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PATENT SPECIFICATION

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Specification Accepted: June 14, 1940.

COMPLETE SPECIFICATION

Leader Gear Equipment, particularly for the Blind Landing of Aircraft

I, EDWARD NELSON DINGLEY, Jr., of 1300, North Glebe Road, Arlington, Virginia, United States of America, a citizen of the United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to leader gear equipment, particularly for the blind landing of aircraft.

My invention relates chiefly to circuit arrangements in which the relative magnitude of two electromagnetic fields produced on or near the surface of the earth is indicated visually at a point in space occupied by an aircraft.

One of the objects of my invention is to provide a blind landing system by means of which a predetermined glide path is fixed in space regardless of the variations of ground conductivity normally encountered.

Another object of my invention is to provide a means for establishing and maintaining under all conditions a glide path in space having any desired curvature or configuration.

Still another object of my invention is to provide equipment suitable for installation on the ground and other equipment suitable for installation in aircraft which will at all times make possible the determination, by the pilot of the craft, the exact position of the craft relative to the predetermined glide path.

It has been proposed to give the pilot of a vessel or aircraft an indication of the distance that the moving vessel or aircraft is from a guiding cable by varying the intensity of the magnetic field around it. Again, it has been proposed, in a system for enabling a movable object to follow a route electrically to use a conducting cable from which branch cables are led off perpendicularly at predetermined distances and also to use parallel cables which are connected with one source of current and are connected with each other by transverse or branch cables.

According to the invention, leader gear, particularly for the blind landing of aircraft, comprises electric circuit means including at least one conducting member extending towards an objective point to be reached by a travelling body, means for producing, around said circuit means, a fluctuating magnetic field or fluctuating magnetic fields which diminishes or diminish in strength progressively up to said objective point and, on said travelling body, means responsive to current or currents induced by said magnetic field or fields, so that said travelling body can travel towards said objective point by following the locus of points of equal field strength.

The invention is represented by way of example by the accompanying drawings in which:—

Fig. 1 shows one embodiment of the ground equipment of my invention;

Fig. 2 is a section taken through A—A of Fig. 1;

Fig. 3 is a side elevation of Fig. 2;

Fig. 4 is a plan view of one embodiment of the aircraft collector system of my invention;

Fig. 5 is an end elevation of Fig. 4;

Fig. 6 shows schematically one embodiment of the amplifying and indicating aircraft equipment of my invention;

Fig. 7 shows a conventional type of instrument that may be used to indicate the phase relations of the currents from the coils;

Figs. 8 and 9 depict, respectively, the use of a vertical and a horizontal coil, and a single vertical coil instead of the two coils at angles of 45° to the horizontal;

Fig. 10 illustrates the use of a single grounded cable instead of two interconnected cables as in Figs. 1, 2, 8 and 9;

Figs. 11, 12 and 13 show different coil arrangements that may be used in conjunction with the single cable of Fig. 10;

Fig. 14 shows in diagrammatic side elevation one method of mounting the coils on an aircraft;

Fig. 15 is a cross-sectional elevation taken on the line 15—15 of Fig. 14;

Fig. 16 illustrates an alternative method of producing the magnetic field; and

Fig. 17 illustrates an alternative method of producing the magnetic field.

Figure 1 represents one embodiment of my invention wherein the horizontal cables 1 and 2 are laid on, under, or above the surface of the earth on each side of and equally spaced from a landing runway 24. The cables 1 and 2 are interconnected at intervals throughout their their length by the cables 6 in series with each of which there are inserted the resistors 7. Point 10 represents the point at which a landing aircraft should make contact with the earth. The alternating current source 3 is connected by means of the cables 4 and 5 to the ends of the cables 1 and 2 which are the most remote from point 10.

Fig. 2 represents a section taken through A—A of Fig. 1. The aircraft carrying loops 28 and 29 is represented as being at the height h above the runway 24 and the cables 1 and 2 are represented as being spaced from the runway by the distance d. It is desirable but not mandatory that the distance h and the corresponding distance d at any point of the runway should be equal.

Fig. 3 shows a side elevation of Fig. 2 taken through the runway 24. A section B—B of Fig. 3 is represented by Fig. 2.

In the preferred mode of operation of my invention, the voltage of the alternating source 3 is adjusted to produce a current flow through cables 1 and 2 at Section A—A of sufficient value to produce an alternating field having the value F at a radial distance X from the cables 1 and 2; the value F being such that the maximum potential induced in a loop collector mounted in the aircraft will be considerably in excess of the potentials induced in the same loop by locally generated fields surrounding the aircraft, and the distance X being the hypotenuse of the triangle d—h—x of Fig. 2 where h is the desired height of the aircraft at the start of the glide path.

In order to establish the desired glide path 9, the shunting cables 6 are located at such points and the resistors 7 are adjusted to such values that the current flowing through the cables 1 and 2 diminishes as a linear or any other desired function of the distance along the cables from the start of the glide path. In this manner the radial distance X from the cables 1 and 2 to the point of field strength F is caused to diminish as a linear or any other desired function of the distance along the cables from the start of the glide path.

