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(54) Aiming system.

(57) An aiming system for aiming an object device 12 by movement of the head of a human operator comprises a movable structure 16 on which the object device 12 is fixedly mounted, a seat 18 for the operator mounted on the movable structure, a helmet 22 having associated therewith a line of sight 26, and detecting means 34 for detecting the angular deviation of the helmet with respect to the movable structure. If any deviation is detected, servo drives 80.1, 80.2 operate in response to the detecting means to move the movable structure in the direction of the deviation. The detecting means is connected magnetically to the helmet, along a connecting interface which is perpendicular to the line of sight. The detecting device 34 comprises an articulated telescopic link 40 which is covered by an air-impervious concertina tube 58 to provide damping.

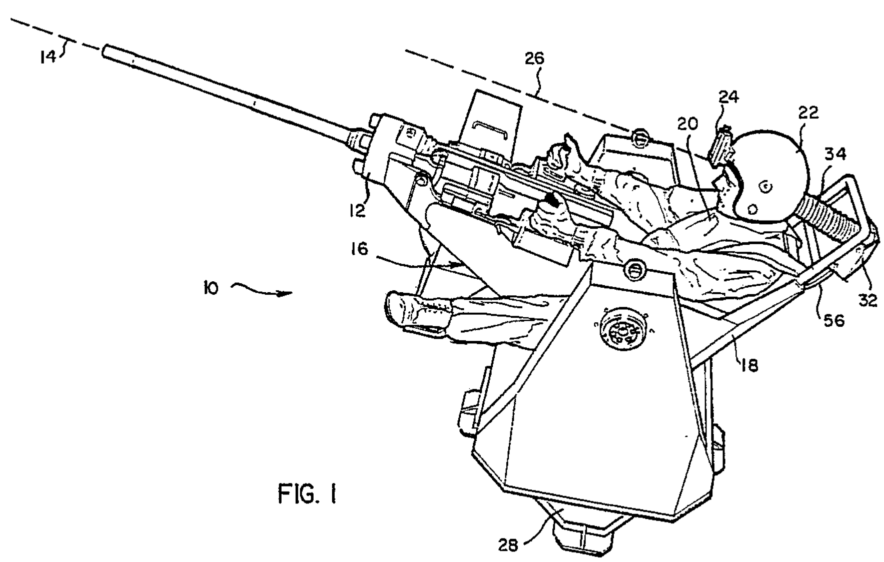

FIG. I

EP 0 413 525 A2

AIMING SYSTEM

THIS INVENTION relates to an aiming system for aiming an object device by movement of the head of a human operator.

The object device could, for example, be a weapon, camera, or the like.

DE-A-2436169 discloses an aiming system for aiming an object device in the form of a weapon, the system comprising a servo drive for moving the weapon, a head mount in the form of a helmet having a sight, detecting means for detecting the angular position of the helmet, and control means for controlling the servo drive, the control means operating in response to the detecting means to aim the weapon in the direction in which an operator wearing the helmet looks. The detecting means detects the angle of the helmet with respect to a fixed reference frame which does not move with the weapon. This requires the angle sensing devices of the detecting means and the control loop between the detecting means and the servo drive to be extremely accurate and linear, to ensure that the weapon is aimed accurately in the direction of the line of sight of the operator for all angles.

US-A-3262210 and GB-A-2122731 disclose aiming systems having detecting means in the form of an articulated mechanical link connected to a helmet. These systems suffer from the same disadvantages as the one described in DE-A-2436169.

According to the present invention the detecting means is arranged to detect angular deviation of the head mount with respect to a movable structure on which the object device is mounted, whereby the reference frame is angularly fixed with respect to the movable structure; and the servo drive is operative in response to the detecting means to move the movable structure in the direction of said angular deviation.

The movable structure may include a seat for the operator.

Where the detecting means comprises an articulated mechanical link disconnectably connectable to the head mount, connection between the detecting means and the head mount may be is along a flat connecting interface perpendicular to the line of sight.

Where the servo drive is arranged to move the movable structure about a slew axis and about an elevation axis perpendicular to the slew axis, and where the mechanical link is connected at one end to the head mount via a first articulated joint having first and second mutually perpendicular articulation axes and at the other end to the movable structure via a second articulated joint having first and second mutually perpendicular articulation axes, the first articulation axis of the first articulated joint may be in the same plane as the first articulation axis of the second articulated joint, which plane is parallel to the slew axis; and the second articulation axis of the first articulated joint may be in the same plane as the second articulation axis of the second articulated joint, which plane is parallel to the elevation axis.

The system may further comprise magnetic means for magnetically connecting the detecting means to the head mount along said connecting interface.

