June 17, 1958 K. N. ANDERSSON 2,839,713

ELECTRIC CONTROL SYSTEM FOR SUPERVISING RELATIVELY MOVABLE MEMBERS

Filed Feb. 15, 1954 2 Sheets-Sheet 1

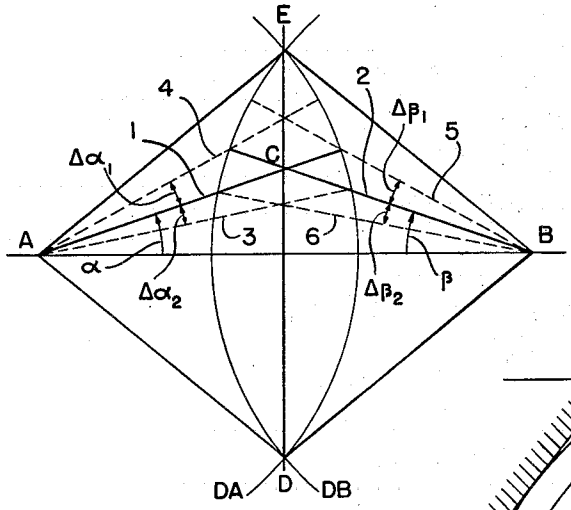


FIG. 1

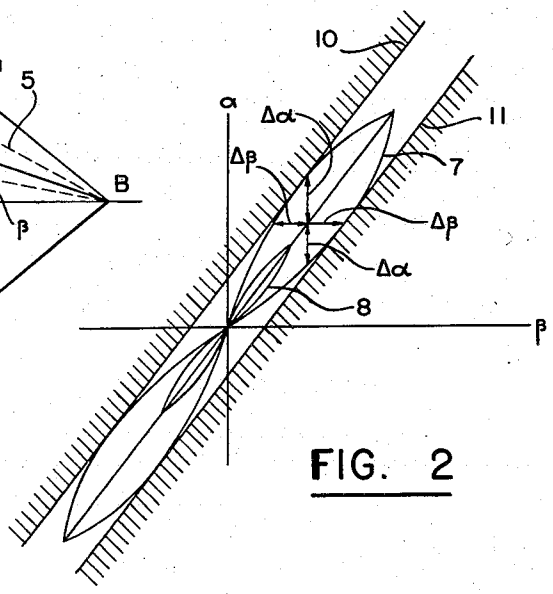


FIG. 2

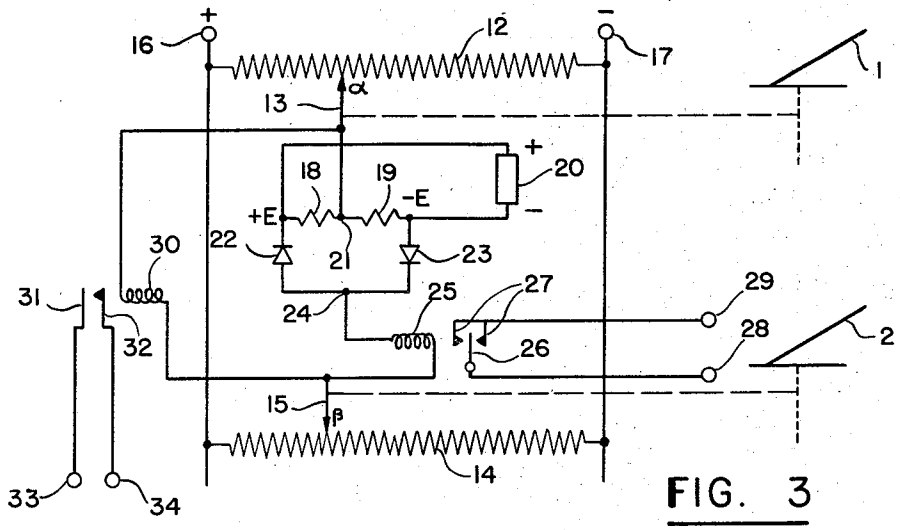


FIG. 3

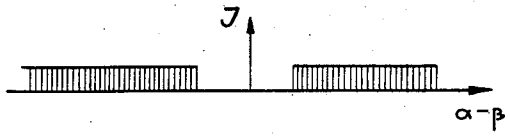


FIG. 4

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ELECTRIC CONTROL SYSTEM FOR SUPERVISING RELATIVELY MOVABLE MEMBERS

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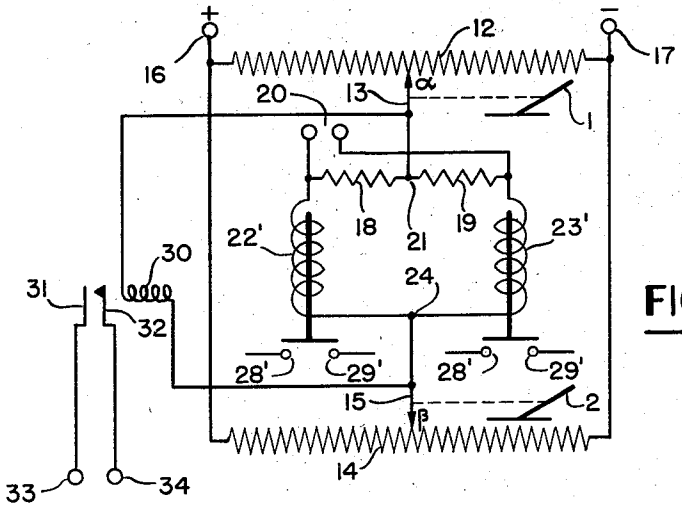