Having thus established in space a glide path represented by the locus of the points of equal field strength F, it is only necessary to provide in the aircraft 8, means to indicate the position of the aircraft relative to this locus in order to make possible the guidance of the aircraft along the predetermined glide path, such means being next described.

Fig. 4 is a plan view and Fig. 5 is an end elevation of two loop type collectors having terminals 11—12 and 13—14 respectively. The said two loops are mounted coaxially in space quadrature within the fuselage of the aircraft and are oriented so that the plane of each loop lies at an angle of 45 degrees to the earth when the aircraft is in normal flight. Under these conditions when the aircraft is flying along and centered on the established glide path, one or each of the said loop collectors will lie in a plane producing a maximum of induced voltage from one of the ground cables 1 and 2 and a minimum of induced voltage from the other of said cables.

Fig. 6 is a diagrammatic representation of two amplifiers 15 and 16 of conventional design which include substantially linear detectors of conventional design and which are capable of delivering at their output terminals 18—19 and 20—21 direct currents which are substantially proportional in amplitude to the amplitudes of the voltages applied to their respective input terminals 11—12 and 13—14. The instrument 17 of conventional design contains two d'Arsonval current indicating instruments of conventional design mounted in such a manner that their respective pointers 22 and 23 intersect or cross, as shown, at the approximate center of the instrument whenever each pointer is indicating approximately half scale deflection. One d'Arsonval instrument is connected to the output terminals 18—19 of amplifier 15 and the other said instrument is connected to the output terminals 20—21 of the other amplifier 16 as shown.

In the preferred mode of operation of my invention the input terminals 11—12 of amplifier 15 and the input terminals 13—14 of amplifier 16 are connected directly to the identically numbered output terminals of the loop type collectors shown in Figs. 4 and 5 and the gain or amplification of each of the said amplifiers is adjusted so that a field of strength F cutting each of said loops causes each of said pointers 22 and 23 to deflect half its total scale distance. Under these conditions the said two pointers will cross at the designated centre of the instrument 17 and thus indicate that each of said loops is being cut by a field of strength F or, conversely, that the aircraft is situated exactly on the desired glide path. It follows from the foregoing description that should the aircraft deviate to a point directly above or below the glide path, the fields cutting the said loops will decrease or increase respectively by like amounts and the pointers 22 and 23 will cross at a point respectively above or below the designated center of the instrument 17 and thus indicate the position of the aircraft relative to the glide path. In the same manner should the aircraft deviate to the right or left of the glide path, the field cutting one of the said loops will increase while the other will decrease thus causing the said pointers to cross at a point to the right or left of the designated center of the said instrument.

A conventional source, such as a vacuum tube oscillator, of a calibrated alternating potential of the same frequency as that supplied to the cables 1 and 2 by the ground station source 3 is preferably used on the aircraft. By means of conventional switches this said aircraft source will be connected to the input terminals of the amplifiers 15 and 16 in place of the loops of Fig. 5 whenever it is desired to calibrate the apparatus of Fig. 6. Calibration of the loops of Fig. 5 will be accomplished at the time of their installation by conventional means.

Conventional types of bias circuits are preferably used in connection with the d'Arsonval instruments contained in instrument 17. Such circuits will permit the use of more sensitive instruments and will therefore provide a more sensitive off-course indication.

A cathode ray tube may be used to serve the same purpose as the indicating instrument 17. The connection of the deflection plates of the cathode ray tube to output terminals of the amplifiers 15 and 16, the various means for biasing the cathode ray beam to cause it to be centered within the tube for normal DC output of each of said amplifiers and the means whereby the detectors could be omitted from each of the said amplifiers and the AC outputs of the amplifiers used to deflect the beam of the cathode ray tube are entirely conventional and will be obvious to anyone skilled in the art.

The output terminals 18—19 and 20—21 of amplifiers 15 and 16 may be connected to the control circuits of any conventional type of automatic pilot or gyropilot in order that the control of the flight of the aircraft along the glide path may be entirely automatic. The means for accomplishing this interconnection will be obvious to anyone skilled in the art.

Conventional means for indicating the phase relationship between the voltages induced in the two loops as mounted in the aircraft are also preferably used. This phase indicating means may be utilized to indicate whether the aircraft lies within or without the zone bounded by the two vertical projections of cables 1 and 2. One such phase indicating means of conventional design consists of a relay, the armature 32 (Fig. 7) of which is actuated by the moving coil 33 of a dynamometer-type electrical indicating instrument. In the preferred mode of operation, the moving coil 33 of the dynamometer instrument is energized by a portion of the amplified alternating current obtainable from amplifier 15, and the field coil 34 is energized by a portion of the amplified alternating current obtainable from amplifier 16. Under these conditions, the armature 32 of the dynamometer instrument will contact one of its relay springs 35 whenever the alternating outputs of the amplifiers 15 and 16 have a given phase relationship, or conversely, whenever the outputs of the loops of Fig. 5 have a given phase relationship, and will contact the other of its relay springs 36 whenever the alternating outputs of the amplifiers 15 and 16 or of the loops of Fig. 5 have the opposite phase relation. The relay armature and its springs may be used to close the circuit of a pilot light to indicate whenever the aircraft is inside the aforesaid zone or may be used to render inoperative the instrument 17 whenever the aircraft is outside of the aforesaid zone.