The magnetic means may be fixed to the head mount and have co-planar pole faces which define a flat surface perpendicular to the line of sight; and the detecting means may comprise at the end thereof a rotatable connector disc of a ferro-magnetic material, having a flat face perpendicular to its axis of rotation for contacting said pole faces.

The system may further comprise disconnect sensing means for detecting disconnection of the detecting means from the head mount and, in response thereto, to inhibit operation of the servo drive.

The disconnect sensing means may include a reed switch sensitive to proximity of the magnetic means.

The system may further comprise an end-piece at each end of the articulated mechanical link, and a tube of flexible, air-impervious material extending from one said end-piece to the other to form an enclosed space around the link, from which enclosed space air can escape or into which it can enter at a restricted rate.

The articulated link may be telescopically extendable; and the tube may be a concertina tube.

The invention will now be described in more detail, by way of example, with reference to the accompanying drawings.

In the drawings:

Figure 1 is a three dimensional view of an aiming system in accordance with the invention, showing also its operator;

Figure 2 is a cut-away three dimensional view of an angle detecting device forming part of the system;

Figure 3 is a three-dimensional diagram, showing the various pivot axes associated with the angle detecting device;

Figure 4 is an axial section through the front end of the angle detecting device;

Figure 5 is an end view in the direction of arrow V in Figure 4; and

Figure 6 diagrammatically shows the control loop between the angle detecting device and the servo motors of the system.

Referring first to Figure 1, reference numeral 10 generally indicates a system for aiming a weapon 12 whose line of fire is indicated at 14. The weapon is mounted on a movable structure 16 on which a seat 18 for supporting an operator 20 is mounted as well. The operator wears a helmet 22. The helmet is fitted with a sight 24 whose line of sight is indicated at 26.

The movable structure 16 (including the weapon 12 and the seat 18) is mounted on a fixed pedestal 28, drive means in the form of two servo motor drives being provided to change the elevation and slew angles, respectively, of the movable structure with respect to the pedestal. One of the trunnions about which the movable structure 16 pivots to change the elevation angle is indicated at 30.

At the back of the seat 18 there is a bracket 32 which is fixed with respect to the movable structure 16. Between the bracket 32 and the helmet 22, there is an angle detecting device 34, the rear end of the device 32 being connected to the bracket 32 and the front end of the device 32 being connected to the rear of the helmet 22.

Referring now to Figures 2 to 5, the angle detecting device 34 comprises, at the front end thereof, a connector 36 which includes a mild steel disc 38, and a telescopically extendible link 40 which extends from the connector 36 to the bracket 32. The link 40 is connected to the connector 36 via a first articulated joint 42 and to the bracket 32 via a second articulated joint 44. The first articulated joint 42 permits the link 40 to pivot with respect to the connector 36 about two mutually perpendicular articulation axes 46.1 and 46.2. With each articulation axis 46.1, 46.2 there is associated a linear potentiometer 48.1 and 48.2 respectively. As will be described hereinafter, these potentiometers are connected in an electrical circuit so as to be able to provide an electrical output corresponding to the degree of pivotal displacement of the link 40 about the respective articulation axes 46.1 and 46.2. The second articulated joint 44 permits the link 40 to pivot with respect to the bracket 32 about two mutually perpendicular articulation axes 50.1 and 50.2. Here again, with each articulation axis 50.1, 50.2 there is associated a linear potentiometer 52.1, 52.2 respectively. These provide electrical outputs corresponding to the degree of pivotal displacement of the link 40 about the respective articulation axes 52.1 and 52.2.

The line 46.3 in Figure 3 is a reference line which is fixed with respect to the helmet 22 and parallel to the line of sight 26 (see Figure 1). The line 50.3 in Figure 3 is a reference line which is fixed with respect to the movable structure 16 and parallel to the line of fire 14 (see Figure 1).

The arrangement of the articulated joints 42 and 44 is such that the articulation axes 46.1 and 50.1 are always in the same plane, this plane being parallel to the slew axis of the movable structure 16. Furthermore, the arrangement of the articulated joints 42 and 44 is such that the articulation axes 46.2 and 50.2 are always in the same plane, this plane being parallel to the elevation axis of the movable structure 16. Conveniently, the articulation axes 46.2 and 50.2 are both fixed with respect to the link 40 and parallel to one another. This considerably simplifies the control circuitry as will be described hereinafter with reference to Figure 6.

In a region of the helmet 22 near the neck of the operator, there are secured three permanent magnets 54 with flat and co-planar pole faces, to which the mild steel disc 38 can attach magnetically. The plane of the pole faces is perpendicular to the line 46.3, and thus also perpendicular to the line of sight 26.