FIG. 5

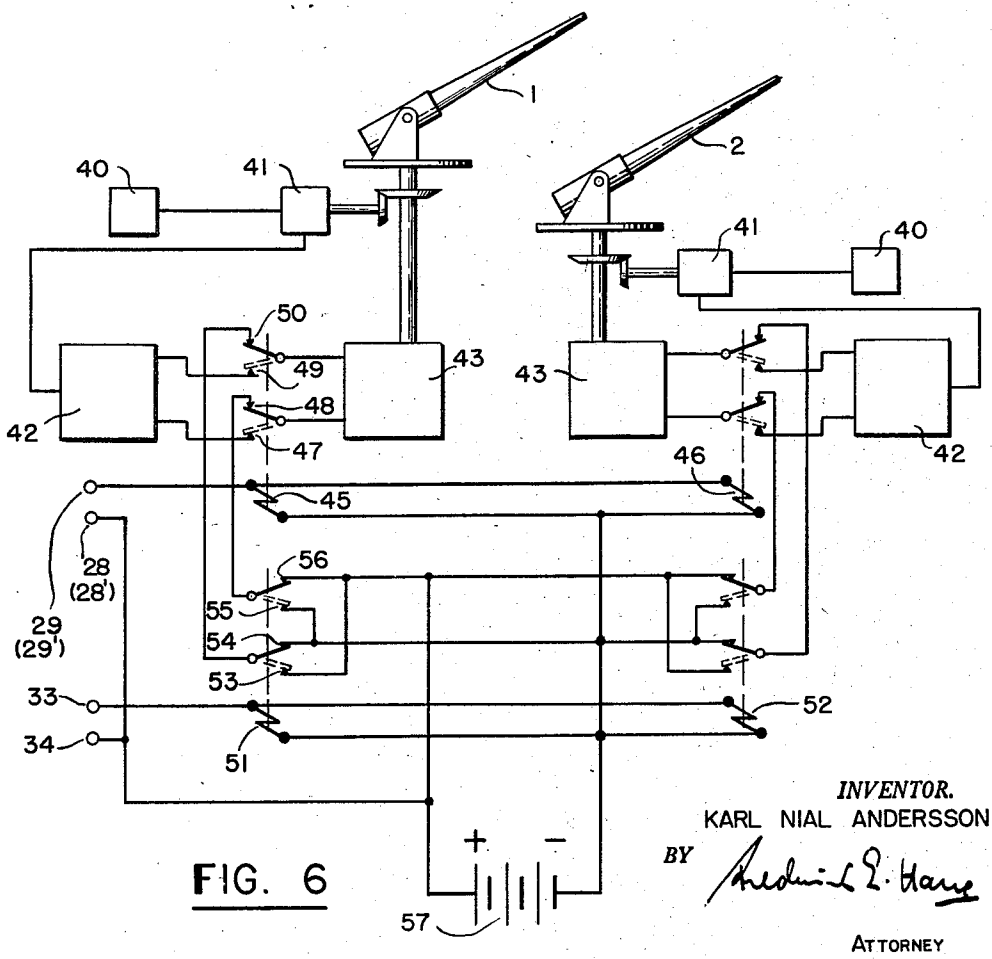


FIG. 6

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ELECTRIC CONTROL SYSTEM FOR SUPERVISING RELATIVELY MOVABLE MEMBERS

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Application February 15, 1954, Serial No. 410,134

20 Claims. (Cl. 318—286)

This invention relates to electric control systems for supervising the movements of two members movable relative to each other and disposed in close proximity. More particularly, the invention relates to electric control systems for supervising the relative movements of elongated members, such as gun barrels, which are so mounted that there is a danger of physical contact or collision between the elongated members.

A control system of the general type, above referred to, is useful in many fields of application. A particularly useful though not exclusive field of application is the supervision of the aiming movements of guns or gun batteries on naval craft. The available space on warships is often so limited that the guns must be mounted so closely together that the gun barrels can collide in certain relative positions which is of course highly undesirable or that the discharge from one gun will strike the barrel of another gun which is equally undesirable. To avoid accidents of this nature, a member of a gun crew is frequently detailed to watch the movements of the gun barrels and to stop the barrel movements by a suitable control device when there is a dangerous approach between the barrels. Such reliance upon a person is not very satisfactory since it involves human reaction, subjective judgment, and the danger that the detailed crew member becomes incapacitated during an engagement just at a critical moment.

Accordingly, one of the principal objects of the present invention is to provide a control system which continuously and automatically supervises the relative positions of the gun barrels or other elongated members.

Another object of the present invention is to provide a novel and improved control system which is continuously controlled by the movements of the gun barrels or other elongated members and which automatically initiates corrective measures if there is a danger of collision or, more generally, a dangerous approach between the gun barrels.

Other objects, features and advantages will be pointed out hereinafter and set forth in the appended claims forming part of the application.

This application is a continuation-in-part of our copending application Ser. No. 221,786 filed April 19, 1951, and now issued as Patent 2,750,553.

