

April 1, 1947.

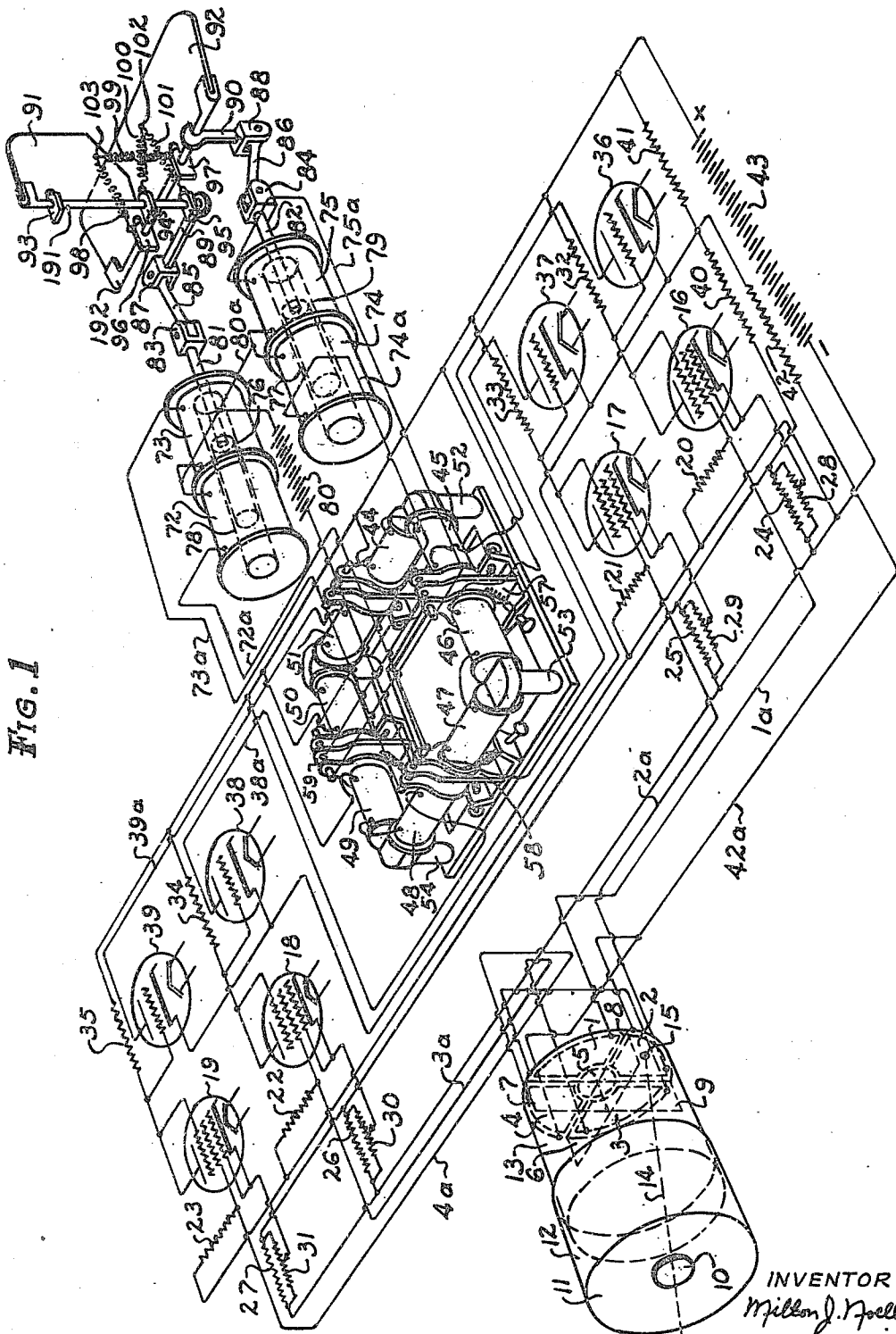
M. J. NOELL

2,418,137

MEANS FOR GUIDING PROJECTILES TOWARD PREDETERMINED DESTINATIONS
AND FOR ASCERTAINING THE POSITIONS OF THE DESTINATIONS

Filed June 3, 1943

4 Sheets-Sheet 1



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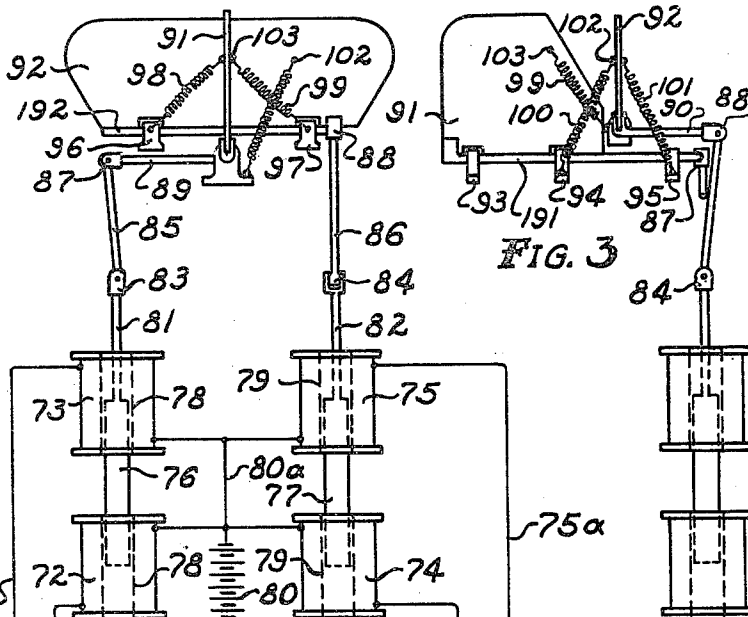
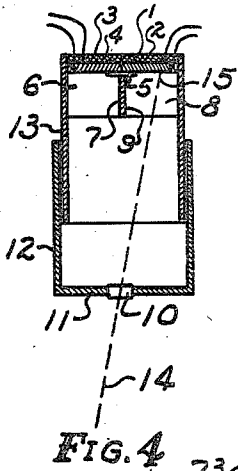
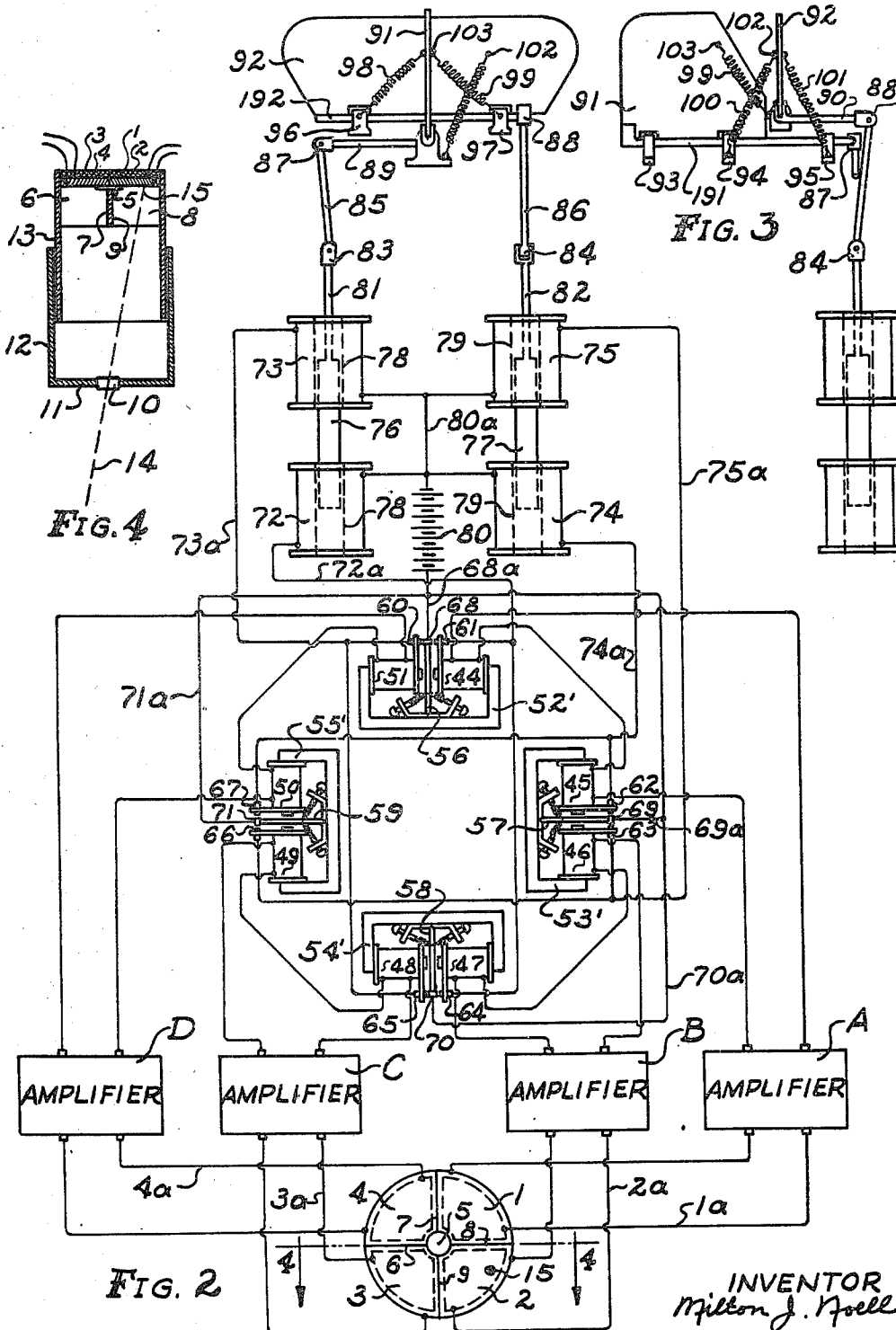
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4 Sheets-Sheet 3

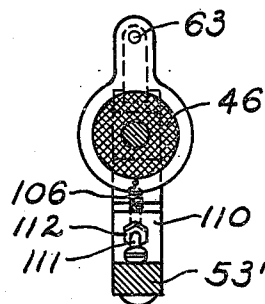
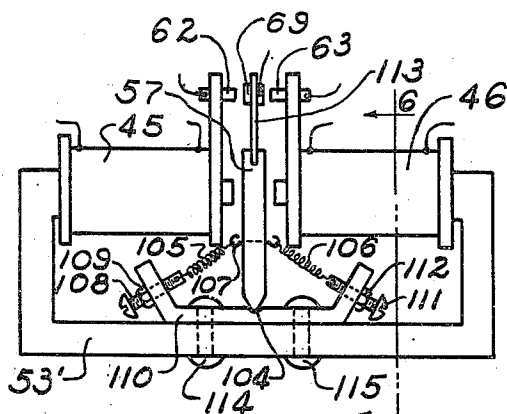