Wiring 56 leads from the potentiometers 48.1, 48.2, 52.1 and 52.2 to control circuitry which controls the elevating and traversing drives of the movable structure 16. This will be described in more detail with reference to Figure 6.

The link 40 and the articulated joints 42 and 44 are covered by a flexible cover consisting of a concertina tube 58 of rubber or the like flexible, air-impervious sheet material. At the connector end the concertina tube is fitted on an end-piece 60 which forms part of the connector 36, and at the opposite end it is fitted on an end-piece 61, to form a relatively air-tight enclosure.

The two parts of the link 40 are telescopically movable with respect to one another, as indicated by the arrow A in Figure 3. The connection between these parts is, however, such that they cannot rotate with respect to one another about the longitudinal axis of the link, but the construction of the connector 36 is such that the disc 38 is able to rotate with respect to the articulation joint 42 about the axis 46.3, as indicated by arrow B in Figure 3. This allows complete freedom of movement of the operator's head, within the reach of the link 40.

The construction of the connector 36 is illustrated in more detail in Figures 4 and 5. The end-piece 60 referred to earlier is of aluminium or other non-magnetic material. The disc 38 has a flat annular face 62, and a frusto-conical boss 63 which houses frictionless bearings 64 and 66. The assembly is held together by means of a circlip 68 and a fixing screw 70, the latter being covered by a plastic cap 72. The positions of the three magnets 54 when they engage with the disc 38 are shown in Figure 5.

Referring now to Figure 6, the potentiometers 48.2 and 52.2 are connected in an electrically back-to-back configuration, and their wipers are connected to a summing amplifier 74.1. Because of the electrically back-to-back connection of the potentiometers, the output of the summing amplifier 74.1 corresponds to the difference in pivotal displacement of the link 40 about the articulation axes 46.2 and 50.2 respectively. Thus, whatever the pivotal displacement of the link 40 about the articulation axes 46.2 and 50.2, if the lines 46.3 and 50.3 are parallel, the output of the summing amplifier 74.1 is zero. The output of the summing amplifier 74.1 is fed via a further summing amplifier 76.1 to a servo power amplifier 78.1, which in turn is connected to drive a servo motor 80.1. The servo motor 80.1 is operative to displace the movable structure 16 with respect to the pedestal 28 about the elevation axis.

The summing amplifiers 74.1 and 76.1, and the power amplifier 78.1 form a first channel 82.1. The circuitry comprises a second channel 82.2 including summing amplifiers 74.2 and 76.2, and a power amplifier 78.2 which is connected to drive a servo motor 80.2. The servo motor 80.2 is operative to displace the movable structure 16 with respect to the pedestal 28 about the slew axis. Inputs to the second channel 82.2 derive from the potentiometers 48.1 and 52.1 (not shown in Figure 4). The arrangement here is also such that, whatever the pivotal displacement of the link 40 about the articulation axes 46.1 and 50.1, if the lines 46.3 and 50.3 are parallel, the output of the summing amplifier 74.2 is zero.

The particular arrangement of the articulated joints 42 and 44 makes it possible to use two simple independent channels or control loops, one for the servo motor 80.1 and one for the servo motor 80.2.

Whenever the angle detecting device 34 senses any angular deviation between the axes 46.3 and 50.3, one or both of the servo motors 80.1, 80.2 operate to move the movable structure 16 (and thus the line 50.3) in the direction of the angular deviation. If the operator 20 keeps his eyes fixed on the object to which the weapon is to be aimed, this will have the effect of reducing the deviation down to zero. In this manner the line of fire 14 will follow the line of sight 26.

The summing amplifiers 76.1 and 76.2 each have a second input 84.1 and 84.2 respectively. The second inputs are derived from a joystick control which permits the operator to make lead angle and trajectory corrections.

Air is able to enter into or leave the enclosed space formed by the concertina tube 58 and the end-pieces 60, 61 via a restricted opening (not shown) in, for example, the end-piece 61. This has a damping effect on the detecting device 34, to prevent excessively rapid movement thereof and to avoid resonance problems.

To prevent the servo drives 80.1, 80.2 from driving the weapon downwardly should the connector 36 be disconnected from the helmet 22 and allowed to drop, a reed switch 86 is mounted in the connector 36 such that its contacts are open or closed depending on whether the magnets 54 are or are not attached to the mild steel disc 38. The reed switch 86 is connected to the control circuitry 82.1, 82.2 in such a manner that when the magnets 54 have been detached from the disc 38, operation of the servo motors 80.1 and 80.2 is inhibited.