The interconnecting cables 6 (Fig. 1) may be omitted and the conducting earth substituted therefor.

A single amplifier 15 provided with means for switching its input leads alternately from one loop to the other while simultaneously switching its output leads alternately from one element to another of the indicating instrument 17 will simplify and cheapen the apparatus in addition to reducing the weight, which is desirable in aircraft.

My invention is also applicable to the guidance of surface vessels along narrow channels under which circumstances the cables 1 and 2 will be mounted one on each side of and equally spaced from the desired channel and the two loops will be mounted, with their planes vertical, one on each extremity of the bridge of the vessel.

Figs. 8 and 9 show other arrangements of coils 28 and 29 that, while not so desirable as the apparatus above described, may be used to practice the present invention. In Fig. 8 the coils are disposed with coils 28 lying vertically and coil 29 lying horizontally and hence when the loops are in the positions shown in the figure there will be output current from loop 29 but none from loop 28. However, when the loops are moved laterally from the position shown there will be a change in the output of loop 29 and furthermore there will also be output from loop 28 having a direction of flow that will depend upon the direction of the lateral movement. In Fig. 9 there will be no current induced in the single loop 31 when in the symmetrical position shown, but lateral deviation from that position will result in the flow of current in loop 31 in a sense that will indicate the position of the loop with respect to the glide path.

Fig. 10 shows a single conductor 30 disposed along the landing path, grounded at intervals through the resistors 7 to effect a progressive diminution of the magnetic field strength around the conductor, the return being through earth. Inequalities of current through the several ground connections that might result from differences of conductivity in the ground may be compensated by empirically adjusting the values of the resistors to attain the desired result.

Fig. 11 depicts the use of loops 28 and 29 set at 45° to the horizontal, Fig. 12 shows loop 29 horizontal and loop 28 vertical and Fig. 13 illustrates a single vertical loop 31, all used with the single grounded conductor 30. In view of the foregoing, it appears unnecessary to discuss in detail the operation of the devices shown in these figures.

Fig. 14 discloses an effective arrangement for mounting the loops upon an aircraft 40. The loops 28^1 and 29^1 are made by taking a cable of suitable length having, for example, twenty conductive wires in a suitable sheath and connecting the ends of the wires in series, leaving the two ends of each coil thus formed to be connected to leads 11, 12 and 13, 14, respectively. The loops 28^1 and 29^1 are attached to the inside or outside of the fuselage of aircraft 40 with longitudinal side portions 41, 42 and 43, 44, respectively, so disposed that a plane through the side portions of each loop lies at an angle of 45° to the horizontal, when the plane is in normal attitude, the ends of the respective loops being designated 45, 46 and 47, 48. It is apparent that this construction will provide loops of length approximating that of the aircraft, and that these loops may be arranged in any of the positions indicated in other figures of the drawing.

Fig. 16 shows a further method of producing the magnetic fields of varying strength. Here the source 3 of alternating current is adjacent the designated landing point, and the current flows through a conductor 1^1 and a plurality of sectional conductors 2^1 so arranged as to set up a substantially continuous field, each of the conductors 2^1 being connected to conductor 1^1 through a transformer coil 49 which may be so connected to the next conductor 2^1 by a tap 50 so as to constitute an auto transformer, thereby giving rise to progressively increasing magnetic field strength away from source 3. It is within the purview of my invention to make conductor 1^1 also in sections and use transformers having separate primary and secondary coils instead of the auto transformers illustrated, as will be readily apparent to those skilled in this art. If the distance between successive transformers increases logarithmically, the transformers may all be alike, otherwise the transformation ratio must be varied to secure the uniform incremental change in the magnetic fields.

Fig. 17 shows an alternative method of producing the magnetic field of varying strength. Here the source 3 of alternating current is adjacent to the designated landing point.

Conductors 51, 53, 55, 57, 59 and 61 represent part of the conductors contained in a multiconductor cable 63 and conductors 52, 54, 56, 58, 60 and 62 represent part of the conductors contained in another multiconductor cable 64.

Cables 63 and 64 are shown placed on, under or above the surface of the earth on opposite sides of a landing runway 24. It is desirable, but not mandatory, that the cables 63 and 64 should each lie at an angle to the runway 24 equal to the desired vertical angle of the glide path and that they should converge at the point on the runway at which the airplane, in landing, is to contact the earth.

Conductors 51 and 52 are connected to the secondary 65 of a transformer, the primary 66 of which is connected to the source of alternating potential 3. The distant ends of conductors 51 and 52 are grounded as shown thus producing a horizontal triangular loop. The magnitude and phase of the current flowing through cables 51 and 52 is controlled by impedance 67 and the magnitude is measured by ammeter 68.

Conductors 53, 55, 57, 59 and 61 are

connected through the variable impedances 69, 70, 71, 72 and 73 respectively to the source of alternating potential 3 and conductors 54, 56, 58, 60, and 61 are connected through the ammeters 74, 75, 76, 77, and 78 respectively to the source of alternating potential 3. Conductors 53 to 62 are cut to progressively diminishing lengths and their distant ends are grounded as shown.