FIG. 5

FIG. 6

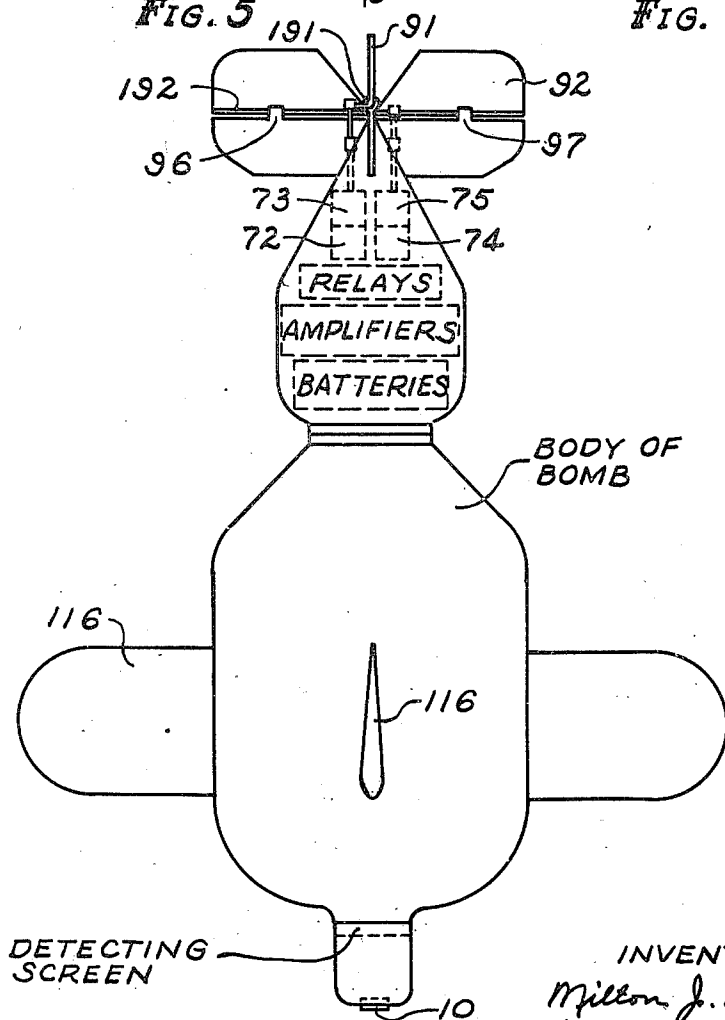


FIG. 7

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4 Sheets-Sheet 4

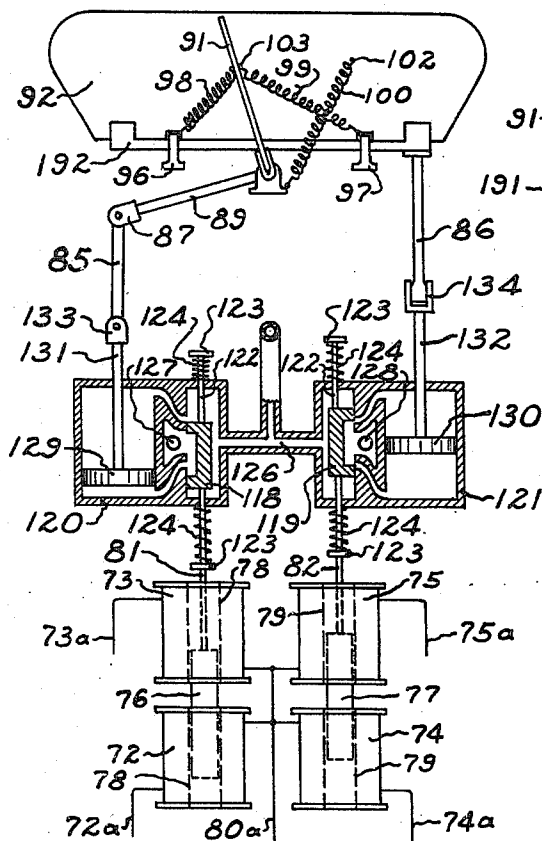


FIG. 8

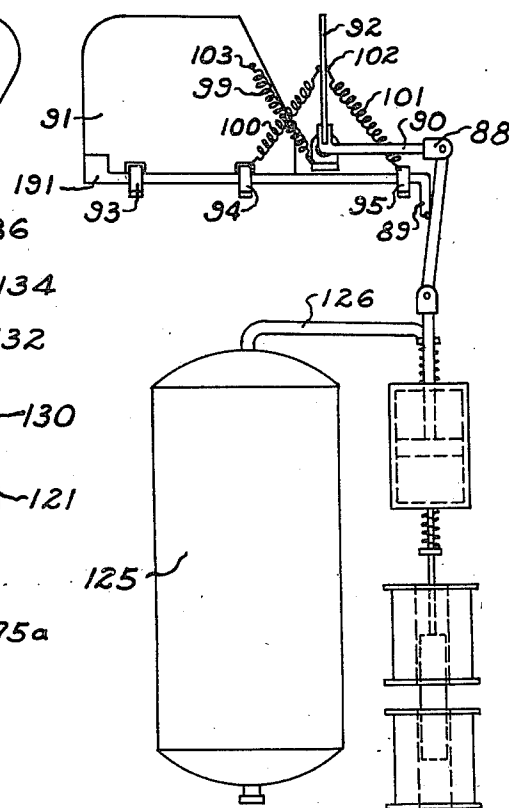


FIG. 9

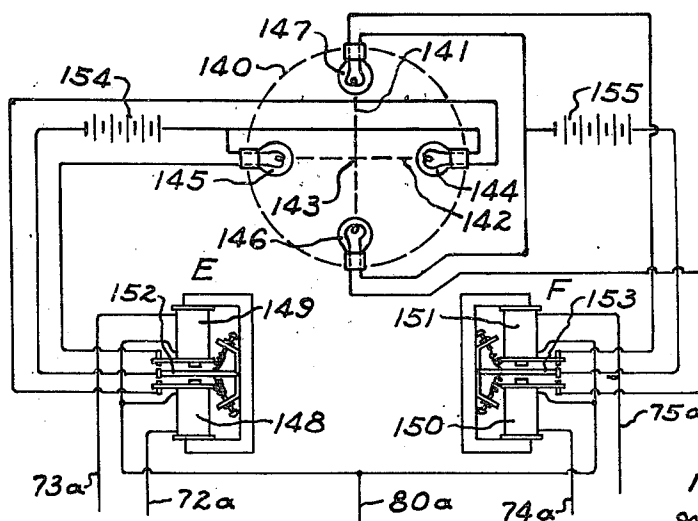


FIG. 10

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MEANS FOR GUIDING PROJECTILES TOWARD PREDETERMINED DESTINATIONS AND FOR ASCERTAINING THE POSITIONS OF THE DESTINATIONS

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Application June 3, 1943, Serial No. 489,504

12 Claims. (Cl. 250—41.5)

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This invention relates to new and useful improvements in means for guiding projectiles toward predetermined destinations and for ascertaining the positions of the destinations.

More particularly, this invention relates to an aerial projectile having a self-contained mechanism with automatic guiding controls which determine its course of travel. In accordance with the present invention, a projectile released on a course of travel toward a chosen target will pursue that course of travel regardless of whether the target is stationary or moving. More specifically, in accordance with the present invention, a projectile released on a course of travel toward a chosen target will strike that target regardless of possible changes in the position of the target during the projectile's period of movement.

At the present time, projectiles are fired at or dropped toward targets only after careful calculations have been made with respect to known influences of force, time, distance, movement, etc. When any one of these elements or influences is miscalculated, then the desired result of striking the target with a certain degree of accuracy is not attained and the effectiveness of the projectile is lost. Accordingly, it has been necessary to resort to planting many projectiles in a pattern bearing the best possible preconceived relation to the target in order to increase the chance that a hit will be made. Frequently, one or more of the influences of force, time, distance, movement, etc. varies beyond the best known methods of precise calculation, thereby causing great inaccuracy in directing the projectile toward the target. On the other hand, great risk of life may be taken by person in too closely approaching the target in order to obtain greater accuracy. My invention relates to greatly increasing this accuracy and at the same time reducing the risk of life attendant upon too closely approaching the target.

Specifically, with reference to a system of automatic controls for guiding a projectile, I propose to use a photo-detecting screen composed of a plurality of photo-electric cells which are sensitive to light, housed within the body of the projectile and upon which the image of a target will be cast. The photo-electric cells of the screen are arranged in such a manner as to permit each cell to convey to a point of central control its individual reaction to any change in light intensity. My invention provides for the control of a projectile by the following steps: (1) receiving an image on a screen of photo-electric cells; (2) amplifying the electrical reaction due to the image from each individual photo-electric cell;

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(3) balancing the group of amplified reactions from the screen as a whole so as to permit the photo-electric cells with predominating electrical reactions to operate magnetically-controlled electric contact points; (4) arranging a system of magnetically-controlled electric contact points in such a manner as to operate a plurality of electrical solenoid coils having a relationship directly affected by each and every photo-electric cell both in order and in magnitude; (5) utilizing the magnetic impulse from the solenoid coils to operate reciprocable plungers; and in turn (6) employing the mechanical reaction or movement of the plungers to control the movement of a set of guiding fins exposed to the slipstream of air. In the foregoing novel arrangement, step (6) may be carried out by using the mechanical reaction or movement of the reciprocable plungers to operate the guiding fins either directly or to manipulate a system of switches, valves, contact points, or other controlling elements which in turn would operate the guiding fins.

When the invention is employed as a detecting instrument, relays are substituted for the solenoid coils of step (4) and the same are electrically connected to a visible indicator, such as a panel divided into quadrants to represent a complete field of vision and having electrical lamps mounted thereon for denoting the location of an object relative to the center of the field of vision.