It will be seen that the angle detecting device does not rely for its operation on a fixed reference frame intermediate the helmet 22 and the weapon 12. The connection of the angle detecting device 34 is direct between the helmet and the movable structure 16 (on which the weapon is fixedly mounted). This has the advantage that any non-linearities in the control circuitry, changes in the loop gain, etc. will not affect the accuracy of operation. This, for example, makes it possible to use inexpensive potentiometers instead of expensive synchros. Also, the accuracy of the system is not affected by inaccuracies in orthogonality of the slew and elevation axes.

Because the connecting interface between the helmet 22 and the angle detecting device 34 is perpendicular to the line of sight 26, disconnection and reconnection of the helmet can easily and rapidly be effected without affecting the accuracy of operation. Any rotational or translational misalignment when reconnecting the detecting device 34 to the helmet 22 will not affect the accuracy of operation, so long as the face 62 of the disc 38 is aligned with the pole faces of the magnets 54. Also, disconnection of the helmet 22 from the detecting device 34 does not require the unfastening of any fasteners. The parts can be disconnected by simply pulling them away from one another. This can be important in case of an accident or other emergency situation.

Claims

1. An aiming system for aiming an object device (12) by movement of the head of a human operator and which comprises a movable structure (16) on which the object device is fixedly mounted or mountable, a servo drive (80.1, 80.2) for moving the movable structure, a head mount (22) adapted to be mounted on or affixed to the head of the operator, and detecting means (34) for detecting angular deviation of the head mount with respect to a reference frame (50.1, 50.2, 50.3), characterised in that

the detecting means (34) is arranged to detect

angular deviation of the head mount (22) with respect to the movable structure (16), whereby the reference frame (50.1, 50.2, 50.3) is angularly fixed with respect to the movable structure; and
the servo drive (80.1, 80.2) is operative in response to the detecting means (34) to move the movable structure in the direction of said angular deviation.
2. An aiming system as claimed in claim 1,
characterised in that
the movable structure includes a seat (18) for the operator.
3. An aiming system as claimed in claim 1 or claim 2, wherein the head mount (22) has associated therewith a line of sight (26) and wherein the detecting means (34) comprises an articulated mechanical link (40) disconnectably connectable to the head mount,
characterised in that
connection between the detecting means (34) and the head mount (22) is along a flat connecting interface (62) perpendicular to the line of sight (26).
4. An aiming system as claimed in claim 3,
wherein the servo drive (80.1, 80.2) is arranged to move the movable structure (16) about a slew axis and about an elevation axis perpendicular to the slew axis, and wherein the mechanical link (40) is connected at one end to the head mount (22) via a first articulated joint (42) having first and second mutually perpendicular articulation axes (46.1, 46.2) and at the other end to the movable structure (16) via a second articulated joint (44) having first and second mutually perpendicular articulation axes (50.1, 50.2),
characterised in that
the first articulation axis (46.1) of the first articulated joint is in the same plane as the first articulation axis (50.1) of the second articulated joint, which plane is parallel to the slew axis; and
the second articulation axis (46.2) of the first articulated joint is in the same plane as the second articulation axis (50.2) of the second articulated joint, which plane is parallel to the elevation axis.
5. An aiming system as claimed in claim 3 or claim 4, characterised in that
it comprises magnetic means (54) for magnetically connecting the detecting means (34) to the head mount (22) along said connecting interface (62).
6. An aiming system as claimed in claim 5,
characterised in that
the magnetic means (54) are fixed to the head mount (22) and have co-planar pole faces which define a flat surface perpendicular to the line of sight (26); and
the detecting means (34) comprises at the end thereof a rotatable connector disc (38) of a ferromagnetic material, having a flat face (62) perpendicular to its axis of rotation (46.3) for contacting said pole faces.
7. An aiming system as claimed in claim 5 or claim 6,
characterised in that
it comprises disconnect sensing means (86) for detecting disconnection of the detecting means (34) from the head mount (22) and, in response thereto, to inhibit operation of the servo drive (80.1, 80.2).
8. An aiming system as claimed in claim 7,
characterised in that
the disconnect sensing means includes a reed switch (86) sensitive to proximity of the magnetic means (54).
9. An aiming system as claimed in any one of claims 3 to 8,
characterised in that
it comprises an end-piece (60, 61) at each end of the articulated mechanical link (40), and a tube (58) of flexible, air-impervious material extending from one said end-piece to the other to form an enclosed space around the link, from which enclosed space air can escape or into which it can enter at a restricted rate.
10. An aiming system as claimed in claim 9,
characterised in that
the articulated link (40) is telescopically extendable; and the tube (58) is a concertina tube.