In the accompanying drawing two now preferred embodiments of the invention are shown by way of illustration and not by way of limitation.

In the drawing:

Fig. 1 shows diagrammatically two elongated members movably relative to each other in one plane.

Fig. 2 is a diagram illustrating the range of the relative positions within which a collision between the two members is feasible.

Fig. 3 is a typical circuit diagram of an electric control system according to the invention.

Fig. 4 is a graph showing the function of the system according to Fig. 3 or 5.

Fig. 5 is a modification of the circuit diagram of Fig. 3, and

Fig. 6 is a typical circuit diagram of a gun moving system controlled by the control system according to the invention.

Referring first to Fig. 1 in detail, this figure shows two gun barrels or other elongated members indicated by the two solid lines 1 and 2. These lines (or barrels) should be visualized as being movable in the plane of the drawing and pivotal about the points A and B respectively. The curves which the free ends of the lines 1 and 2 describe when the barrels are pivoted, are indicated by O_A and O_B. The line which connects the intersecting points of the two curves O_A and O_B is designated by DE. Let it now be assumed that the two lines are in the positions shown in Fig. 1 in full lines. Then, they will intersect with each other at the point C on the connecting line DE. Let it be further assumed that the two members as represented by lines 1 and 2 are very nearly in the same plane. The angles of the lines relative to the horizontal line AB are designated α and β. If one of the lines, for instance line 1, remains stationary while the other line 2 is moved within the same plane as the line 1, line 2 will collide with line 1 when the line 2 approaches the line 1 from below and reaches the position indicated by the dashed lines 6. Similarly, line 2 will collide with line 1 when line 2 approaches line 1 from above and reaches the position indicated by dashed line 5. It can geometrically be shown that the angles $\Delta\beta_1$ and $\Delta\beta_2$, which lines 5 and 6 form with line 2 when this latter line intersects with point C, have the same value and are identical with the angles $\Delta\alpha_1$ and $\Delta\alpha_2$ between line 1 and dashed lines 3 and 4 when line 2 remains stationary and line 1 is movable in the same plane as line 2. If the two lines 1 and 2 are moving at the same time along the curve as drawn folowing the variations of angles $\Delta\alpha$ and $\Delta\beta$, it will be found that such curve assumes the form of a double loop 7.