Grounding conductors 53 to 62 at progressively spaced distances throughout the length of cables 63 and 64 makes them, in effect, horizontal triangular loops of progressively diminishing size which hereinafter are referred to as secondary loops whereas the loop formed by conductors 51 and 52 is hereinafter referred to as the primary loop. The number of secondary loops may be increased as desired to enhance the smoothness of the glide path. The circuits of the horizontal triangular loops may be completed through individual wires instead of by grounding if desired.

In operation, the current flowing through the primary loop is adjusted by any suitable means, such as impedance 67, to a value such that a desired electromagnetic field strength F is produced at a height h vertically above the runway 24 in the vertical plane containing the ground points of cables 51 and 52. The height h is preferably equal to the horizontal distance from the runway 24 to the grounding points of cables 51 and 52.

The current through each secondary loop is adjusted to a value proportional to its length and in phase opposition to the current flowing through the primary loop. In this manner, the electromagnetic flux emanating from each of the cables 63 and 64 is caused to diminish as a linear function of the distance along the cables toward their point of convergence or, conversely, the point of constant electromagnetic field strength F vertically above the runway 24 is caused diminish in altitude as a linear function of the distance along the runway toward the desired landing point.

The value of current flowing in each secondary loop may be adjusted to values other than those specified above in order to cause the electromagnetic field strength to vary in accordance with any other function of the distance along the cables 63 and 64.

The following formula is used to determine the voltage induced in each loop collector mounted in the aircraft:

$$V = 384\ f\ I\ N\ b\ 10^{-3} \log_e \frac{X_b\ X^1_a}{X_a\ X^1_b}$$

Where: V = Microvolts induced in each loop.

f = Cycles per second frequency of source 3.

I = Amperes flowing in cables 1 and 2 at any point.

N = Number of turns in each loop.

b = Length in feet of loop sides parallel to earth.

X_a = Radial distance in feet from cable 1 to first limb of loop.

X_b = Radial distance in feet from cable 1 to second limb of loop.

X^1_a = Radial distance in feet from cable 2 to first limb of loop.

X^1_b = Radial distance in feet from cable 2 to second limb of loop.

As an example of the large values of induced loop voltages obtainable, assume that an aircraft having loops 12 feet by 4 feet of 80 turns each, is located on the glide path at an altitude of 1000 feet and is flying in a level altitude. Also assume that a 500 cycle current of 5 amperes is flowing through cables 1 and 2 at a point directly below the aircraft. Considering the loop the plane of which intersects cable 1, it is found that X_a equals 1414 feet, X_b equals 1417 feet and that X^1_a/X^1_b equals unity. Upon substituting the foregoing values in the above formula, it is found that 2600 microvolts are induced in the loop.

It will be noted, when the radial distance is large compared to the radial dimensions of the loop, that to a close approximation, the voltage induced in loop is inversely proportional to the radial distance of the loop from the cable.

While I have described my invention in certain preferred forms, I desire that it be understood that modifications may be made and that I intend no limitations upon my invention other than are imposed by the scope of the appended claims.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Leader gear equipment, particularly for the blind landing of aircraft, comprising electric circuit means including at least one conducting member extending towards an objective point to be reached by a travelling body, means for producing, around said circuit means, a fluctuating magnetic field or fluctuating magnetic fields which diminishes or diminish in strength progressively

up to said objective point and, on said travelling body, means responsive to current or currents induced by said magnetic field or fields, so that said travelling body can travel towards said objective point by following the locus of points of equal field strength.

2. Leader gear equipment, according to claim 1, for the blind landing of aircraft, comprising means to set up two converging fluctuating magnetic fields symmetrical about a median horizontal line and diminishing in strength toward the point of convergence of said fields as a function of the rate of said convergence, and the responsive means on the aircraft having devices responsive to said fields, and indicating means actuated by said devices to show the position of said aircraft with respect to the locus of points common to both said fields having a predetermined field strength.

3. Leader gear equipment, according to claim 1 or 2, for the blind landing of aircraft, comprising a pair of electrically conductive members spaced apart a distance of the order of twice a suitable height to begin a landing glide and lying parallel to each other in a horizontal plane and then converging toward a median horizontal line at an angle substantially of the order of a suitable angle of glide for landing, means to supply alternating current to said members, parallel cross connections between said converging portions to reduce the current in said members as a function of the distance from the beginning of said convergence whereby the perpendicular distance from each member to a point of predetermined magnetic field strength decreases in accordance with said function, so that the locus of said points defines a glide path, and means carried abroad an aircraft including means responsive to the magnetic field around each said member, and means actuated by said responsive means to indicate the position of said aircraft with respect to said glide path.

4. Leader gear equipment according to claim 2 or 3, for the blind landing of aircraft, wherein the responsive means on the aircraft includes separate coil means disposed to be differentially responsive to the magnetic fields around the electrically conductive members and to have electric currents induced therein, and means actuated by said induced currents to indicate the position of said aircraft with respect to said glide path.