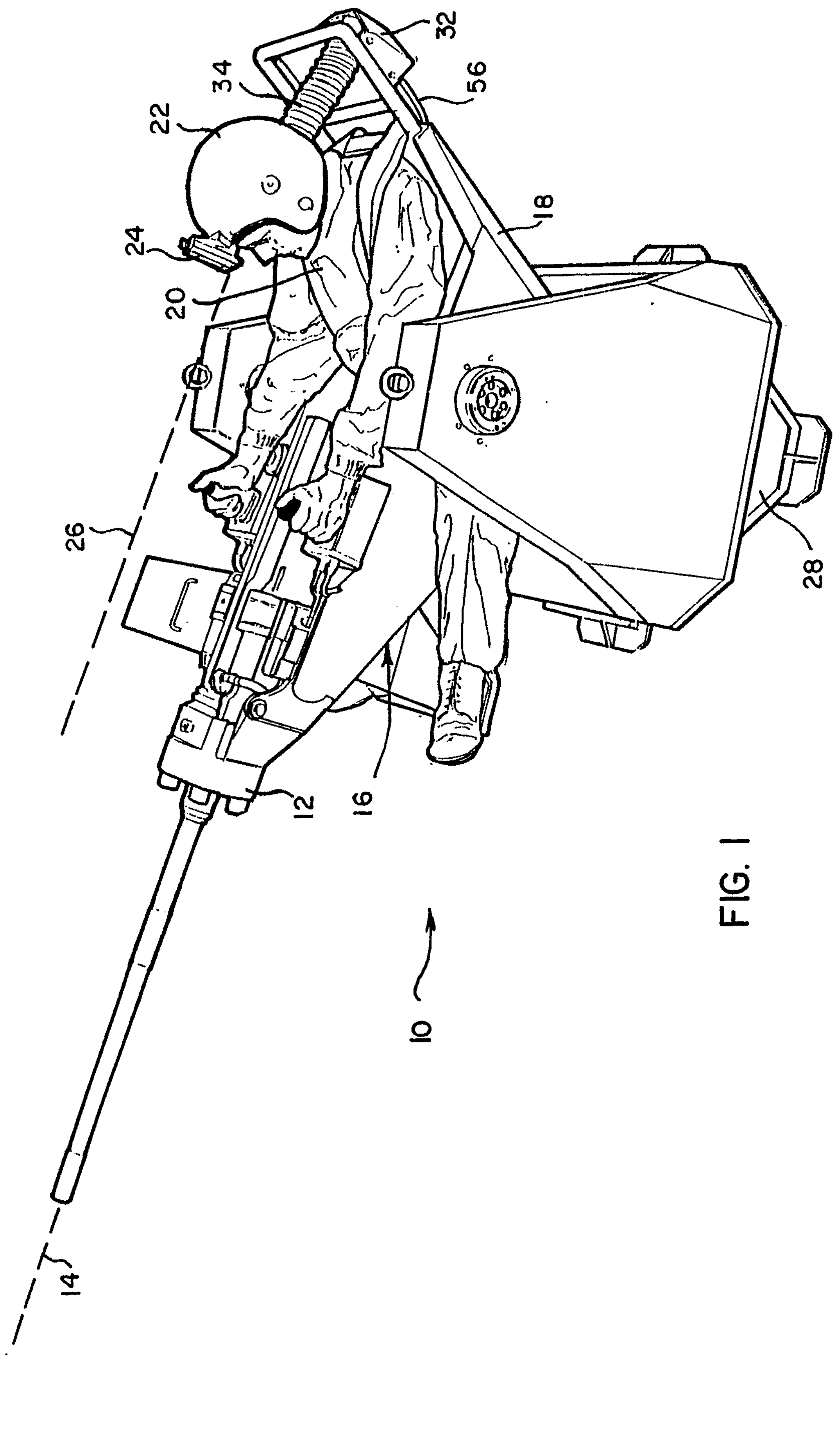

FIG. 1

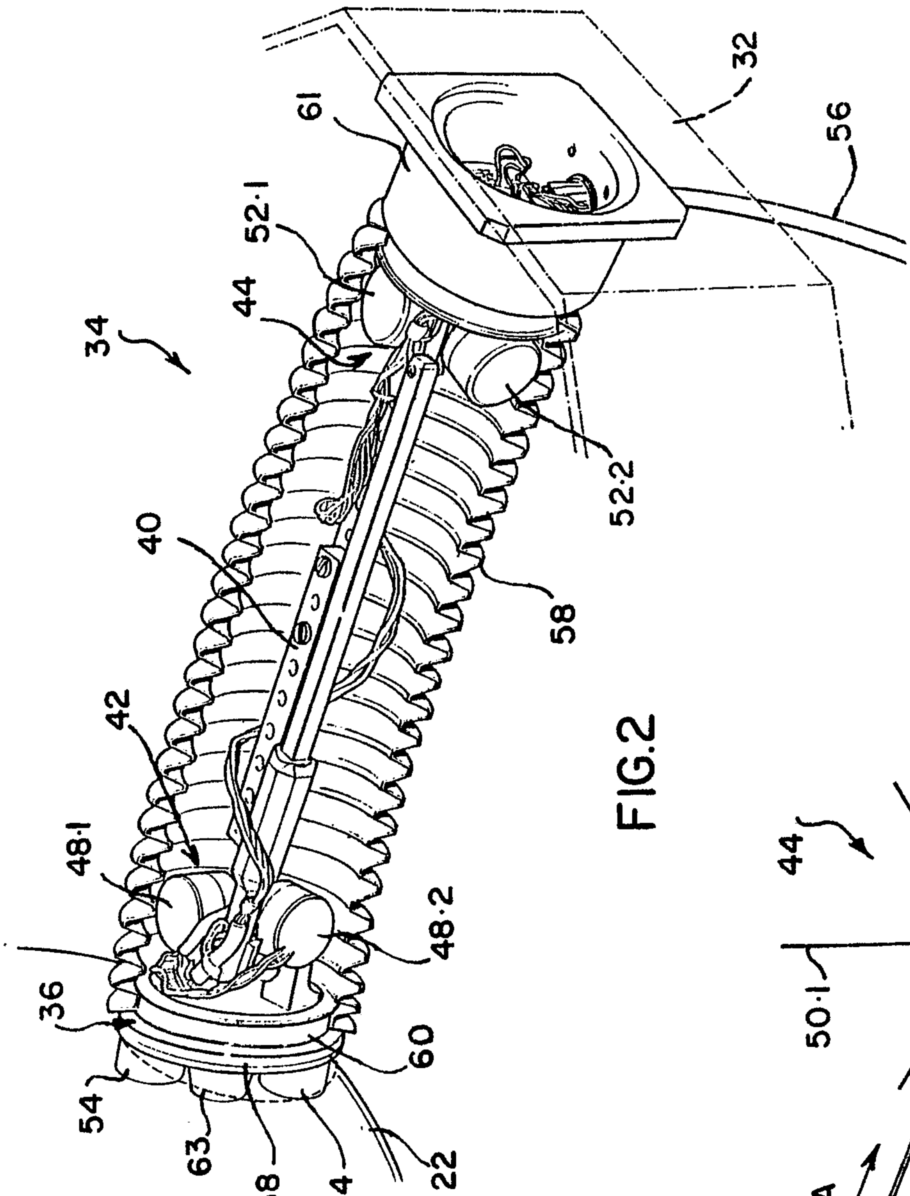
34
32
56
61
52·1
44
40
42
48·1
48·2
36
54
63