A construction designed to carry out the invention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, wherein an example of the invention is shown, and wherein:

Figure 1 is a diagrammatic view of the guiding mechanism constructed in accordance with the invention,

Figure 2 is a diagrammatic plan of the guiding mechanism, showing the relationship of the elements in simplified form,

Figure 3 is an elevation of the guiding fins shown in Figure 2,

Figure 4 is a horizontal, cross-sectional view of the detecting element, taken on the line 4—4 of Figure 2,

Figure 5 is an enlarged elevation of one of the sensitive type electric relays having an arrangement designed for balancing an armature between two relay coils,

Figure 6 is a transverse, vertical, sectional view, taken along the line 6—6 of Figure 5,

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Figure 7 is a plan view of the automatic guiding mechanism mounted in an aerial bomb of standard design having fixed gliding fins,

Figure 8 is a plan view, partly in section, of an arrangement designed for using the mechanical motion furnished by the solenoids to operate a system of valves for controlling compressed air or gases to operate the guiding fins,

Figure 9 is an elevation of the control mechanism shown in Figure 8, and

Figure 10 is a plan view of an electrical indicating mechanism adapted to be substituted for the control mechanism shown in Figure 8.

The guiding mechanism as illustrated is described herein as functioning upon the reception of the image of a target as would be visible from a position of altitude upon release of a projectile toward a ship or other object, or as would be visible when a projectile is discharged on a course of travel in an upward direction toward a body in the sky, such as an airplane.

The invention relates broadly to the controlling of position of one body with relation to another or to the controlling of a body with relation to a designated point and is not intended to be limited merely to warfare use only, but to any application wherein it is desired to direct one body into engagement or contact with another.

Stated simply, the principle of operation of my automatic guiding mechanism involves the maintaining of the image of a target or object within a certain area, hereinafter to be referred to as the blind spot. Considering the fact that such an object, for example, a ship on a body of water, would appear from a position of altitude, with relation to the actual object or ship, as a spot of very little reflected light on a uniform background of highly reflected light, or, conversely, so to provide a contrast between the object and its immediate surroundings. Then, by way of example, it is evident that the ship on water, or an airplane in the sky, or a fire at night, would form a contrast in light with relation to its immediate surroundings and that means can be employed for detecting the object which is that contrast in light; said means being known as the art of using photo-electric cells (commonly known as electric eyes). Therefore, it is the object of this invention to incorporate the art of detecting changes in light intensity by means of photo-electric cells with a novel arrangement of these cells employed in such manner as to control other electrical devices and in turn create mechanical energy.

In accordance with the invention, provision for using a plurality of photoelectric cells, preferably four in number, arranged in such order as to form a uni-plane, circular screen of equally divided segments with relation to a central point, with each segment separated from adjacent segments by a very small clearance space, as for instance by thousandths of an inch.

For purposes of illustration, the screen of photo-electric cells is composed of four individual cells 1, 2, 3 and 4, in the shape of generally semi-circular segments or quadrants and spaced equidistantly apart around a centrally-disposed disc 5. The cells have their sensitive surfaces disposed in a common transverse plane and the disc 5 is formed of a thin, non-light sensitive material and is used as a blind spot on the screen, whereby a change in light intensity thereon will cause no electrical reaction. The four cells composing the screen are each separated from the other by guard members or plates 6, 7, 8 and 9,

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these guards being of thin, opaque material designed to keep any source of light from being reflected from one cell to another. The point of intersection of the guard members 6, 7, 8 and 9 is in a plane at a right angle to the plane of the surface comprising the cells 1, 2, 3 and 4.

A port of entry or opening 10 for admitting light to the sensitive surfaces of the cells is axially aligned with the intersection point of the guard members. The part 10 is the only source of light admitted to the cells, since the cells and the guard members are contained within a cylindrical body 13 and said port is formed in the circular end plate 11 of a cylindrical housing 12, the body and housing being adjustable relative to each for adjusting said port relative to the screen.

It is within the concepts of my invention to include the possibility that for certain functions it may be necessary to have more than one screen of cells, and that such multiplicity of screens would also include several possible combinations of lenses, prisms, or mirrors well known to the art of physics in order to form the port 10. The port 10 is shown in Figure 1 as being represented by an opening or orifice in plate 11, but for certain functions it may be necessary for said port to be composed of a lens, a prism, a mirror, or any combination of these optical instruments, either in singular or in a multiplicity of individual pieces, all of said possibilities and combinations being well known to the art.

The line 14 represents a beam or pencil of light of different intensity from all other beams striking the screen after passing through the port 10, the beam being that beam of light which would represent the amount of light reflected from an object having either greater or lesser reflective qualities than its surroundings or the amount of light emanating from a source having greater light generating power than its surroundings. For purposes of illustration, it will be considered hereinafter that the beam 14 represents the amount of light emanating from an object having lesser light reflective qualities or less power as a source of light than the surrounding background, such an object being, for example, a ship or an airplane during the daylight hours.

The photo-electric cells 1, 2, 3 and 4 are shown as being of the conductive type, such cells being well-known to the art as having electrical characteristics similar to a variable resistance. Since the electrical resistance of a conductive-type of cell varies in an inversely proportional relation to the intensity of the light striking the cell, when one of the cells is affected by the beam 14, with all other factors equal with regard to the characteristics of the cells, said cell will be affected by beam 14 in such a way as to have its electrical resistance increased in comparison with the resistance prevailing in the other cells. Although the photo-electric cells have been described as being of the conductive-type, it is well-known that an emissive-type or a voltaic-type of photo-electric cell may be employed for performing the same functions.

Thus far, I have described a novel way of arranging four cells in such order as to form a screen of cells with the lines of separation between the respective cells being so small as to be negligible insofar as the functioning of the screen as a unitary light-sensitive surface is concerned. Assuming all of the cell characteristics of the cells to be similar and equal in value, then it will follow that when the total light intensity focused on one cell is less than the total focused on each

of the other cells, the electrical resistance of said cell will be greater than that for each of the other cells. It is evident that whereas beam 14 has been shown as striking cell 2, it might have been either one of the other cells.

Considering that the object is within the angle of vision formed by the line of centers established by a continuation of the common point of intersection between guard members 6, 7, 8 and 9, said line of centers being aligned with the axis of the port 10, and a line extending through the center of said port to the external peripheral edge of the screen, it is evident that any change in position of the object with relation to said line of centers will be accompanied by a directly related movement of the image of said object as cast on the screen, said image being represented by an image 15 and being conveyed to the screen by the beam of light 14. For example, if the object moves to the diametrically-opposite side of the line of centers, then the image 15 will likewise travel to the diametrically-opposite side of the line of centers, thereby causing a reaction on cell 4. When the object is aligned either on the line of centers or is within the angle of vision established by said line of centers and a line extending through the center of port 10 to the external peripheral edge of the disc 5, then said object will cast its image by way of the beam 14 upon said disc which has been described previously as a blind spot insensitive to changes in light intensity; consequently, there is no resultant electrical reaction and the object is disposed in what is hereinafter referred to as the blind area.

It is well-known that a photo-electric cell has commonly but two electrical connections insofar as external electrical circuits are concerned, hence I have shown each cell having two electrical connections leading to the system used for amplifying the individual reactions that may occur because of a change of light intensity on any one of the cells. It will be shown later that it is necessary to include means for amplifying the electrical reaction from any one or from any possible combination of the cells as individual reactions acting at one and the same time.

The diagram shown in Figure 1 represents one of the many different and well-known electrical circuits for amplifying the electrical reactions from photo-electric cells and includes a plurality of individual amplifiers A, B, C and D operating from a single source of electrical power supply. Each of the amplifiers is arranged in such order relative to the electrical connections 1a, 2a, 3a and 4a of the cells as to establish each amplifier in position for being directly affected by a corresponding cell. Each amplifier is composed of two stages of amplification, the stages being represented in Figure 1 by commonly used designations for radio vacuum tubes and associated accessories which are well known to the trade. The invention is not limited to the use of two stages of amplification for each amplifier, since it is obvious that a greater or lesser number of stages may be required according to the sensitivity desired of the guiding mechanism.

The cells 1, 2, 3 and 4 each have one electrical connection leading in corresponding order to the respective control grids of tubes 16, 17, 18 and 19. The remaining connection from each of the cells is electrically connected by a conductor 42a to a source of electric power supply, such as the battery 43, through a voltage control resistance 42 and by way of a voltage divider which is com-

posed of resistances 40 and 41 in principle to the power supply 43.

Resistances 20, 21, 22 and 23 are arranged in such order as to oppose the electrical voltage drop across resistances established by the cells in like order and with a different electrical sign, thereby resulting in a condition of balanced control over the respective grids of the tubes 16, 17, 18 and 19 until said balance is disturbed by a change in the resistance value of either of the corresponding cells, such a disturbance being occasioned by a change in light intensity focused on said cell. It is well-known that reversing the respective positions of the resistances 20, 21, 22 and 23 relative to the positions of the cells will also reverse the direction in polarity of the control grid of the corresponding tube as affected by resistances from either of said group. Therefore, in order for the device to function on the reception of the image of an object constituting a greater source of light than the surrounding background, only the reversing of position of the said resistances and the said cells as described hereinabove would be necessary. Systems of electrical switches for facilitating such a reversal of electrical polarity as occasioned by demands for flexible operating characteristics are well known and will not be described herein.

Resistances 24, 25, 26 and 27 are each connected in parallel with variable resistances 28, 29, 30 and 31 in like order, such a combination offering one means of obtaining an adjustable control over the electric current flow through the corresponding tubes 16, 17, 18 and 19. Resistances 32, 33, 34 and 35 are affected by the plate current flowing through the corresponding tubes 16, 17, 18 and 19, such current flow causing a potential across the resistances which in turn is used as a means of grid control over tubes 36, 37, 38 and 39.

All of the different electrical power supplies used in the amplification system are shown in Figure 1 as being obtained from one high potential source 43 by means of resistance voltage dividers and resistance voltage drops; however, more than one source of power, such as for example a group of batteries of either the dry type or the wet type could be used to advantage in certain applications. Still another plan is shown in Figure 2 where the different amplifiers are indicated as being entirely independent of each other. The filament voltage required for each of the tubes can be obtained in different ways, such as for example by way of connecting all of the filaments in series or by way of connecting all of the filaments in parallel, either of said combinations then being connected to a power supply. The filaments of all the tubes, shown diagrammatically in Figure 1, are left open according to conventional practice, since it is well known that their principal function is to serve only as a source of heat and that it is naturally assumed that a power supply will be furnished for their benefit.

Thus far I have shown that the individual reactions from the cells 1, 2, 3 and 4 are directly associated with a system for amplifying said reactions and that in turn each amplified reaction is available in electrical form from the plate circuit of the final stage of amplification for each of said cells. I have shown that the plate current from each of the tubes 36, 37, 38 and 39 is, in order of its natural consequence, capable of being the same electrical reaction as that from each of the cells except that said plate current would be obtainable as an amplified reaction, the

amount of amplification being dependent upon the capacity of the amplifier.

