and through the same angle. As is apparent from Fig. 1, such simultaneous movement of the wedge members will rock the gun **30** about an axis substantially parallel to its own axis, and in this way any tilt in the position of the mounting means **9** will have no effect on the positioning of the gun **30**. During this simultaneous turning movement of the wedge members **13** and **16**, the ring **45** turns about the axis of pivot pin **46** with respect to the semicircular member **28**.

It is to be understood that any type of operating levers or the like may be provided to enable the operator to position the gun **30** at any location in space. For example, a single lever or hand wheel or the like may be provided to be turned about three mutually perpendicular ordinates in order to bring about changes in the position of the gun **30** corresponding to movement of such a hand wheel and/or lever. Also, it is possible to provide the apparatus with a gyroscope which will automatically register changes in the position of the gun **30** and which will actuate suitable automatic controls to compensate automatically for any undesired changes in the position of the gun **30**.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of adjustable supporting apparatus differing from the types described above.

While the invention has been illustrated and described as embodied in adjustable ordnance apparatus, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully

reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Adjustable support apparatus comprising, in combination, a frame; means supporting said frame for free rotation about a first axis passing through said frame; first positioning means mounted on said frame for free rotation with respect to the latter about said first axis; second positioning means mounted on said first positioning means for rotation with respect to the latter about a second axis inclined to said first axis; a carrier located over said second positioning means and being connected to said frame for rotation therewith about said first axis, said carrier being adapted to carry an article whose position is to be adjusted; and means interconnecting said second positioning means and carrier for rotation with respect to each other about a third axis inclined to said first and second axes, said first, second, and third axes all intersecting each other at a common point.

2. Adjustable support apparatus comprising, in combination, a frame; means supporting said frame for free rotation about a first axis passing through said frame; first positioning means mounted on said frame for free rotation with respect to the latter about said first axis; second positioning means mounted on said first positioning means for rotation with respect to the latter about a second axis inclined to said first axis; a carrier located over said second positioning means and being connected to said frame for rotation therewith about said first axis, said carrier being adapted to carry an article whose position is to be adjusted; means interconnecting said carrier and frame for movement with respect to each other about a third axis normal to said first and second axes; and means interconnecting said second positioning means and carrier for rotation with respect to each other about a fourth axis inclined to said first and second axes, said first, second, third, and fourth axes intersecting each other at a common point.

3. Adjustable support apparatus comprising, in combination, a frame; means supporting said frame for free rotation about a first axis passing through said frame; first positioning means mounted on said frame for free rotation with respect to the latter about said first axis; second positioning means mounted on said first positioning means for rotation with respect to the latter about a second axis inclined to said first predetermined axis; turning means connected to said first and second positioning means for turning said first positioning means about said first axis and said second positioning means about said second axis; a carrier adapted to carry an article to be positioned by the apparatus, said carrier being located over said second positioning means and being connected to said frame for rotation therewith about said first axis; means interconnecting said carrier and frame for movement with respect to each other about a third axis normal to said first and second axes; means interconnecting said second positioning means and carrier for rotation with respect to each other about a fourth axis inclined to said first, second, and third axes, said first, second, third, and fourth axes all intersecting each other at a common point, when said second positioning means moves about said second axis; and control means operatively connected to said turning means for setting the latter in a first operative position where said turning means simultaneously turns said first and second positioning means in opposite directions about said first and second axes, respectively, and in a second operative position where said turning means simultaneously turns said first and second support means together about said first axis.

4. Adjustable support apparatus comprising, in combination, a frame; means supporting said frame for free rotation about a first axis passing through said frame; first positioning means mounted on said frame for free rotation with respect to the latter about said first axis; second positioning means mounted on said first positioning means for rotation with respect to the latter about a second axis inclined to said first predetermined axis; turning means connected to said first and second positioning means for turning said first positioning means about said first axis and said second positioning means about said second axis; a carrier adapted to carry an article to be positioned by the apparatus, said carrier being located over said second positioning means and being connected to said frame for rotation therewith about said first axis; means interconnecting said carrier and frame for movement with respect to each other about a third axis normal to said first and second axes; means interconnecting said second positioning means and carrier for rotation with respect to each other about a fourth axis inclined to said first, second, and third axes, said first, second, third, and fourth axes all intersecting each other at a common point, when said second positioning means moves about said second axis; and second turning means connected to said supporting means and frame for turning the latter and said first and second positioning means and carrier therewith about said first axis.