38
54
22
60
58
52·2

FIG.2

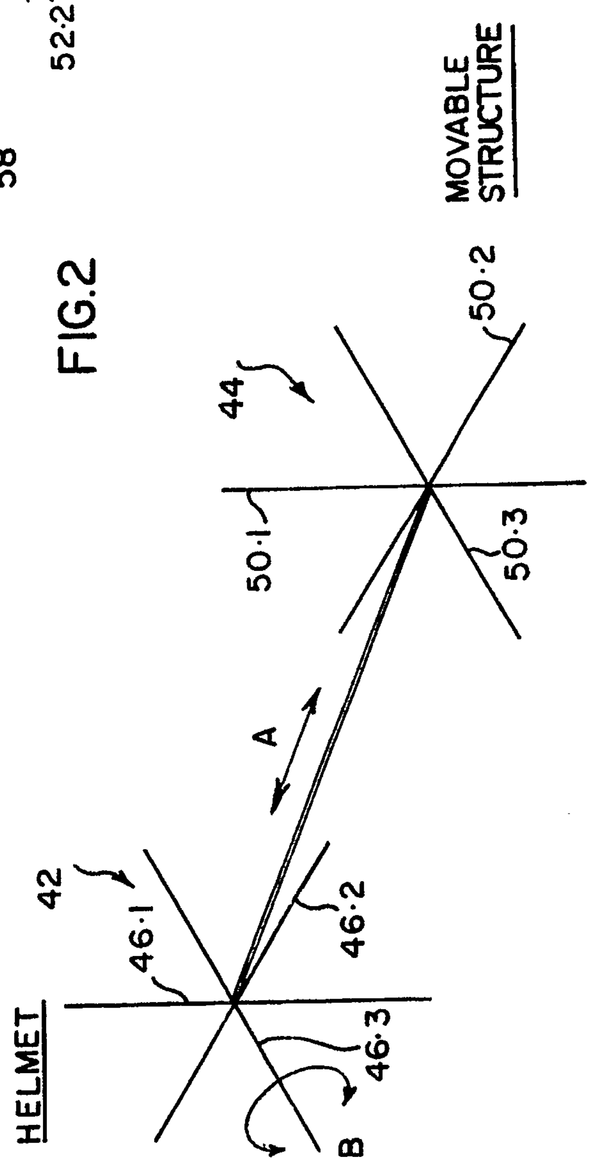
MOVABLE STRUCTURE
44
50·2
50·1
50·3
A
42
46·1
46·2
46·3
HELMET
B