Fig. 2 shows loop 7, the angles α being entered on the ordinate and the angles β on the abscissa. The loop 7 indicates that a collision between the two barrels represented by lines 1 and 2 can occur within the area defined by loop 7.

A similar loop is obtained when it is assumed that the barrels represented by lines 1 and 2 are movable in a plane perpendicular to the plane of the drawing instead of in this plane. For high values of the angles α and β in the last mentioned plane, a curve following the variations of $\Delta\alpha$ and $\Delta\beta$ in the first mentioned plane would take the form of a small double loop 8. Consequently, a collision between the two barrels movable in two planes perpendicular relative to each other can be avoided by means of a device for each plane which is so designed that it indicates when either of the barrels or lines 1 and 2 reaches an angular position within the area defined by the double loop. However, it has been found in practice that indicating devices with a sensitivity characteristic as represented by a double loop, are unnecessarily complicated.

When two tangents are drawn parallel to each other corresponding to the maximal width of a double loop as is shown in Fig. 2 for double loop 7, the parallel tangents are tangential with the two loops forming the double loop. If a device be designed which indicates or otherwise reacts when one of the two barrels represented by lines 1 and 2 reaches an angular position within the area defined by two tangents, such a device will satisfy all practical requirements for avoiding a collision between the two barrels.

A device of this type can be simply and reliably manufactured and in Fig. 3 is shown a now preferred embodiment of such a device or control system.

The control system according to Fig. 3 comprises two potentiometers having resistors 12 and 14 respectively, and movable or slidable contacts 13 and 15 respectively. The two potentiometers are preferably of identical resistance value. The two resistors 12 and 14 are connected at both ends to terminals 16 and 17 of a source of direct current. The position of contact 13 is controlled by the position of the barrel or line 1, and the position of contact 15 by barrel or line 2. For this purpose, the two contacts 13 and 14 are coupled as is indicated by any suitable conventional means with barrels 1 and 2. It is assumed that these barrels are moved relative to each other in the plane of the drawing.

Hence, the voltage which is tapped by contacts 13 and 15 from the resistors 12 and 14 respectively, is directly proportional to the angle between barrels 1 and 2 respectively and the horizontal reference line AB. As a result, the two angles are measured from the right side of the two points A and B or from the left side of these two points. The two potentiometers being identical, the same position of contacts 13 and 15 will represent the same angle of the barrels 1 and 2. As is obvious from the previous explanation, the two potentiometers are in effect angle detecting means. It is of course, quite possible and in some instances preferable, to use other types of detecting means such as variable transformers.

Contact 13 is connected to a point 21 which forms the junction point between the two inner ends of two resistors 18 and 19 connected in series. The two outer ends of the resistors are connected to a D.-C. source 20 and also to one side of two rectifiers 22 and 23 connected in opposition in series.

As is apparent the source 20 together with the resistors 18 and 19 can be replaced by two sources of current.

The junction point 24 between the two rectifiers 22 and 23 is connected to slidable contact 15. This connection includes a coil 25 of a polarized relay which has two fixed contacts 27 and controls a movable contact 26 normally biased into a neutral position. The contacts 27 are connected to a terminal 29 and contact 26 is connected to a terminal 28. Terminals 28 and 29 are connected with the actuating means of the gun as shown in Fig. 6.

The control system according to Fig. 3 further includes a second polarized relay having coil 30 connected to slidable contacts 13 and 15. Coil 30 controls a movable contact 32 which coacts with a fixed contact 31 and is normally biased into a disengaged position. Contacts 31 and 32 are connected to terminals 33 and 34 which in turn are connected to the actuating means of Fig. 6. The energization of coil 30 and, hence, contacts 31 and 32 are controlled by the direction of the flow of current between contacts 13 and 15.