In order to make use of the individual reactions as obtained from the plate circuits of the tubes 36, 37, 38 and 39, a novel assembly of sensitive type electrically-operated relay switches is employed, the switches being combined into one common body and bearing a definite relationship to each other. It is evident that the same operating features can be obtained through other arrangements of parts common to individual groups of switches. For example, instead of having coils 46 and 47 supported on a single post 53, which is common to the magnetic circuit of said cells, the same function might be performed with both coils being combined into one coil wound around post 53. For purposes of illustration, I have chosen to have the special assembly of relay switches assume the form as shown in Figure 1 so that it will be obvious that the assembly is composed basically of a plurality of conventional electrically-operated, sensitive-type, magnetically-controlled relay switches, said switches being electrical circuit contact points for both opening and closing the circuit, with certain parts of any one of the relay switches being common to another relay switch.

Armatures 56, 57, 58 and 59 are each common to two different relay magnetic circuits. For example, armature 57 is subject to magnetic pull from either coil 45 or coil 46. Likewise, armature 57 is also subject to magnetic repulsion from either coil 45 or coil 46. Consequently, it is obvious that the movement of the armature is influenced by the coils so as to be drawn to the coil with the stronger attraction irrespective of whether that attraction be due to one coil being strong while the other is comparatively inactive, or due to a partial attraction by one and a partial repelling action by the other, or due to both of said coils offering an attraction at the same time and the differential pull between the two attractions being sufficient to move the armature toward the coil with the stronger attraction of the two. Therefore, it is evident that when both of the coils 45 and 46 are furnishing a magnetic attraction of equal intensity and the armature 57 is in its normal neutral position, such position being half-way between the respective poles of said coils, then said armature will be balanced between two equal and opposed forces thereby constituting a condition of equilibrium or no movement of the armature toward either of said coils.

From the foregoing, it is manifest that armature 58 is subject to magnetic attractions furnished by the coils 47 and 48; armature 59 is subject to magnetic attractions furnished by the coils 49 and 50; and armature 56 is subject to magnetic attractions furnished by the coils 44 and 51.

As previously mentioned, the embodiment of conventional, plain-type relays into one assembly as shown in Figure 1 is not essential to my invention, since certain operational, design, or space limitations may make it more desirable to divide the system of relays into individual groups. It is evident that whereas posts 52, 53, 54 and 55 have each been shown as common to two different magnetic circuits and are all mounted on a common base 117, certain advantages may be gained by substituting therefor unitary U-shaped frames 52', 53', 54' and 55', and entirely separating the magnetic circuit established by the coil 46 from the magnetic circuit established by the coil 47 by using one arm of the frame available for each of

the two said magnetic circuits. It is intended that such a division of the relays into groups would constitute the forming of four different bodies of relays, with two relay coils in each of said bodies and with one armature acting between said coils in each body. In Figures 2, 5 and 6 I have shown one design for such a body of relays, the body being composed of two magnetic circuits with one armature being common to both circuits.

Referring back to Figure 1, the coils 44 and 45 are connected in series and are in turn electrically connected in the plate circuit 36a of the tube 36, thereby establishing said coils in such position as to be directly affected by the electrical current flowing through the plate circuit. As previously mentioned, the current flowing in the plate circuit 36a varies according to the total light intensity focused on cell 1; therefore, it is readily apparent that the electric current flowing through the coils 44 and 45 will also vary according to the total light intensity focused on said cell. It is well known that the magnetic attraction offered by the core of the coil in an electric relay is affected by the amount of electric current flowing through said coil, therefore, it follows that the separate magnetic forces attracting the armatures 56 and 57 toward the coils 44 and 45 are both affected by the total amount of light or any variation in the intensity of the light focused on cell 1.

By way of using the above description of the coils 44 and 45 and their behavior with relation to the plate circuit 36a as an example, it can be said that the coils 46 and 47 are connected in series and are connected in the plate circuit 37a of the tube 37, coils 48 and 49 are connected in series and are connected in the plate circuit 38a of the tube 38, that coils 50 and 51 are connected in series and are connected in the plate circuit 39a of the tube 39, and that each pair of said coils is affected in the same manner and creates a magnetic attraction toward the armatures corresponding to the coils in the same manner as that previously described for said coils 44 and 45 when the latter are connected in the plate circuit 36a.

The armature 57 is subject to magnetic attraction from the coil 45 which in turn is controlled by the cell 1. Also, the armature is subject to magnetic attraction from the coil 46 which in turn is controlled by the cell 2; therefore, it is manifest that said armature is subject to one magnetic attraction which is variable according to the total light intensity focused on said cell 1 and to another magnetic attraction which is variable according to the total light intensity focused on said cell 2. Thus, it is obvious that the armature 58 is also subject to two different magnetic attractions, one being furnished by the coil 47 which in turn is controlled by the cell 2 and the other being furnished by the coil 48 which in turn is controlled by the cell 3. Likewise, it can be said that the armature 59 is located between two magnetic attractions, one being controlled by the cell 3 and the other by the cell 4; and that the armature 56 is also located between two magnetic attractions, one being controlled by the cell 4 and the other by the cell 1.

As previously mentioned, the normal position of any of the armatures 56, 57, 58 and 59 is a neutral one, such position being half-way between the pole or core faces of the two coils which are located one on each side of said armature. A method is required for recalling each of the armatures to its respective neutral position when

there is no magnetic attraction from either side sufficient to offer a retaining force greater than the tendency to return to neutral. In Figures 5 and 6 I have shown one means for providing such a system of forces as would be necessary to recall any one of the armatures to its respective neutral position after it has been displaced from said neutral position by a magnetic force pulling said armature to one side or the other.

The armature 57 is pivotally mounted on fulcrum point 104 of an angular bracket 110 while held in a neutral position between the relay coils 45 and 46 by means of a pair of coiled or helical springs 105 and 106, which are connected to opposite sides of said armature by a pin 107 extending through the armature.

The anchor end of spring 105 is secured to the end of a machine screw 108 which is slidably mounted within an opening formed in the angular bracket 110. A nut 109 is screw-threaded upon the screw 108 and engages the undersurface of the bracket 110, whereby the tension of the spring 105 may be adjusted by rotation of the nut. Likewise, the anchor end of spring 106 is connected to the end of a similar machine screw 111 and is loaded or unloaded by rotating a nut 112 on the screw-threads of the screw which slidably engages within a similar opening in the bracket 110, the nut 112 bearing against the lower face of said bracket for holding spring in adjusted positions. The bracket is fastened to the U-shaped frame by suitable rivets 114 and 115. Since the tension or load on either spring 105 or 106 can be adjusted, it is obvious that the armature 57 is in a position of having its relative location with respect to the pole faces of the relay coils 45 and 46 subject to change by loading or unloading either one of said springs.

It has been shown that the armatures 56, 57, 58 and 59 are each maintained in a neutral position by predetermined means and that each armature will remain in said state of neutrality until it is attracted by a magnetic force emanating from either of the electric relay coils which are located on two opposite sides of said armature. Since any one of the armatures will return to its respective neutral position when released by the magnetic force attracting it from said neutral position, then it is readily apparent that a system of electric contact points may be arranged relative to said armatures in order to make and break electrical circuits by movement of the armatures. An upright arm 113 is carried by the armature 57 and is formed at its upper end with a pair of opposed contact points 69, for making an electrical contact with either of two stationary contact points 62 and 63 which are mounted on the inner end plates of the coils 45 and 46, respectively, on either side of the armature in its plane of travel. The contact points 69 are electrically-insulated from the armature and are free to move with the said armature by means of a flexible connection to the electrical circuit 69a, such connection being well known to the art. One of the contact points 69 will engage the fixed contact point 63 when the armature is drawn toward the coil 46, while the other contact point engages the fixed contact point 62 when said armature is drawn toward the coil 45. The contact points 62 and 63 are fixed to the frame of the relay in one of the many different ways which are well known to the trade. Likewise, corresponding relay contact points 60 and 61, 64 and 65, 66 and 67 are secured to the relay frames 52', 54' and 55', respectively, while switch points 68, 75

70 and 71 are carried by the armatures 56, 58 and 59, respectively, and are electrically insulated therefrom.

It is now evident that regardless of the movement of any one of the armatures, whether such movement be to one side or the other as a result of the magnetic attraction furnished by the opposing relay coils on either side of the respective armatures, an electrical circuit will be completed by the movement of each of said armatures and irrespective of whether the armatures move one at a time or whether two or more move at the same time.

Electrical solenoid coils 72, 73, 74 and 75 are provided and are divided into two pairs, solenoid coils 72 and 73 being one pair and solenoid coils 74 and 75 a second pair. Each pair is wound upon a cylinder, common to both coils, and is either in one piece or is composed of several pieces which are mounted in axial alignment adjacent to each other.

One embodiment of the solenoid coils 72, 73, 74 and 75 which has been found desirable consists of the solenoid coils 72 and 73 being wound around a cylinder 78 while the solenoid coils 74 and 75 are wound around a cylinder 79. Each solenoid coil is wound as an individual coil independent of the others. A plunger 76 is reciprocally mounted within the cylinder 78 and a similar plunger 77 is similarly mounted within the cylinder 79, both of the plungers being affected by the magnetic fields set up within their corresponding courses of travel. The lengths of the plungers 76 and 77 are established in accordance with well-known principles which involve the sizes and lengths of the solenoid coils when two coils are axially aligned and are in close proximity to each other. The plungers are each arranged to operate as one plunger; that is, subject to the magnetic forces set up in its corresponding cylinder by either or by both of the solenoid coils wound therearound. Each plunger will return to a neutral position, such position being located midway of the course of travel of said plunger as well as midway between the solenoid coils which are wound around its respective cylinder. The return to neutral position is a necessary part of the cycle of operation of each plunger when said plunger is drawn to either end of its stroke or course of travel as a result of the magnetic field established by one of the solenoid coils.

As is clearly shown in Figures 1 to 3, each plunger may be returned to its respective position by resilient means, such as a system of springs. The plunger 76 is connected to a rod 81 which in turn is fastened to a link 85 by a clevis or flexible joint 83. A second clevis or flexible joint 87 attaches the link 85 to a radius arm 89 which is normally disposed at substantially a right angle to said link and the rod 81. A rudder guiding fin 91 has its upright operating rod or shaft 191 secured to the free end of the arm 89, whereby the position of the rudder will be controlled by the movement of the plunger 76. An elevator guiding fin 92 has connection with the plunger 77 through a horizontal elevator rod or shaft 192, radius arm 90, clevis 88, link 86, clevis 84 and rod 82, whereby the movement of the elevator is controlled by said plunger. The rudder shaft 191 is journaled or otherwise supported in the sockets of brackets or hinges 93, 94 and 95 which are secured to the body of the projectile, while the elevator shaft 192 is journaled in the sockets of similar brackets or hinges 96 and 97 also mounted on said projectile.