FIG. 3

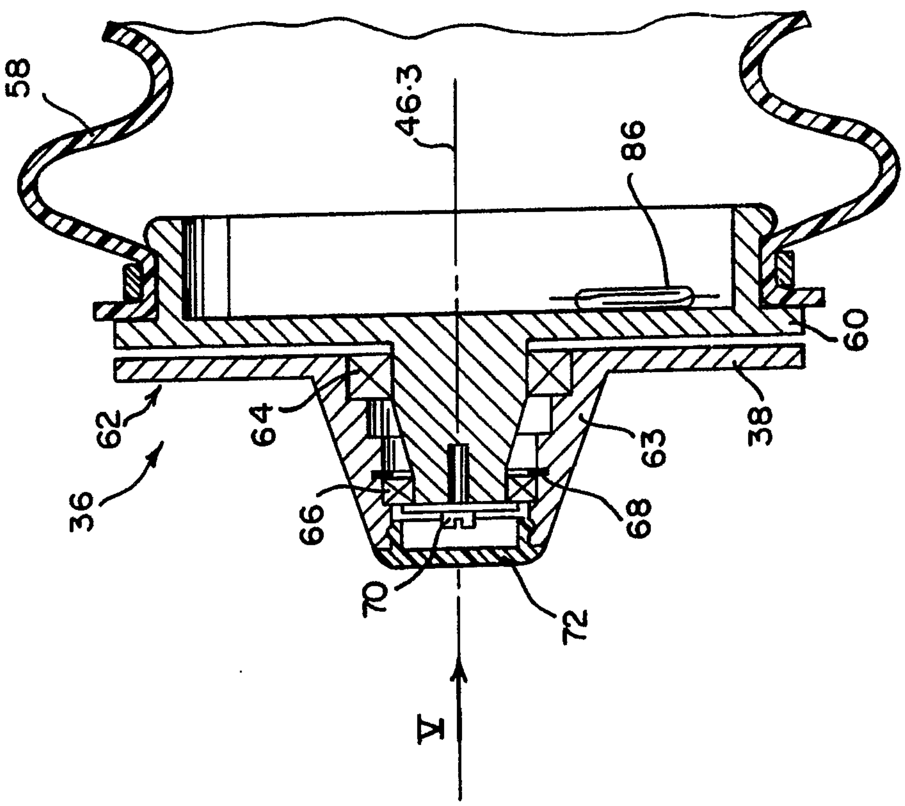

FIG. 4

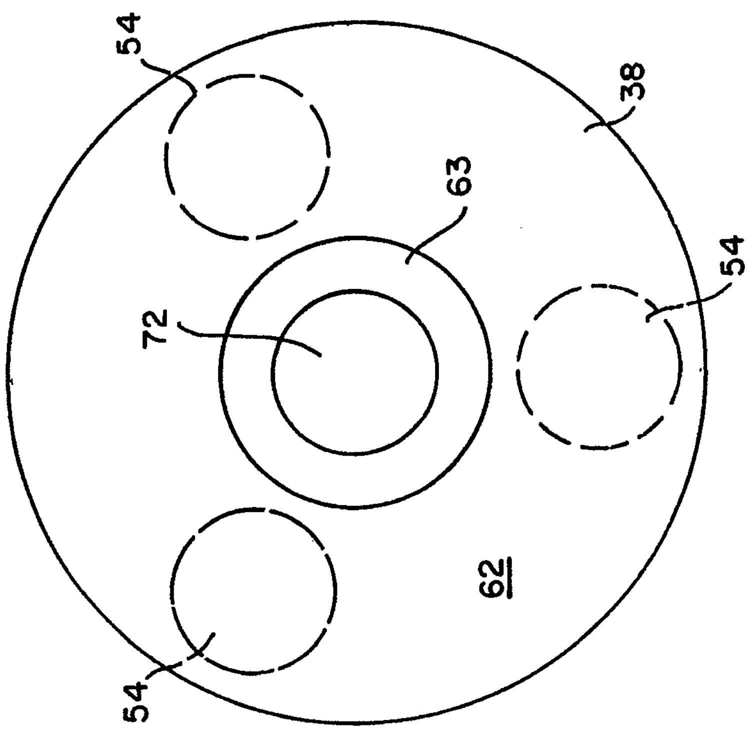

FIG.5

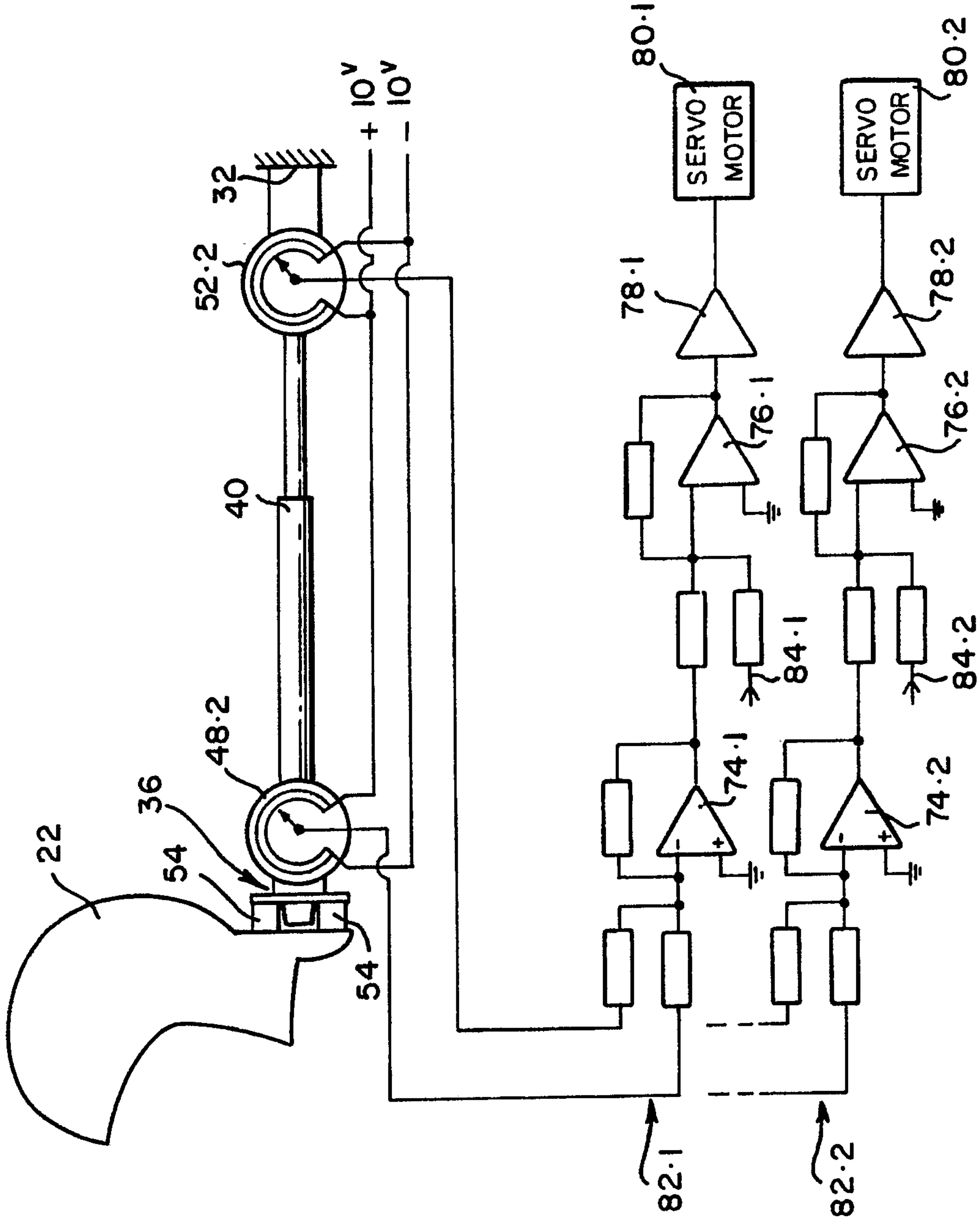
22
54
54
36
48·2
40
52·2
32
+ 10V
− 10V
SERVO MOTOR
80·1
SERVO MOTOR
80·2
78·1
78·2
76·1
76·2
84·1
84·2
74·1
74·2
82·1
82·2

FIG.6