The graph according to Fig. 4 shows the current flow through the control system as a function of the difference in the angular positions of the gun barrels.

The control system according to Fig. 5 is similar to the control system according to Fig. 3, except that the rectifiers 22 and 23 of Fig. 3 are replaced by two polarized relays 22′ and 23′. These relays control contacts 28′ and 29′ corresponding to contacts 28 and 29 of Fig. 3. One or the other of the relay coils will actuate its switch contacts 28′ and 29, depending upon the direction of a flow of current between the two potentiometers. In other words, the two polarized relays of Fig. 5 perform the same function as the polarized relay 25 of Fig. 3.

As previously mentioned, the control system either of Fig. 3 or Fig. 5 serves to control the actuating means for moving the gun barrels 1 and 2 relative one to the other. For this purpose, the terminals 28, 29 or 28′, 29′ and 33, 34 are connected in circuit with the actuating means.

A typical circuit diagram of actuating means suitable for the purpose is shown in Fig. 6. The actuating means according to this figure are designed to traverse the guns, and it will be evident that a similar actuating means may be used to effect elevational control of the gun barrels.

The azimuth positions of the two guns are independently controlled by a follow-up system of conventional or nonconventional design. As the follow-up systems do not constitute part of the invention, they are merely symbolized by blocks 40, 41, 42 and 43. Blocks 40 and 41 represent the two coacting components of a selsyn system, block 40 being the control or pilot point. Block 43 represents the moving means including a reversible drive means which is controlled from the control point 40 and block 42 represents a control component controlling the signals received by the moving means from the control point 40. While as mentioned, various types of follow-up systems are suitable for the purpose of the invention, a particularly suitable one is described in the co-pending application Ser. No. 293,472 filed June 13, 1952, now Patent No. 2,767,361, October 16, 1956, and assigned to the assignee herein. The guns 1 and 2 are normally under the control of the aforedescribed follow-up systems.

The actuating means according to Fig. 6 further comprise a relay 45 coacting with the follow-up system of gun 1 and a relay 46 coacting with the follow-up system of gun 2. Relay 45 controls switch contacts 47, 48 and 49, 50 included in the circuit connections between blocks 42 and 43, the contact arms of the relay being biased into a position closing contacts 47 and 49. Similar switch contacts are controlled by relay 46. There is further associated with each follow-up system relays 51 and 52 respectively. Relay 51 controls switch contacts 53, 54, 55 and 56, the contact arms of the relay being biased into positions closing 53 and 55. Similar switch contacts are controlled by relay 52. The actuating means finally comprise a source of direct current 57.

The operation of the system as hereinbefore described, is as follows:

Let it be first assumed that the two slidable contacts 13 and 15 are in the same position on the respective resistors 12 and 14. This means that the two contacts indicate the same angular position for the barrels represented by lines 1 and 2 and that, hence, these barrels are parallel one with the other and point into the same direction. As a result of equal positions of the contacts 13 and 15, no current will flow between the two contacts as they tap the same voltage. Let it now be assumed that the angular position of barrel 1 is slightly changed and that as a result contact 13 is moved a little toward the right. Then, there will be a voltage difference between the two contacts. However, no current can flow between the two contacts as yet due to the voltage drop over resistor 19 and also due to the blocking effect of rectifier 22. When, now, the movement of barrel 1 is continued and contact 13 is further moved to the right, current will begin to flow between the two contacts as soon as the voltage difference betwen the two contacts exceeds the voltage drop.

Similarly, if contact 15 had been moved to the right, no current between the two contacts can flow due to the voltage drop over resistor 18 and the blocking effect of rectifier 23 until the voltage difference exceeds the voltage drop over resistor 18.

It is also apparent that when both slidable contacts are moved, the flow of current will begin when the two contacts reach a relative position such that the voltage difference between them exceeds the voltage drop over resistors 18 and 19 respectively.

The resistance values of resistors 18 and 19 are preferably selected so that the voltage drops across the resistors are equal. The flow of current will begin and the relay coil 25 will be energized when the absolute value of the difference between the angular positions of the two barrels exceeds a certain value which is determined

by the voltage drops across the resistors 18 and 19 respectively.