5. Leader gear equipment according to claim 2 or 3, for the blind landing of aircraft, wherein the responsive means on the aircraft includes two coils oppositely inclined at angles of substantially 45° to the horizontal in which coils voltages are induced by the magnetic fields round the electrically conductive members, means to amplify said induced voltages, and means actuated by said amplified voltages to indicate the relative positions of said coils with respect to said glide path.

6. Leader gear equipment, according to claim 1, for the blind landing of aircraft, comprising a conducting member, a plurality of means each including a resistor to ground said member at intervals, said resistors each having such respective values that the current in said member decreases as a function of the length of said member, and means to supply alternating current to said member to set up a magnetic field around said member such that the locus of points vertically above said member having a predetermined field strength defines a glide path for landing an aircraft.

7. Leader gear equipment, according to claim 1, for the blind landing of aircraft, comprising means to set up, around the circuit means, two like fluctuating magnetic fields symmetrically disposed with respect to a median horizontal line, the responsive means on the aircraft including a vertically disposed coil with or without a horizontally disposed coil wherein voltages are induced by said magnetic fields, and means actuated by said induced voltages to indicate the relative positions of said coils with respect to said glide path.

8. Leader gear equipment, according to claim 1, for the blind landing of aircraft, comprising means to set up, around the circuit means, two like fluctuating magnetic fields symmetrically disposed with respect to a median horizontal line, the means carried aboard an aircraft including two coils oppositely inclined at angles of substantially 45° to the horizontal wherein currents are induced by said magnetic fields, means to amplify said induced currents, means actuated by said amplified currents to indicate the relative positions of said coils with respect to said glide path, and other means actuated by said amplified currents to indicate the phase relations of said currents.

9. Leader gear equipment according to claims 3 and 4, for the blind landing of aircraft, wherein the responsive means on the aircraft includes means actuated by said amplified voltages to indicate the phase relations of the currents induced in the separate coil means.

10. In leader gear equipment according to claim 1, an inductive loop comprising a multi-conductor cable wherein the ends

of the conductors are connected together to form a continuous conductive path through all of said conductors.

11. For leader gear equipment according to claim 1, electric circuit means comprising a conductive member, transformer means connected to said member at intervals, and means coacting with each of said transformer means to constitute a closed circuit in which there flows a current dependent upon the ratio of transformation in each of said transformer means, each said circuit including a portion disposed to give rise to a magnetic flux equal to and symmetrically disposed with respect to that portion of said member included in the same circuit therewith, and a source of supply alternating current thereto.

12. For leader gear equipment, according to claim 1 or 2, for the blind landing of aircraft, means for setting up a magnetic field around a line on each side of an aircraft landing runway, and means for setting other magnetic fields on each said side in opposition to the first mentioned said fields, said other fields being of progressively increasing strength toward an end of said runway, whereby the resultant field is of progressively diminishing strength toward said end of the runway.

13. Means according to claim 12, comprising a plurality of parallel juxtaposed conductors on each side of an aircraft landing runway and the groups of said conductors converging toward the landing point, said conductors on each side being of progressively diminished length and grounded or cross-connected by wires at corresponding ends, means to supply alternating current to the other end of the longest conductor on each said side whereby a fluctuating magnetic field is set up therearound, and means to supply to the other end of each other conductor on each side a current of the same frequency as the aforesaid current but opposite in phase, the currents in said other conductors having a value proportional to their lengths, whereby the resultant magnetic field diminishes toward the converging ends of said conductors and the locus of points having a predetermined field strength is a line midway between the groups of conductors and of progressively diminishing height to define a glide path for landing an aircraft.

14. Means according to claim 12, comprising a plurality of parallel juxtaposed conductors on each side of an aircraft landing runway and the groups of said conductors converging toward the landing point, said conductors on each side decreasing in length toward said converging ends according to a predetermined function, means electrically uniting the respective corresponding ends of the conductors of equal length, means to supply alternating current to the other end of the longest conductor on each side whereby a fluctuating magnetic field is set up therearound, and means to supply to the other end of each other conductor on each side a current of the same frequency as the aforesaid current but opposite in phase, the currents in said other conductors having values according to a predetermined function, whereby the resultant magnetic field diminishes toward the said converging ends according to a predetermined function.

15. For leader gear equipment, according to claim 1, for the blind landing of aircraft, an inductive loop mounted on the fuselage of the aircraft, said loop having longitudinally extending portions on opposite sides of the median longitudinal plane of said craft so disposed that a plane through said portions lies at substantially 45° to the horizontal, and a like loop mounted on said fuselage to lie substantially at right angles to the first mentioned loop.

16. For leader gear equipment, according to claim 1, for the blind landing of aircraft, means on the aircraft comprising two coils wherein voltages are induced by a varying magnetic field, said coils being disposed substantially parallel to the longitudinal axis of an aircraft, with the planes of said coils intersecting in a line parallel to the said longitudinal axis and with the planes of said coils at right angles to each other and at substantially 45° to the horizontal in normal flight attitude, means for amplifying and rectifying the voltages induced in each said coil, an indicating means including two movable pointers parallel to each other when said indicating means is not energized, each pointer being connected to be actuated by the rectified voltage from a respective one of said coils, the circuit values of the connecting means to operate said pointers being so adjusted that each said pointer is moved through an angle of substantially 45° to intersect the other pointer in the predetermined point when said voltages from the two coils are equal and of a selected value, and by the departure of that point of intersection from said predetermined point indicating substantially linearly the direction and magnitude of displacement of said coils from a position in said magnetic field where such induced voltages will be equal and of said selected value.