The axis of the rudder shaft is substantially at a right angle to the axis of the elevator shaft in the usual manner and the brackets 96 and 97 are spaced equidistantly from said rudder shaft. Coiled or helical springs 98 and 99, with identical dimensional and performance characteristics, connect the brackets to the outer or rearward portion of the rudder 91 on opposite sides thereof as shown by the numeral 103, whereby said rudder will be normally maintained in an intermediate or neutral position. In order to have the plunger 76 located in a corresponding neutral position at the same time that the rudder is in a neutral position and in order to provide the most desirable mechanical arrangement and movement of the associated elements with relation to each other, the radius arm 89 is preferably disposed perpendicular or at a right angle to the plane of said rudder and the relative lengths of the rod 81 and link 85 are so chosen as to position said link at a right angle to said radius arm when said plunger is in its neutral position.

Likewise, the brackets 94 and 95 are spaced equidistantly from the elevator shaft 192 and helical or coiled springs 100 and 101, with identical dimensional and performance characteristics, are secured between said brackets and the outer portion of the elevator 92 on opposite sides thereof as shown by the numeral 102. Thus, the elevator is normally held in an intermediate or neutral position. Also, in order to have the plunger 77 located in a corresponding neutral position at the same time that the elevator is in a neutral position and in order to provide the most desirable mechanical movement of the associated elements relative to each other, the radius arm 90 is preferably perpendicular to the plane of said elevator and the relative lengths of rod 82 and link 86 are so chosen as to position said link at a right angle to said radius arm at the same time that said plunger is in its neutral position.

The principles involved in the operation of solenoids, such as those composed of coils 72, 73, 74 and 75 and plungers 76 and 77, as well as the mechanical movement of said plungers when connected to a system of guiding fins, such as those composed of the rudder 91 and elevator 92, are well known and it can be shown that a planned system of controlling the operation of these solenoids will provide a positive means for the controlling of direction of a body, such as an aerial projectile.

As is clearly shown in Figure 2, the floating contact points 68, 69, 70 and 71 are all connected by electrical conduits 68a, 69a, 70a and 71a to the same terminal of a source of electrical current, such as the battery 80. The opposite terminal of the battery 80 is connected to one end of each of the solenoid coils 72, 73, 74 and 75 by a lead wire 80a. The remaining unattached ends of the solenoid coils are each connected to two different fixed contact points by way of electrical conductors 72a, 73a, 74a and 75a in such a manner as to have one end of each solenoid connected to a corresponding pair of contact points, the conductor 72a leading from the solenoid 72 to contact points 61 and 64, solenoid 73 being connected to contact points 60 and 65 by the conductor 73a, solenoid 74 to contact points 62 and 67 by the conductor 74a, and contact points 63 and 66 being connected to solenoid 75 by the conductor 75a. As previously mentioned, not any one of the electrical circuits made possible by the

connection of the contact points to the solenoid coils through battery 80 will function until a magnetic field is established by any one or several of the various relay coils in such magnitude as to attract the armature or armatures bearing the floating contact points which must contact corresponding fixed contact points before electrical circuits can be completed.

It has been previously shown that the photoelectric cell 1 controls the relay coils 44 and 45 and that as a natural consequence, when the magnetic attractions emanating from said coils are sufficient either due to their influence as individual coils or by reason of a differential magnetic attraction being in their favor as opposed to that emanating from the coils 46 and 51, then the armatures 56 and 57 will be drawn toward the combination of coils 44 and 45. As a result, the floating contact point 68 engages the fixed contact point 61 and the floating contact point 69 engages the fixed contact point 62. By reason of these contact points, it is evident that two electrical circuits will have been completed and that electric current being free to flow from the battery 80 will follow a course through the solenoid coils 72 and 74, thereby establishing a corresponding magnetic field for each of said coils, which in turn draws the plunger 76 from a neutral position to its extreme end of travel in a forward direction toward the coil 72, and draws the plunger 77 from a neutral position to its extreme end of travel in a forward direction toward the coil 74. It has also been previously shown that when the reaction from cell 1 affects the relay coils 44 and 45 in such manner as to cause them to release the armatures 56 and 57, then the electrical contacts as established by the contact points will be broken and the plungers 76 and 77 will return to their corresponding neutral positions by reason of forces previously described.

From a viewpoint as established by looking from the end composed of the assembly including the rudder 91 and elevator 92 toward the end composed of the housings 12 and 13, it will be evident that when the plunger 76 is drawn toward the coil 72, then said rudder will be turned toward the right and that when the plunger 77 is drawn toward the coil 74, then said elevator will be swung downwardly. Assuming the rudder and the elevator to perform the same function as the well-known function of the empennage or tail group of an airplane, then it follows that when said rudder is turned to the right in a slipstream of air, the tail end of say an aerial torpedo will be forced to the left. When the elevator 92 is turned down, then the tail will be forced up.

Likewise, it can be shown that since the cell 2 controls the relay coils 46 and 47 in such manner as to make possible the closing of electric circuits by means of attracting the armatures 57 and 58 in such direction as to establish electrical contacts between the floating contact point 69 and the fixed contact point 63 and between the floating contact point 70 and the fixed contact point 64, then the electric current flowing through the solenoid coil 75 will establish a magnetic field which in turn will draw the plunger 77 in such direction as to force the elevator 92 up and the electric current flowing through the solenoid coil 72 will establish a magnetic field which in turn will draw the plunger 76 in such direction as to force the rudder 91 to the right. By the same reasoning, as evidenced by the previous description of the relations existing between the cell 1 and the guiding fins 91 and 92,

it is obvious that the cell 3 controls the relay coils 48 and 49 in such manner as to make possible the closing of electrical circuits which in turn will draw the plunger 76 toward the solenoid coil 73 and force the rudder to the left and will draw the plunger 77 toward the solenoid coil 75 and force the elevator up. Also, the cell 4 controls the relay coils 50 and 51 in such manner as to make possible the closing of electrical circuits which in turn will draw the plunger 76 toward the solenoid coil 73 and force the rudder to the left while the plunger 77 is drawn toward the solenoid coil 74 and in turn forces the elevator down.

A summary of the movements available at the guiding fins 91 and 92 as a result of reactions from the cells 1, 2, 3 and 4 when said cells are considered as acting one at a time due to an image 15 being cast upon each of the cells in corresponding order will show that when said image is cast upon said cell 1, the rudder turns to the right and the elevator turns down; when the image is cast upon said cell 2, the rudder turns to the right and the elevator turns up; when said image is cast upon said cell 3, the rudder turns to the left and the elevator turns up; when the image is cast upon said cell 4, said rudder turns to the left and said elevator turns down. As a result, it can be seen that regardless of the position of the object which casts its image by the beam 14 upon the screen, composed of the cells 1, 2, 3 and 4, there will be a resulting reaction from whichever one of said cells said image falls upon and said reaction will control the movement of the rudder and elevator in such manner as to cause the body of the projectile to be oriented with relation to said object and image until the image is cast upon the blind area or spot 5. When the body of the projectile is finally turned in such direction toward a target as to cause the image to be cast on the blind area, then the reactionary forces tending to change the direction of travel of said body will be diminished to such an extent as to return to neutral and the body will continue on such course of travel as established until the object again shifts enough relative to the direction of travel of said body to move outside of said blind area and as a result cause the image to be cast again upon one of the cells 1, 2, 3 and 4.

The process of controlling the guiding fins 91 and 92 by reactionary forces as established due to an image 15 being cast upon one of the cells until said image 15 shifted onto the blind area with a following period of all controls being in neutral, and then a recurrence of the same procedure the instant the image moves off said blind area, will continue until the projectile is so close to the object as to form an image cast upon the screen which is larger than the blind area. When this point has been reached by the projectile on its course of travel toward a target, then the unique features of design incorporated into the assembly of the relay coils and armatures with relation to each other are used to advantage with the result being a means of effective control over the guiding fins to within a very short time before actual contact occurs between the projectile and the target.

As previously mentioned, the electrical current flowing through each pair of relay coils is directly proportional to the total intensity of the light being focused on the corresponding photo-electric cell from the group being composed of the cells 1, 2, 3 and 4, and any change in said total

intensity of light being focused on said cell will affect the amount of current flowing through said pair of relay coils in like manner and in a degree of proportionality. It is well known that a sensitive type of electric relay requires only a very small electrical current, for instance between one-half and two milliamperes, flowing through the relay coil in order to attract the armature toward the core of the coil and thereby close or open an electric circuit, whichever the case may be. The relay coils 44, 45, 46, 47, 48, 49, 50 and 51 are of the sensitive type as described above and are also capable of carrying much greater amounts of electrical current, as for instance between fifteen and twenty milliamperes.

When the variable resistances 28, 29, 30 and 31 have been so adjusted as to maintain the maximum amount of current flowing through the various relay coils at a level slightly below that required to attract the corresponding armatures to a closed switch position when there is no image being cast upon the screen of cells, then an increase in the amount of current flowing through any pair of said relay coils, which will be barely enough to attract the armatures corresponding to the coils to a closed switch position, will occur when an object is first located within the operating range of my guiding device and its image is cast as a whole on the cells 1, 2, 3 or 4, whichever corresponds to the pair of coils. As the distance between the object and the screen of cells is decreased, the size of the image is increased and, as a result, the amount of current flowing through any pair of relay coils, corresponding to whichever cell in the screen may be affected by the image, is increased in amount by a certain degree corresponding to the resultant amount of change in the electrical resistance of the corresponding photoelectric cell. As the object distance is decreased, the flow of electric current in the pairs of relay coils will continue to increase until the maximum is reached, the said maximum being attained at such position of the object with relation to the screen of cells as to completely cover the screen of cells with the image 15.

As previously mentioned, the magnetic field emanating from any one of the relay coils is directly proportional to the amount of electric current flowing through the coil. The magnetic field as established by a typical coil when an object first comes within the operating range of the guiding device will be due to the smallest electric current flowing through the coil, which in turn will attract its corresponding armature to a closed switch position. Any amount of current greater than the above described current, which is barely enough to operate the relay, will establish a magnetic field which is excessive so far as the operational characteristics of an individual coil and the armature corresponding to said coil are concerned. It has been previously shown that each armature in my special assembly of relays is responsible to not one relay coil but to two relay coils and that the magnetic field as established by either of said coils is the only force capable of attracting the armature from a neutral position toward whichever one of the coils that happens to be acting. As an object moves closer to the screen of cells and soon covers more than one cell with its image, the amount of current flowing, and in turn the magnetic field as established by each of the corresponding relay coils, will be greater than the magnetic attraction actually necessary to move the correspond-

ing armatures; however, there will be a condition existing whereby the magnetic fields emanating from two coils will be opposed to each other and will at the same time be trying to attract the one armature which is common to said coils.