The width of the control zone in Fig. 1 can be varied by varying the voltage drops across the resistors 18 and 19. Generally, the zone is given the relative width as shown in Fig. 1. However, if the elongated members be gun barrels it is preferable to make the zone wider to prevent that a discharge from one gun barrel may strike or come close to the other gun barrel.

Let it be first assumed that the movable potentiometer contacts 13 and 15 are in equal position or that in any event the differential position of the contacts is below the value at which the respective polarized relays will bridge contacts 28, 29 or 28', 29' and 33, 34. This signifies that the relative position of the gun barrels is such that there is no immediate danger of collision between the gun barrels or of damage of one gun barrel by the discharge blast of the other gun barrel. As a result, none of the terminal contacts of the control system is bridged and, as can be easily traced from the circuit diagram of Fig. 6, none of the relays of this diagram is connected in an energizing circuit with the D. C. source 57. Consequently, relay contacts 47 and 49 are closed thereby completing the energizing circuits of the follow-up systems.

Let it now be assumed that the gun crews operating the follow-up systems move the gun barrels into a relative position in which the danger of collision or damage by blast exists. An approach to such dangerous gun barrel positions is detected by a corresponding differential position of potentiometer contacts 13 and 15. As a result, the current flow between the two potentiometers is sufficient to energize relay 25 of Fig. 3 or one of the relays 22' and 23' of Fig. 5. The resulting bridging of terminals 28, 29 or 28', 29' respectively, connects relays 45 and 46 with the D. C. source 57. As a result, relays 45 and 46 open their contacts 47 and 49 and close their contacts 48 and 50 thereby interrupting the energizing circuit of the follow-up systems and connecting the moving means 43 of the follow-up systems in an energizing circuit with D. C. source 57. A tracing of this latter energizing circuit shows that it includes switch contacts of relays 51 and 52. The connection of these relays with D. C. source 57 is controlled through terminals 33 and 34 by the polarized relay 30 the energization of which in turn depends upon the direction of the flow of current between the potentiometers. As is evident from a tracing of the diagram of Fig. 6, both coacting contact pairs 53, 55 and 54, 56 close the aforedescribed energizing circuit of the moving means 43 through the switch contacts of relays 45 and 46 but the direction of the current flow through the moving means depends upon the energization of relays 51 and 52 which in turn, through relay 30, are controlled by the relative position of contacts 13 and 15 and thus of the gun barrels. Hence, de-energization of relay 30 will cause an operation of moving means 43 in one direction and energization of the relay in opposite direction.

Consequently, the control system of Fig. 3 or 5 permits normal and independent control of the guns by the members of the gun crew as long as the guns are not moved into dangerous relative positions and will automatically take over the control of the gun movements when such positions are approached and turn the guns out of the zone of danger. When the two guns are again in safe positions, the control systems of Fig. 3 or 5 will automatically return the control of the gun movements to the follow-up systems.

For the purpose of supervising the movements of the gun barrels or other elongated members in the plane vertically to the drawing, a second control system identical with the one described in connection with Figs. 3 and 5 is provided, the slidable contacts of which are controlled by the vertical turning of the gun barrels. This second system controls a control system corresponding to the one shown in Fig. 6.

While the invention has been described in detail with respect to certain now preferred examples and embodiments of the invention it will be understood by those skilled in the art after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended, therefore, to cover all such changes and modifications in the appended claims.

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

1. An electric safety control system for controlling the relative movements of two elongated members each pivotally mounted for angular movements relative to a reference plane and to each other, the said members being disposed in a spatial relationship in which the two members are capable of approaching each other beyond a predetermined zone of approach, the said control system comprising two electric detecting means each coacting with one of said members and each other for detecting the relative position of said members, electric actuating means operatively connected with said members for movement of the said members relative to each other, and electric control means connected in an energizing circuit with said detecting means and said actuating means, said control means being controlled by the relative position of said members as detected by the detecting means and controlling the actuating means so as to render the actuating means operative for effecting relative movements of said members outside said predetermined zone of approach and preventing such relative movements beyond the said predetermined zone of approach.