17. For leader gear equipment, accord-

ing to claim 1, for the blind landing of aircraft, means on the aircraft comprising two coils mounted on the fuselage of a craft and extending substantially the full length of said fuselage, one of said coils extending through the other whereby the effective planes of said coils are at angles of substantially 45° to the vertical longitudinal plane of said craft when in normal flight attitude.

18. Apparatus according to claim 16, comprising means for indicating the relative values of the voltages induced in said coils by a varying magnetic field.

19. Apparatus according to claim 18, comprising means for indicating the relative phases of said induced voltages.

20. For leader gear equipment, according to claim 1, for the blind landing of aircraft, means on the aircraft comprising an indicating instrument having two movable pointers, electrically actuable means for moving said pointers, said pointers being normally parallel to each other when said pointer-moving means are not energized, two directional collecting means for collecting energy from an energy field and converting the collected energy to electrical current and means for applying the current derived from each collecting means to actuate a respective said pointer, the apparatus being so adjusted that each said pointer is moved toward the other when the currents derived from said two collecting means are equal and of predetermined value to cause said pointers to intersect at a predetermined point and any change of position of said collectors to a portion of said field where said currents are not equal effecting a substantially linear change in said point of intersection that gives a substantially linear indication of the direction and magnitude of such change.

21. Leader gear equipment, constructed, arranged and adapted to operate substantially as hereinbefore described with reference to and as illustrated by the accompanying drawings.

Dated this 16th day of February, 1939.

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94, Hope Street, Glasgow.

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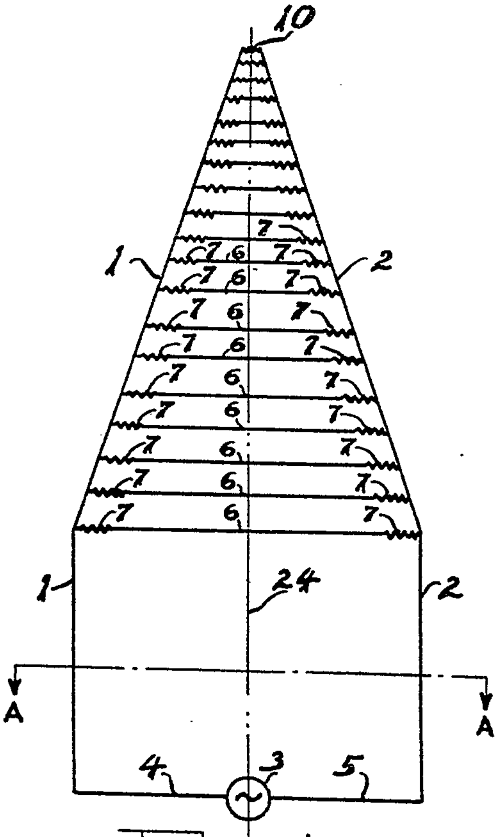