When the image 15 is equally divided between two adjoining cells, then the magnetic fields as established by the relay coils corresponding to the cells will be equal and the armature which is common to said cells will be located midway between two magnetic fields of equal intensity; therefore, there will be no movement of said armature. However, the other two armatures which are subject to the magnetic fields as established by the relay coils corresponding to the same cells will be attracted to a closed switch position and as a result will both close the same electrical circuit, since said cells, as mentioned, are adjoining cells, such as would be the case when the image might be equally divided between cells 1 and 2, 2 and 3, 3 and 4, or 4 and 1. For example, if the image 15 is equally divided between the cells 1 and 2, then the magnetic fields emanating from the coils 45 and 46 will be of equal intensity and the armature 57 will be attracted by forces of equal strength from opposite sides. Therefore, it will remain in a position of static balance or neutrality, while, at the same time, the coils 44 and 47 will be attracting in like order the armatures 56 and 58 without opposition from opposing magnetic fields and as a result said coil 44 will establish contact between the contact points 68 and 61 and said coil 47 will establish contact between the points 70 and 64. After either one of the two above contacts is established, the same function is performed as in the case where both of said contacts are completed, because the line of separation between the cells 1 and 2, which passes through the center of the image 15, is also a line passing through the center of the disc 5, and, therefore, fulfills one of the conditions necessary in order to establish the center of said image and the center of said disc as being one and the same center. The only condition that remains to be fulfilled is that the image should be shifted with relation to the cells 3 and 4 until another center line, such as the line of separation between the cells 2 and 3, will also pass through said image in such manner as to cause the part of the image which is focused on cell 1 to be equally divided between the cells 1 and 4, and the part of said image which is focused on the cell 2 to be equally divided between the cells 2 and 3. The establishment of contact between the points 61 and 68 is the fulfillment of an effort on the part of the coil 44 to shift the image toward the cell 4 and, likewise, the establishment of contact between the points 64 and 70 is the fulfillment of an effort on the part of the coil 47 to shift said image 15 toward the cell 3. However, to shift the image toward either cell 3 or cell 4 would entail the same movement of the rudder 91. Since the movement of said rudder toward one side requires the completion of only one electrical circuit, then the establishment of contact between the points 61 and 68 and the points 64 and 70 is a duplication of purpose in this particular case. By the same line of reasoning, it can be said that when an image is equally divided between the cells 2 and 3, 3 and 4, or 4 and 1, it will be automatically shifted in such manner as to maintain its relative position with relation to the line of separation between said pair of cells and will be shifted

in such direction as to make the line of separation between the half of the screen composed of the pair of cells and the half composed of the remaining cells be also a line of center at a right angle to the original line of division between the two equally divided parts of the image and dividing said image into four equal parts with each of the cells 1, 2, 3 and 4 bearing one of the said parts.

When an image 15 is larger than the blind spot 5 and is shifted with relation to the center of said blind spot in such manner as to establish the image in a position of being equally divided between the cells 1, 2, 3 and 4, then the current flowing through all of the relay coils will be equal and, as a result, all of the magnetic fields as established by these various relay coils will be equal. Even though the magnetic field as established by any one of the said relay coils as an individual might be intense enough to attract its corresponding armature to a closed switch position, there will be no case where an armature is not exposed to two magnetic fields of equal intensity and on opposite sides. Consequently, the various armatures not already in a neutral position will return to their corresponding neutral position due to lack of retaining forces and, as a result, the electrical circuits controlling the operation of the guiding fins 91 and 92 will be broken and the guiding fins will also return to their corresponding neutral positions.

When the image is focused on the screen of cells in such a position as to be mostly on one cell with a portion, for instance one-third, focused on an adjoining cell, then the resultant action of the guiding fins 91 and 92 will be the same as that previously described for a condition where the whole of said image is on one cell. As an example, assuming that two-thirds of the image is focused on the cell 1 and the remaining one-third on the cell 4, then the magnetic fields established by the coils 44 and 45 will be greater than the magnetic fields established by the coils 50 and 51 by an amount proportional to the part of said image focused on said cell 1 as compared to the remaining part of the image focused on said cell 4. In the case of either cell 1 or cell 4, the magnetic fields as established by the corresponding coils would be intense enough to attract their corresponding armatures to a closed switch position, and in the case of the armatures 57 and 59, they would be attracted to a closed switch position since they have only one choice. But, since armature 56 is common to both of the coils 44 and 51, then armature 56 will be attracted by the coil having established the greater magnetic field and the differential between the two opposed forces emanating from coils 44 and 51, when great enough, will attract the armature 56 to a closed switch position. When the differential force attracting the armature 56 is great enough to attract said armature to a closed switch position, then the coil 44 would predominate and the rudder 91 would be turned in such direction as to orientate the projectile with relation to the target until the image 15 would be equally divided between the cells 1 and 4 so far as those cells in particular are concerned. As previously explained, when such a condition occurs as is established by the armature 57 being drawn toward the coil 45 and the armature 59 being drawn toward the coil 50 at the same time, the function performed by the switch closing of either armature is a duplication of function on the part of the other since said coils

are both responsible to adjoining cells. Any time the image is focused on two adjoining cells and the opposite half of the screen is not bearing any part of said image, then the resultant forces acting to shift the image toward the half of the screen bearing no part thereof will be responsible to the half of the screen bearing all of the image and these forces will be parallel in action. The closing of the switches as performed by the armatures 57 and 59 will both turn the elevator 92 in such direction as to orientate the projectile with relation to the target until the image 15 is equally divided between that half of the screen being composed of the cells 1 and 4 and that half of the screen bearing no part of said image. The final result would be that the image would be equally divided between all of the cells and the magnetic fields as established by all of the various coils would be equalized with a consequent return to a neutral position by each of the armatures. The projectile would then continue on such a course of travel as established with relation to the target until a change in position of either the projectile or the target with relation to said course of travel might cause a shifting of the image on the screen composed of cells 1, 2, 3 and 4. At this time, the process of relocating the center of the image 15 with relation to the center of the blind spot 5 would be repeated.

A system of gliding fins 116 as shown in Figure 7 is fixed to the body of the bomb or projectile in order to increase the angle of glide that may be obtainable, thereby increasing the range of effective target area subject to the action of the projectile.

One other provision considered in the design of my novel system of relays allows for such a condition as would exist when an image 15 might be divided between two cells located on opposite sides of the screen, as for instance between cells 1 and 3 or 4 and 2. Assume, for example, that the image is of such long narrow shape as the image of a ship at sea and that said image is divided between cells 1 and 3. To be in such a position, it is evident that the image has to be already located in a desirable position so far as the center of the image with relation to the center of the disc 5 is concerned and that there will likely be no need for a change in the course of travel of the projectile with relation to the target until the image has shifted so far toward being altogether on one or the other of the two cells as to cause the cell not bearing a sizeable portion of the said image to be so little affected as to not attract any of its corresponding relays to a closed switch position. When the image 15 has shifted so far toward being all on one cell as to cause only one cell to operate its corresponding relays, then the ensuing operation of the guiding mechanism is according to principles previously described.

When the image is divided between the cells 1 and 3, as previously stated, and is divided in such proportions as to cause both of said cells to attract their corresponding relays to closed switch positions, then the armatures 56 and 57 will be attracted in corresponding order toward the coils 44 and 45 and in turn electrical circuits will be completed which will cause the solenoid coils 72 and 74 to each establish a magnetic field. Likewise, the armatures 58 and 59 will be attracted in corresponding order toward the coils 48 and 49 and in turn electrical circuits will be completed which will cause the solenoid coils 73 and 75 to each establish a magnetic field. It is now evident

that all four of the solenoid coils 72, 73, 74 and 75 have each been caused to establish their various corresponding magnetic fields and that where the plungers 76 and 77 might each have been attracted from their corresponding neutral positions by a corresponding force from one end or the other, instead, they are each being attracted by two equal forces as from opposite ends and opposed to each other; consequently, said plungers 76 and 77 will each remain in a neutral position of static balance or neutrality and there will be no movement of the guiding fins 91 and 92. Such a condition as described will continue to exist until the image 15 shifts altogether toward one cell or until said image shifts so as to be focused on two adjoining cells, all of which conditions have been previously described.

Since it has been shown that the armatures 56, 57, 58 and 59 are each responsible to two different relay coils and that by reason of their location with respect to these coils, they are each balanced between two forces being opposed to each other and of such variable nature as to be able to establish an attraction force great enough to actuate the armature either by the force emanating from either one of said coils as an individual or by the differential force as applied in favor of the stronger of the two coils when both are acting, then another feature which has been considered in the design of my special system of relays can be shown to be an advantage in such a way as to cause the operation of the guiding device to be much more sensitive to changes in the position of the image 15. As previously mentioned, and as shown in Figure 1, the resistances 20, 21, 22 and 23 each serve to balance in corresponding order the cells 1, 2, 3 and 4 by establishing such voltage potential as that being required in sign and value to oppose the potential being established by each of said cells. So far as the source of power or battery 43 is concerned, the resistance 20 is in series with the cell 1, resistance 21 is in series with cell 2, resistance 22 is in series with cell 3, and resistance 23 is in series with cell 4 and the four combinations are all connected in parallel to said source of power. For purposes of illustration, consider the total resistance of each of the combinations to be the same in all cases. Since it has been previously mentioned that the individual resistance values of all the cells are considered as being equal, then it follows that the individual resistance values of all the resistances 20, 21, 22 and 23 are equal and the magnetic field emanating from each of the relay coils corresponding to the various said cells can be considered as being equal. As previously mentioned, when the resistance value of one of the cells is increased by reason of having a shadow in the form of an image focused thereon, then the magnetic fields emanating from the relay coils corresponding to said cell are increased. The reason for the increase in the magnetic fields is due to the increase in voltage drop across the cell which in turn changes the potential of the voltage being applied to the control grid of the corresponding tube 16, 17, 18 or 19, whichever it may be. Now, since an increase in the voltage drop across one of the cells will cause an increase in the magnetic fields established by the relay coils corresponding to said cell, then it can also be said that a decrease in the voltage drop across the cell will cause a decrease in said corresponding magnetic fields.