2. A control system, wherein said movable members are each mounted for pivotal movements in two different planes, and wherein a control system as defined in claim 1 is provided for controlling the member movements in each plane.

3. A control system as defined in claim 1, wherein each of the said electric detecting means comprises a potentiometer having a resistance means and a movable contact engaging the resistance means, the movable contact of each potentiometer being operatively connected with one one of said members for control of the contact position by the position of the respective member, and wherein said electric control means are connected in circuit with said two movable contacts for control of the control means by the relative position of the said two movable contacts, the said relative position controlling the flow of current between the two potentiometers.

4. A control system as defined in claim 3, wherein said electric control means comprise resistance means and relay means, the coil of the relay means being connected in circuit with the said resistance means and said movable contacts and the relay contacts controlling the actuating means for the purpose aforesaid, said resistance means of the control means controlling the energization of the relay coil, the resistance value of the said resistance means being such that an energizing current for the relay coil flows through the control means in response to the differential position of the movable contacts exceeding a predetermined value, energization of the relay means rendering the actuating means operative for preventing relative movements of the said members beyond the aforesaid predetermined zone of approach.

5. A control system as defined in claim 4, wherein said resistance means of the control means are connected with a source of current, and wherein a pair of rectifiers connected in opposition are included in the circuit connections between the said resistance means and the relay means.

6. A control system as defined in claim 5, wherein the said resistance means of the control means comprise two resistors connected in series, the adjacent terminals of the resistors being connected to one movable contact and

each outer terminal to said source of current and to one terminal of one of the rectifiers, the other terminals of the rectifiers being interconnected and also connected to the other movable contact, one of said resistors controlling the relay means in response to a movement of each member in one direction and the second resistor in response to a movement of each member in opposite direction.

7. A control system as defined in claim 6, wherein the resistance means of the two potentiometers are of equal resistance and the two resistors of the control means are also of equal value.

8. A control system as defined in claim 7, wherein said source of current is a D.-C. source, and wherein said relay means controlling the actuating means comprise a polarized relay.

9. A control system as defined in claim 1, wherein each of the said electric detecting means comprises a potentiometer having a resistance means and a movable contact engaging the resistance means, the movable contact of each potentiometer being operatively connected with one of said members for control of the contact position relative to the respective potentiometer resistance means by the position of the respective member, the said electric control means being connected in an energizing circuit with said two movable contacts for control of the control means by the relative position of the said two movable contacts, the relative position of the two movable contacts controlling a flow of current in either direction between the two potentiometers, and wherein second electric control means are connected with said circuit in parallel with said first control means, the said second control means being controlled by the direction of current flowing between the two movable contacts which flow direction in turn is controlled by the relative position of the said contacts, the said second control means also controlling the actuating means for the purpose aforesaid.

10. A control system as defined in claim 9, wherein said second control means comprise a polarized relay means having a coil and relay contacts controlling the actuating means.

11. An electric safety control system for controlling the relative movements of two elongated members each pivotally mounted for angular movements relative to a common reference plane and to each other, the said members being disposed in a spatial relationship in which the two members are capable of approaching each other beyond a predetermined zone of approach, the said control system comprising two sources of a variable potential, each of said sources being connected with one of said members for control of the respective potential by the angular position of the respective member relative to the said reference plane, control circuit means including two series connected sources of a fixed potential and two uni-directionally conducting electric means series connected in opposition, one of said sources of a variable potential being connected to the connection point between the sources of a fixed potential of the control circuit means and the other of said sources of a variable potential being connected to a connection point between the two uni-directionally conducting electric means, the respective one of the said electric means becoming conductive in response to a flow of potential between the two variable sources of potential and through said control circuit means in one or the other direction, the direction of the said flow being controlled by the relative angular position of the two members, energizing circuit means for effecting relative movements of the two members, and electric control means actuated by the conducting one of the two uni-directionally conducting electric means and controlling the energizing circuit means for moving the two members into a relative position outside the said predetermined zone of approach.