5. Ordnance apparatus comprising, in combination, mounting means having a top wall portion formed with a circular opening located about a first axis; an annular frame having an open top and being mounted on said mounting means for movement about said first axis, said frame extending downwardly through said opening; a first annular wedge member forming a part of a sphere, being turnably mounted on said frame for movement about said first axis, and having a bottom face normal to said first axis and a top face inclined to said first axis at an angle other than a right angle; a second annular wedge member also forming part of a sphere and being mounted on said top face of said first wedge member for movement about a second axis intersecting said first axis at a predetermined point and being normal to said top face of said first wedge member and the bottom face of said second wedge member located adjacent said top face of said first wedge member, said second wedge member having a top face distant from said first wedge member and being inclined to said second axis at an angle other than a right angle; a weapon carrier carried by said top face of second wedge member; means interconnecting said carrier and frame for movement with respect to each other about a third axis normal to said first and second axes and passing through said point and for holding said frame and carrier against movement with respect to each other about said first axis; and means interconnecting said weapon carrier and second wedge member for movement with respect to each other about a fourth axis intersecting said first and second axes at said point and being normal to said top face of said second wedge member.

6. Ordnance apparatus as defined in claim 5 and wherein said carrier is connected to said frame through the medium of a pair of plates respectively fixed to opposite sides of said frame and extending upwardly into said first wedge member; a semi-circular member having opposite free ends turnably connected to said pair of plates, respectively, for movement about said third axis, said semi-circular member having a diameter substantially smaller than that of said wedge members so as to be turnable about said third axis upwardly and downwardly in the space defined by said wedge members; and an elongated bar member fixed to said carrier and being turnably connected to said semi-circular member at a point midway between said free ends thereof, said third axis and said

point midway between said ends of said semi-circular member being located at the same distance from said top face of said second wedge member.

7. Ordnance apparatus as defined in claim 6 and wherein a ring is located within said wedge members at the elevation of said top face of said first wedge member and said bottom face of said second wedge member and in a plane normal to said second axis; means interconnecting said ring and wedge members for free turning movement with respect to each other about said second axis; self-locking turning means connected to said ring and wedge members for respectively turning the latter about said first and second axes so that when said turning means is idle said wedge members are locked to each other and to said ring; and a second semi-circular member having opposite free ends respectively mounted on said plates for turning movement about said third axis, being located within said ring in a plane normal to said second axis, and being connected midway between its ends to said ring, so that when said self-locking turning means is idle said frame, wedge members, and carrier may all be turned together about said first axis.

8. Ordnance apparatus as defined in claim 7 and wherein said turning means includes a differential mechanism for turning said wedge members in any desired directions and speeds with respect to each other.

9. Adjustable support apparatus comprising, in combination, a frame; means supporting said frame for free rotation about a first axis passing through said frame; first positioning means mounted on said frame for free rotation with respect to the latter about said first axis; second positioning means mounted on said first positioning means for rotation with respect to the latter about a second axis inclined to said first axis; a carrier located over said second positioning means and being connected to said frame for rotation therewith about said first axis, said carrier being adapted to carry any article whose position is to be adjusted; means interconnecting said second positioning means and carrier for rotation with respect to each other about a third axis inclined to said first and second axes, said first, second, and third axes all intersecting each other at a common point; and moving means operatively connected to said first and second positioning means for simultaneously turning the latter in opposite directions respectively about said first and second axes.