It has been shown that as the projectile more

closely approaches a target, the size of the image 15 increases to such a point as will make necessary a condition whereby said image is focused on more than one cell and in turn is establishing a condition whereby certain armatures corresponding to affected relay coils will be subject to magnetic forces from two opposite sides. In a majority of cases, the size of the differential force being established by two opposed magnetic fields will be a determining factor; consequently, any increase that can be gained in the value of the differential force being established as attracting an armature without a corresponding change in the image 15 will be tending to increase the sensitivity of the guiding device. Since the combinations of resistances previously mentioned as being selected from the cells and the resistances 20, 21, 22 and 23 are connected in parallel to the power supply or battery 43, it is a well known fact that the individual voltage drops across all four of said combinations will be equal so long as the resistance values of the combinations are equal. It is also well known that when the resistance value of any one of the combinations of resistances might be changed, there will be not only a change in the electric current flowing through said combination but there will also be a change in the amount of electric current flowing through each of the three remaining combinations of resistances because of the relation existing between the group of parallel resistance combinations and the system of resistances serving as a voltage divider for the power supply 43. Since the proportionality existing between divisions of a voltage divider is affected by a change in the resistance value of any one of the divisions and since the previously mentioned combinations of resistances being in parallel are so closely related to one division of the voltage divider system shown in Figure 1 as to be considered a part of said voltage divider system, then any change in the resistance value of one or more than one of said combinations of resistances will cause a corresponding change in the potential voltage as applied to the group of combinations of resistances. The voltage drop across any one of the cells 1, 2, 3 or 4 is less than the voltage drop across the corresponding resistance 20, 21, 22 or 23 being opposed to said cell as a balancing force, by an amount equal to the bias voltage being applied at the control grid of the corresponding tube 16, 17, 18 or 19. Since the difference between the voltages described above is due to the difference between their corresponding resistance bodies and since there is a fixed ratio existing between the voltage drops to be obtained across two such established resistance bodies regardless of the voltage being applied, then any increase in the voltage being applied to said pair of resistance bodies will create two new values for the corresponding voltage drops. The new values will bear the same fixed ratio with regard to each other and will each be of increased amount in such order as to make the voltage differential between the two new voltage drops greater as a result of an increase in applied voltage.

As previously mentioned, for purposes of illustration it has been considered that the image 15 represents an object having less power as a source of light than the background surrounding the object. For example, assume the image to be focused on the cell 2 as shown in Figure 1 and it follows that the resistance of said cell will increase and in turn the voltage drop across the

cell will increase while at the same time the voltage drop across the corresponding fixed resistance 21, which serves in combination with said cell as a balancing force, will be decreased. The resultant differential voltage being applied at the control grid of the tube 17 will be a more positive bias voltage and, as a result, the armatures 57 and 58 will be attracted toward the coils 46 and 47. At the same time that the total resistance of the combination of resistances consisting of the cell 2 and resistance 21 is increased, there is an increase in the voltage being applied to the four combinations of resistances, previously mentioned as being connected in parallel and being so closely related to the voltage divider for the power supply 43 as to be considered a part of the same. This increase in voltage as applied to the combination of resistances being composed of the cell 2 and resistance 21 will not influence the differential voltage of the above combination so much as it will influence the three remaining combinations of resistances because of the more nearly equal ratio being established between the two aforesaid resistance values as a result of the increase in resistance value of said cell. The only change in the conditions under which the three remaining combinations are operating is an increase in applied voltage and, as previously stated, since the ratio between the voltage drops to be obtained across a combination of two resistances in series will remain constant regardless of any change in value of applied voltage, then it follows that since the balancing resistances 20, 22 and 23 are each greater in resistance value than the corresponding cells 1, 3 and 4, there will be an increase in the differential voltage as established in each case between the combinations of resistances being composed of said cell 1 and resistance 20, cell 3 and resistance 22, and finally cell 4 and resistance 23. Since the balancing resistances 20, 22 and 23 are the larger in each case and since these resistances each establish a negative potential at the control grid of their corresponding tubes 16, 18 and 19, then the increase in the differential voltage being established by each combination of resistances is in such direction as to tend toward reducing the magnetic forces attracting the armatures corresponding to the relay coils being controlled by the cells 1, 3 and 4. It is evident that where the differential force between two opposed magnetic fields is a controlling force, then to decrease the smaller of the prevailing forces will exert as great an influence toward increasing said differential force as will be obtained by increasing the greater of the two magnetic forces. When such an advantage can be gained as a natural part of the functioning of my invention for a guiding device, then a definite degree of sensitivity has been added to the normal power of an amplifying system.

As previously mentioned, it is within the concepts of my invention to consider the feasibility of applying the mechanical motion being furnished by solenoid plungers to a system for releasing other forces such as compressed air or high pressure gases. One such system of control is shown in Figures 8 and 9 where the solenoid coils 72, 73, 74 and 75 are considered as being the same solenoid coils shown in Figures 1 and 2 and where only that part of the guiding device which would be different from that previously described is shown as being interposed between the solenoids and the guiding fins.

The plungers 76 and 77 are each directly con-

nected in like order to the ends of sliding valve bodies 113 and 119 by means of connecting rods 81 and 82. Tail rods 122 are connected to the opposite ends of the valve bodies and besides serving as an additional means of support for the valve bodies, they each bear a retainer shoulder 123. The retainer shoulders 123 are considered as being a part of the various rods 81, 82, and 122, their purpose being to serve as a means for limiting the expansion of springs 124. All four springs 124 are so chosen and all retainer shoulders 123 are so located as to serve as a means for returning the valve bodies 113 and 119 to their respective neutral positions when there is no force due to magnetic attraction which is great enough to draw either or both of the plungers 76 and 77 to their various extremes in course of travel. The length of the connecting rods 81 and 82 are so chosen as to locate the plungers 76 and 77 in their respective neutral positions at the same time that valve bodies 113 and 119 are centrally located.

Either of the valve bodies is in a neutral or central location when the valve is in such position as to allow the escape of gases being trapped on either side or from both sides of the corresponding piston at one and the same time. The cylinder on the right hand side in Figure 8 is shown as being in a neutral position where gases trapped on either side of piston 130 are free to flow through passages leading to the chest containing a port opening 128. This port is open to the atmosphere or to any suitably designed chamber which maintains a lower pressure than that prevailing against the piston 130 while work is being done. The cylinder on the left hand side in Figure 8 is shown in a position of having pressure bear on one side of piston 129 while said pressure is exerted due to flow of gases from the tank or reservoir 125 through conduit 126 to the valve chamber containing body 118. Due to the valve body 118 being drawn toward one extremity of its course of travel by plunger 76, the high pressure gases filling the valve chamber are free to flow through an open port and as a result are allowed to enter the cylinder containing piston 129. Such entry of high pressure gases from tank 125 will bear upon the piston 129 and will cause the rudder 91 to be changed in position due to connection with the piston through piston rod 131, clevis 133, link 85, clevis 87, and radius arm 89. The length of the link 85 is so chosen as to establish the radius arm 89 in a position of being substantially at right angles to rudder 91 when said rudder is in its neutral position, as previously described, and when piston 129 is centrally located along its course of travel in cylinder 120. Such a condition as described where high pressure air or gas is allowed to bear on piston 129 will continue to exist until plunger 76 is released by the magnetic force emanating from coil 72 and is allowed to return to a neutral position. The valve body 113 will then close the port allowing entry of working fluid to cylinder 120 and will be located in such position as to allow the trapped fluid to escape through exhaust port 127; thereby, allowing piston 129 to be returned to a neutral position by reason of forces being connected with the rudder 91 which have been previously described.

Likewise, it can be said that piston 130 will control the operation of elevator 92 by means of the connection being furnished by piston rod 132, clevis 134, link 86, clevis 88, and arm 90. The length of link 86 is so chosen as to establish arm 90 at substantially a right angle to elevator 92

at the same time that the elevator and the piston 130 are in their respective neutral positions. Since the arrangement in Figures 8 and 9 will provide the same interrelated movement with regard to the direction of travel of the plungers and the guiding fins as that previously described for Figures 1 and 2, then the resulting behavior of the guiding device would be the same as that previously described for the condition where the plungers are considered as being directly connected to the guiding fins. It is evident that the arrangement shown in Figures 8 and 9 is one means which can be employed for increasing the power of the controlling forces required to operate the guiding fins of my guiding device and that for certain installations such a system would be very desirable.

Another feature which has been considered in the design of my invention is to plan for its use as a detector and locating instrument. One plan for such a device is shown in Figure 10 where the electrical connections 73a, 72a, 89a, 74a, and 75a are considered as being the same electrical connections shown in Figures 1 and 2 by those designations. The description of the device beginning at the detector screen of photo-electric cells and proceeding through the system of amplifiers, the system of relays and up to the system of solenoids, is the same as that shown in Figures 1 and 2 and functions in the same manner as that previously described. It is obvious that where a system of solenoids and guiding fins are considered as being necessary parts of an automatic guiding device, these said parts can be replaced by a system of relays and a locating panel as shown in Figure 10 with the result that a very effective means can be had for locating and fixing the position of the same object or target as that having been previously described for the aerial projectile.

A locating panel or sighting shield being contained within suitable limitations as to size and shape such as suggested by mark 140 is divided into quadrants by lines of division as indicated by marks 141 and 142. The lines 141 and 142 are substantially at right angles to each other and cross at such point on a locating panel as to form a convenient reference point or center point 143, this point being available as part of a system for sighting or aligning two bodies or merely as an indicated point on a panel which is neutral with relation to an object which may be termed as being to the right, to the left, above, below or on center. For purposes of illustration, it will be hereinafter considered that the means for detecting and locating an object is according to demands for locating the object with relation to a line of centers such as would be the case if my invention were being used for sighting a gun. It is immediately evident that the line of centers being associated with the detecting element and being previously described as that line of centers which passes through the center of port 10 and through the center of disc 5 is the only line of centers which will be truly in line with an object regardless of object distance, at the same time that the locating panel might indicate perfect alignment. A well known example of the same condition is illustrated by the fact that fixed sights on a rifle will not be in perfect alignment with a distant point at the same time the centerline of the rifle barrel is in perfect alignment with the same point except for one particular object distance.