12. An electric safety control system for controlling the relative movements of two elongated members each pivotally mounted for angular movements relative to a common reference plane and to each other, the said members being disposed in a spatial relationship in which the two members are capable of approaching each other beyond a predetermined zone of approach, the said control system comprising two sources of a variable potential, each of said sources being connected with one of said members for control of the respective potential by the angular position of the respective member relative to the said reference plane, control circuit means including two series connected sources of a fixed potential and two uni-directionally conducting electric means series connected in opposition, one of said sources of a variable potential being connected to the connection point between the sources of a fixed potential of the control circuit means and the other of said sources of a variable potential being connected to a connection point between the two uni-directionally conducting electric means, the respective one of the said electric means becoming conductive in response to a flow of potential between the two variable sources of potential and through said control circuit means in one or the other direction, the direction of the said flow being controlled by the relative angular position of the two members, energizing circuit means for effecting relative movements of the two members, and electric control means actuated by the conducting one of the two uni-directionally conducting electric means and controlling the energizing circuit means for moving the two members into a relative position outside the said predetermined zone of approach.

13. A control system as defined in claim 12, wherein the said two sources of a variable potential each comprise potentiometer means connected in circuit with a source of current, the variable contacts of the said potentiometer means being operatively coupled with the said members for movement of the same and electrically connected to the connection point between the two sources of a fixed potential and the two uni-directionally conducting means respectively.

14. A control system as defined in claim 12, wherein the said two sources of a fixed potential comprise two resistance means connected in series with a source of current.

15. A control system as defined in claim 12, wherein the said two uni-directionally conducting electric means comprise two rectifying means connected in series opposition, and wherein the said electric control means comprise polarized relay means, the said relay means including coil means included in the circuit connection between the connection point of the two rectifying means and the respective source of a variable potential and two switch means each connected in circuit with said energizing circuit means, the said coil means causing actuation of one or the other of said switch means for control of the energizing circuit means for the purpose aforesaid when one or the other of the rectifying means becomes conductive.

16. A control system as defined in claim 15, in combination with additional polarized relay means connected between the two sources of a variable potential and responsive to the direction of a flow of potential between the said two sources, the said additional relay means being connected in circuit with said energizing circuit means to control the same for the purpose aforesaid.

17. A control system as defined in claim 12, wherein each of the said unidirectionally conducting electric means comprises a polarized relay means including a coil means and a switch means controlled by the energization of the coil means, the said relay coil means being connected in series with each other and the said two sources of a fixed potential, the said two switch means being con-

nected in circuit with said energizing circuit means for control of the latter for the purpose aforesaid by actuation of either of the switch means as controlled by the direction of flow of a potential through the control circuit means.

18. An electric control system according to claim 1, wherein the said electric actuating means comprise an electric moving system for varying the relative position of said two members, the said moving system including two reversible moving means each coupled with one of said members for movement thereof, two control means, and a first energizing circuit connecting each of said control means with a respective one of said moving means for independently controlling the said moving means and hence the position of the respective member; a second energizing circuit for said moving means, and switch means included in said energizing circuits and controlled by the said control means controlled by the detecting means, the said switch means being biased to close said first circuit means and arranged to close said second circuit means and to open the first circuit means.

19. A control system as defined in claim 18, wherein each of said electric detecting means comprises a potentiometer having a resistance means and a movable contact engaging the resistance means, the movable contact of each potentiometer being operatively connected with one of said members for control of the contact position relative to the respective potentiometer resistance means by the position of the respective member, the said electric

control means being connected in an energizing circuit with said two movable contacts for control of the control means by the relative position of the said two movable contacts, the relative position of the two movable contacts controlling a flow of current in either direction between the two potentiometers, and wherein second electric control means are connected with said energizing circuit in parallel with said first control means, the said second control means being controlled by the direction of current flowing between the two potentiometers, and wherein said second switch means are included in said second energizing circuit, the said second switch means being controlled by the said second control means and controlling, in coaction with the first switch means, said moving means for movement of the respective members in one direction or the other depending upon the direction of the current flowing between the two potentiometers.

20. A control system according to claim 19 and further comprising a source of direct current included in the second energizing circuit means, actuation of the said second switch means effecting a reversal of the current flow through said moving means.

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