10. Adjustable support apparatus comprising, in combination, a base; a frame mounted on said base for free rotation about a first axis; a first wedge-shaped member forming part of a sphere and having a bottom face normal to said first axis and a top face inclined to said first axis; means located between said frame and bottom face of said first member to support the latter for free rotation with respect to said frame about said first axis; a second wedge-shaped member identical with said first member and having a bottom face located adjacent and being parallel to and opposite said top face of said first member, said second member having a top face inclined to said bottom face thereof; means located between said top face of said first member and bottom face of said second member to support said first and second members for rotation with respect to each other about a second axis normal to said top face of said first member and bottom face of said second member and inclined to said first axis, and intersecting the latter at a predetermined point; a carrier located over and adjacent to said top face of said second member, said carrier being adapted to carry an article whose position is to be adjusted; means interconnecting said carrier and second member for rotation with respect to each other about a third axis normal to said top face of said second member, inclined to said first and second axes, and passing through said predetermined point; and means interconnecting said carrier and frame for rotation together about said first axis and for turning movement with respect to each other about a fourth axis normal to said first, second and third axes, and also passing through said predetermined point.

11. Adjustable support apparatus comprising, in combination, a base; a frame mounted on said base for free rotation about a first axis; a first wedge-shaped member forming part of a sphere and having a bottom face normal to said first axis and a top face inclined to said first axis; means located between said frame and bottom face of said first member to support the latter for free rotation with respect to said frame about said first axis; a second wedge-shaped member identical with said first member and having a bottom face located adjacent and being parallel to and opposite said top face of said first member, said second member having a top face inclined to said bottom face thereof; means located between said top face of said first member and bottom face of said second member to support said first and second members for rotation with respect to each other about a second axis normal to said top face of said first member and bottom face of said second member and inclined to said first axis, and intersecting the latter at a predetermined point; a carrier located over and adjacent to said top face of said second member, said carrier being adapted to carry an article whose position is to be adjusted; means interconnecting said carrier and second member for rotation with respect to each other about a third axis normal to said top face of said second member, inclined to said first and second axes, and passing through said predetermined point; means interconnecting said carrier and frame for rotation together about said first axis and for turning movement with respect to each other about a fourth axis normal to said first, second and third axes, and also passing through said predetermined point; first turning means connected to said base and said frame for turning the latter and said wedge-shaped members and carrier therewith about said first axis; and second turning means connected to said wedge-shaped members for turning said first member about said first axis and said second member about said second axis.

12. Adjustable support apparatus comprising, in combination, a base; a frame mounted on said base for free rotation about a first axis; a first wedge-shaped member forming part of a sphere and having a bottom face normal to said first axis and a top face inclined to said first axis; means located between said frame and bottom face of said first member to support the latter for free rotation with respect to said frame about said first axis; a second wedge-shaped member identical with said first member and having a bottom face located adjacent and being parallel to and opposite said top face of said first member, said second member having a top face inclined to said bottom face thereof; means located between said top face of said first member and bottom face of said second member to support said first and second members for rotation with respect to each other about a second axis normal to said top face of said first member and bottom face of said second member and inclined to said first axis, and intersecting the latter at a predetermined point; a carrier located over and adjacent to said top face of said second member, said carrier being adapted to carry an article whose position is to be adjusted; means interconnecting said carrier and second member for rotation with respect to each other about a third axis normal to said top face of said second member, inclined to said first and second axes, and passing through said predetermined point; means interconnecting said carrier and frame for rotation together about said first axis and for turning movement with respect to each other about a fourth axis normal to said first, second and third axes, and also passing through said predetermined point; first turning means connected to said base and said frame for turning the latter and said wedge-shaped members and carrier therewith about said first axis; second turning means connected to said

wedge-shaped members for turning said first member about said first axis and said second member about said second axis; and control means operatively connected to said second turning means for setting the latter in a first operating position where said wedge-shaped members are simultaneously turned in opposite directions through the same angles and in a second operating position where said wedge-shaped members are simultaneously turned in the same direction through the same angle.

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