Fig_1_

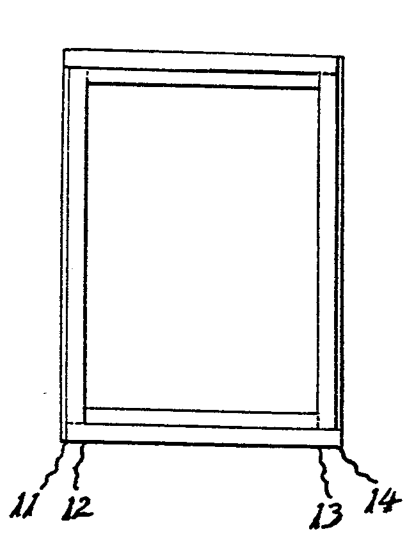

Fig_4_

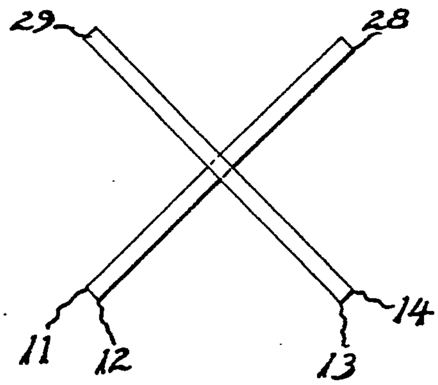

Fig_5_

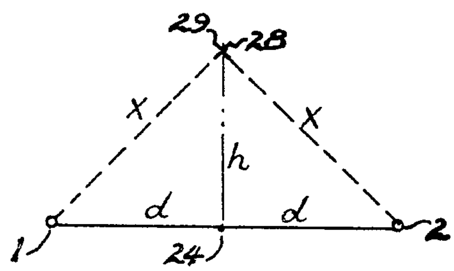

Fig_2

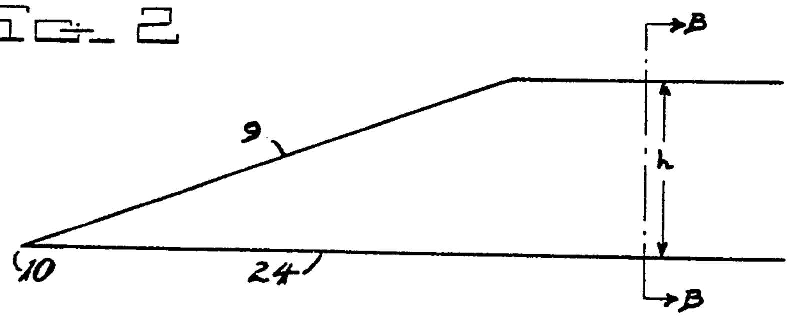

Fig_3_

SHEET 1

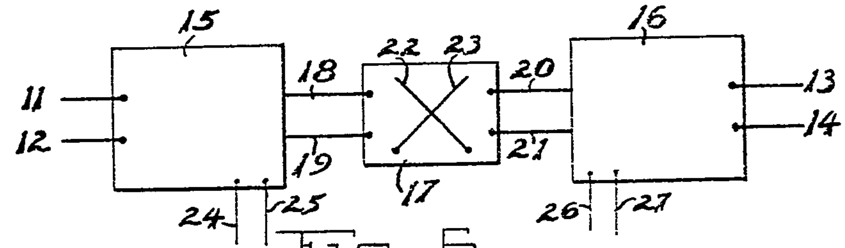

FIG. 6.

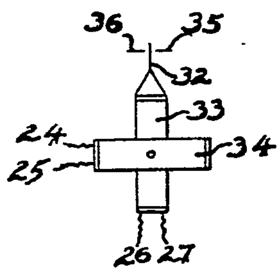

FIG. 7.

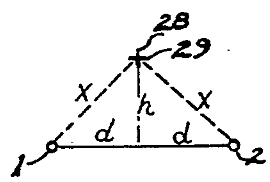

FIG. 8.

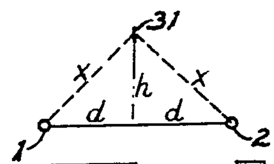

FIG. 9.

14

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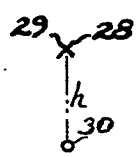


FIG. 11

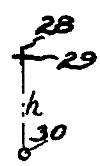


FIG. 12

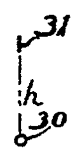


FIG. 13

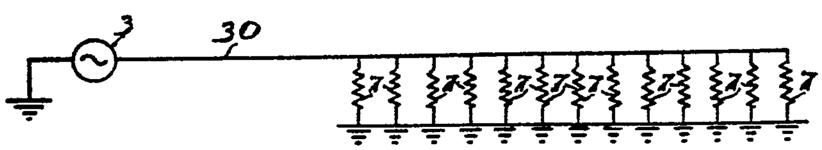


FIG. 10.

SHEET 1

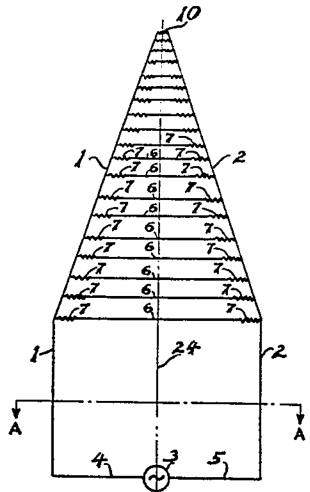


FIG. 1.

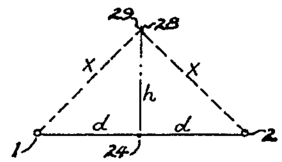


FIG. 2

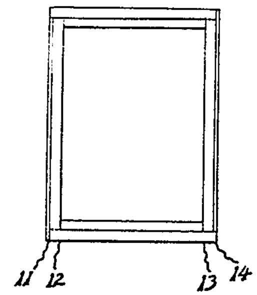


FIG. 4.

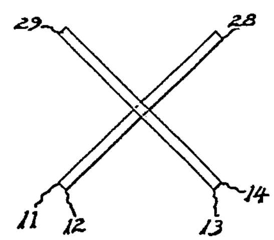


FIG. 5.

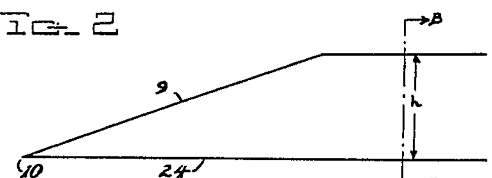
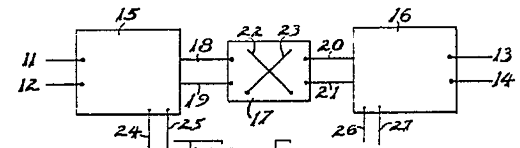


FIG. 3.

SHEET 2



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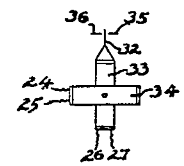

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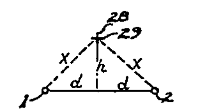
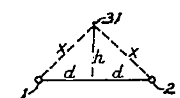


FIG. 8.