Considering the case where a detecting element of photo-electric cells and associated parts

would be used in close proximity with relation to the locating screen as described above, then an observer would naturally face in such direction as to be facing the target or object of detection and would be observing the reference point 143 on the panel from such an angle as to have his line of sight be an imaginary line passing through the center of the reference point at the same time that he would be viewing the object. Also, the locating panel would be turned to such position as to have line 142 be parallel to the plane being established by guards 6 and 8 in the detecting element. It is at this point during the location of an object that the unique features of design embodied in my invention are most desirable because the location of an object that may be considered as being invisible to the human eye is immediately located with reference to the point 143 and is indicated by an appropriate signal such as for example by an arrangement of electric lights as shown in Figure 10. The lights 144 and 145 are controlled by relay E while lights 146 and 147 are controlled by relay F. These relays are of the same type and description as shown in Figures 5 and 6 and function in the same manner as previously described.

The solenoid coils 72 and 73 are replaced by the relay coils 148 and 149 but the function of the coils is the same since in either case the primary function of the coils is to serve as a means for converting electrical energy into mechanical energy. In the case of the solenoid coils, the plunger 76 is attracted toward whichever one of the coils that happens to be acting, while in the case of the relay coils, the armature 152 is attracted toward whichever one of the coils that happens to be acting. From a viewpoint taken at the tail end of the guiding mechanism while looking toward the detector element, it is apparent that when the plunger 76 is attracted toward coil 72, the detector element of photo-electric cells has been affected by an object in such manner as to indicate that the object is to the right hand side of the course of travel being pursued by the projectile and that the rudder 91 should be turned to the right in order to change the said course of travel in such manner as to be directed toward the right hand side. From the same said viewpoint as taken above except that one is considered to be observing the locating panel at the same time that he is facing toward the detector element from the back end, it is apparent that the same action on the part of the detector element as described above, when the object is off to the right hand side, will attract the armature 152 toward coil 148 and as a result will close an electrical circuit involving battery 154 which in turn will cause electric light 144 to be lighted. Since light 144 is located on the right hand side of reference point 143 and is also located on the dividing line 142 then it is immediately apparent that a system has been provided which will indicate that the object of detection is to the right hand side of the line of centers being established by the detecting element.

According to the same line of reasoning as previously described for the guiding mechanism, it is understood that when an image is cast upon the screen of the detecting element, there are several possible combinations of lights which might be turned on to indicate the position of an object with relation to a reference point 143. It is apparent that where relay coils 150 and 151 will function in the same manner as that previ-

ously described for the operation of solenoid coils 74 and 75, then armature 153 will be attracted toward one or the other of the coils in such a manner as to close electrical circuits involving battery 155 and will turn on light 146 when the object is located below the line of centers as established by the detector element or will turn on light 147 when the object is above the same said line of centers. For instance, if both lights 144 and 146 are turned on, then it is immediately apparent that the object is located to the right hand side and at the same time is below the reference point. If the detecting element were then redirected in such a line as to cause say only the light 144 to be turned on, then it would be apparent that the aim so far as elevation is concerned is on center but that the target is still to the right hand side. When the object is known to be within the operating field of the detector element and all lights are out, then it is known that the above said line of centers is pointed directly in line with the target and that such course of direction as established will lead directly toward the target or will furnish a means of alignment for other equipment which may be directed toward the target. It is apparent that where marks 144, 145, 146 and 147 have been indicated as being electric lights, they might as easily have been electric motors or controls for operating power machinery to perform still another duty other than those suggested.

It will be apparent that I have provided an improved arrangement for directing or locating a body in direction toward or with relation to another body. As an important feature in solving the problem of eliminating the chance for human error while releasing a projectile toward a given target with the intent of striking the target with the projectile, I have devised an improved means for making the path of travel as established by a projectile while traveling toward said target be controlled by an automatically operated mechanism which is housed within the body of said projectile and is affected by no exterior influences except an image of the target as received by the detecting instrument of the controlling device which guides the projectile toward the given target.

My invention has the distinct advantage that as shown in Figure 7, the guiding device may be installed in combination with a projectile of an explosive type. When the projectile is released to travel in direction toward a chosen target, it may be released at such great altitude or at such great distance with relation to the target as to make the target invisible to the human eye because of fog, clouds, smoke, distance or darkness. After the projectile might fall or pass through these obstructions to visibility, the image of the target being located within the operational angle of vision of the guiding device would be received within the body of the projectile and said projectile would be caused to change its course of travel in such direction and by such amount as would be necessary in order to assure there being a collision between the projectile and the target. In the case of darkness at night, my invention is particularly susceptible to functioning on such a target as would exist as a generator of heat waves or such a target as would be capable of generating color in the ultra violet or infra-red range which is not visible to the human eye.

While I have illustrated and described one specific form and function which my invention may assume, it will be understood that the invention is

not restricted to the particular constructions and arrangements shown, but may be variously modified within the contemplation of the invention and under the scope of the following claims.

What I claim and desire to secure by Letters Patent is:

1. In a system for detecting the location of an object including, light-sensitive means for receiving the image of an object, a peripherally arranged combination of electrical magnetic relays having oppositely disposed relay coils connected with the light-sensitive means so as to actuate a plurality of neutrally located relay armatures in accordance with the position of the image thereupon, and actuating means having differentially controlled electrical connection with said magnetic relays so as to be operated by the magnetic variations thereof in accordance with the movement of said image relative to said light-sensitive means.

2. A system as set forth in claim 1 together with means for balancing the magnetic variations induced in the relay means by the electrical reactions of the light-sensitive means so as to permit the predominate reactions to actuate at least two pairs of oppositely disposed electrical induction coils, having electrical connection with the relay means, in such manner as to either actuate circuits closing means or maintain a condition of magnetic balance in said circuits closing means whereby the center of the image will be automatically held in the center of the light sensitive means by an electrically controlled mechanism.

3. In a detecting system for ascertaining the location of an object including, means responsive to light contrast for receiving the image of an object, the means being divided into sections, each section being independent of the other sections and reacting electrically to said image independently of said other sections, a closed chain system of individually controlled magnetic relays, each relay having electrical connection with at least two adjacent sections of the light-responsive means so as to receive and be actuated by either the independent electrical reactions thereof, or the resultant reaction thereof, and actuating means containing induction coils having electrical connection with and operated by the magnetic variations of the relay chain in accordance with the movement of the image relative to said sections so as to assure flexible operational control from the instant the object is first detected until said image of the object completely covers all light responsive sections.

4. A detecting system as set forth in claim 3 wherein the light-responsive means has a substantial part of its total area included in a central portion non-responsive to light contrast and its sections disposed around the central portion whereby the actuating means is inoperative when the object is aligned with said central portion and no image is cast upon said sections, each section being shielded from its adjacent sections to prevent the reflection of the image from one section to another.

5. In a detecting system for ascertaining the location of an object including, means responsive to light contrast having a central non-responsive portion and surrounding light-sensitive sections adapted to receive and electrically react to the image of an object, each section being independent of the other sections and having individual reactions, a plurality of magnetic relays arranged in a closed chain paralleling said sections and having electrical connections with corresponding

sections, each relay receiving the electrical reactions of at least two adjacent sections so as to be actuated by the differential magnetic force created by same when applied as opposed forces, and actuating means containing oppositely disposed pairs of induction coils having electrical connection with said relays and operated by the magnetic variations thereof in accordance with the reactions of said sections so as to assure continuous uniplane control of a system of indicators regardless of image distribution on said light responsive means.

6. In a system for actuating a mechanism in accordance with the position of an object including, means for receiving the image of an object and having a plurality of responsive sections adapted to react electrically to said image, each section being independent of the other sections and having individual reactions, a closed system of magnetically opposed electric relays corresponding in number to said sections and arranged so that each relay having electrical connection with at least two adjacent sections will either be actuated by a differential force favoring the stronger section or will return to a neutral position due to the magnetic forces being balanced, and actuating means containing induction coils electrically connected to the relays so as to actuate the mechanism in accordance with the magnetic variations induced in said relays by balancing a plurality of opposed inductive forces having fixed relation to the reactions of said sections.

7. A system as set forth in claim 6 wherein the relays are balanced so as to cause one or more individual induction coils or pairs of axially aligned induction coils in the actuating means to be electrically charged by the section or sections having predominate electrical reactions.

8. In a system for actuating a mechanism in accordance with the position of an object including, means for receiving the image of an object and having responsive sections adapted to react electrically to said image, each section being independent of the other sections and having individual reactions, a closed chain system of opposed type magnetic relays corresponding in number to the light responsive sections with each relay being electrically connected to two adjacent sections so as to be actuated by either section or by the section having predominate action or so as to remain neutral when the sections have equal reactions, and at least two pairs of axially aligned electrical solenoids serving as actuating means with each solenoid coil being electrically connected to two of the relays so as to be operated by or balanced with the magnetic variations of either of the same, and a source of electrical energy.

9. In a system for actuating a mechanism in accordance with the position of an object including, means for receiving the image of an object and having responsive sections adapted to react electrically to said image, a system whereby each section is electrically connected to a common source of electrical energy with the combined circuit resistances of the said sections being a voltage divider tending to amplify the individual reactions in those cases where the resistance of a light responsive section is increased and tending to decrease the individual reaction of a section where at the same time the corresponding resistance of a light responsive section is either unchanged or is decreased, an electrical magnetic control means containing an endless chain arrangement of relay coils with one double acting

relay armature mounted between each combination of adjacent coils and with each relay coil having electrical connection with a corresponding light responsive section so as to be actuated by the reactions thereof, electrical actuating means having connection with the system of control relays so as to actuate the mechanism in accordance with the reactions of said sections due to arrangement of said control relays whereby two or more diametrically opposed sets of relays are electrically connected to each set of induction coils in the actuating means and will magnetically attract or balance control features of the actuating means which will in turn close a circuit or circuits to the actuating means and operate same in accordance with the predominate reactions of said sections.

10. A detecting system as set forth in claim 3 together with means for balancing the magnetic impulses set up in the relay means by the reception of the independent electrical reactions from the sections of the light-responsive means whereby said relay means will operate the actuating means in accordance with the distribution of said image on the light responsive means so as to maintain the center of gravity of the image pattern in the center of the light responsive means regardless of variation in the size of the image.

11. A detecting system as set forth in claim 3 wherein each electrical induction coil in the actuating means is connected to more than one relay means, each relay means having electrical

connection with different adjacent light-responsive sections so as to receive individual magnetic variations, whereby each said coil in the actuating means is operated in accordance with the movement of the image relative to the several adjacent sections with which the operating relay means of said actuating means have connection.

12. A system for actuating a mechanism as set forth in claim 9 wherein each induction coil of the actuating means is common to two circuits closing means which are each in turn common to two different control means whereby said coil of actuating means will be operated by the predominate reaction of a plurality of sections.

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