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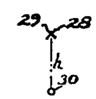

FIG. 11

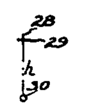

FIG. 12

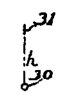

FIG. 13

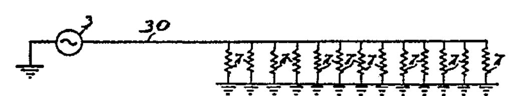

FIG. 10.

[This Drawing is a reproduction of the Original on a reduced scale]

Malby & Sons, Photo-Lith

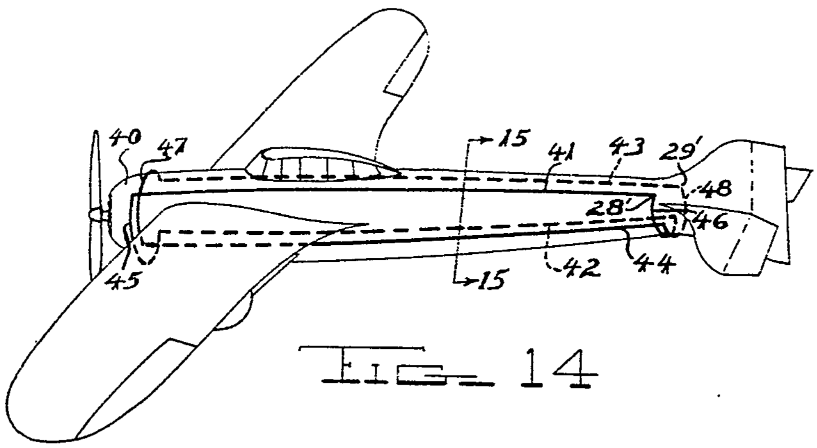

FIG. 14

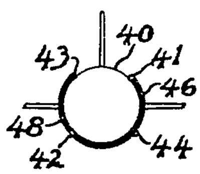

FIG. 15

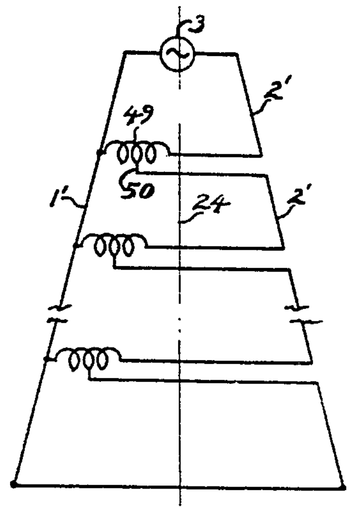

FIG. 16

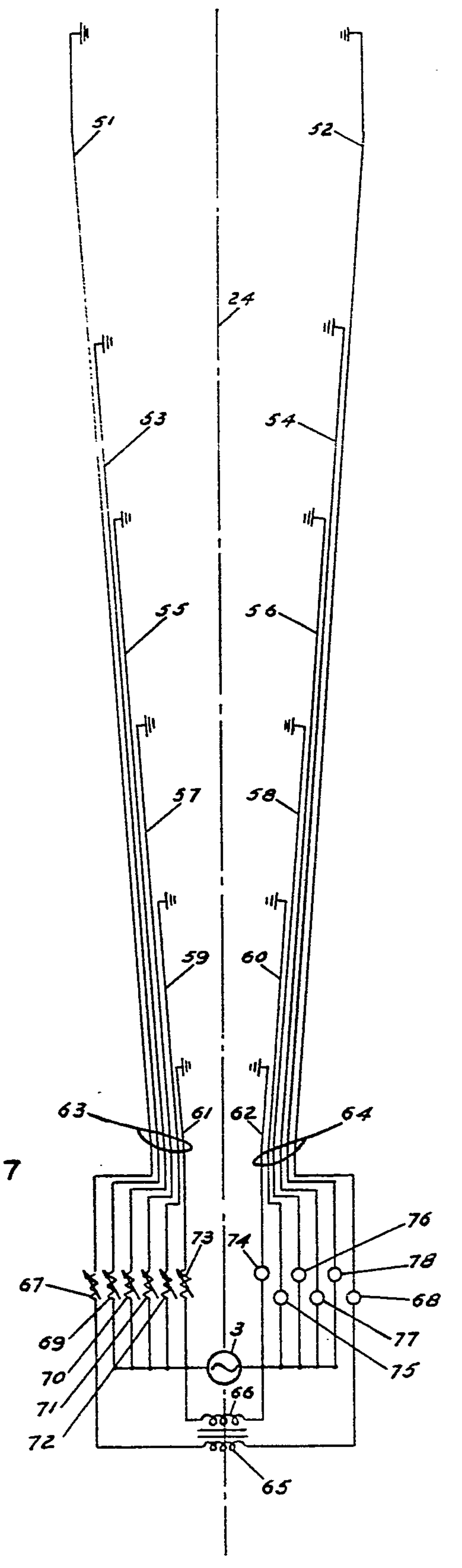

FIG. 17

Malby & Sons, Photo-Litho.

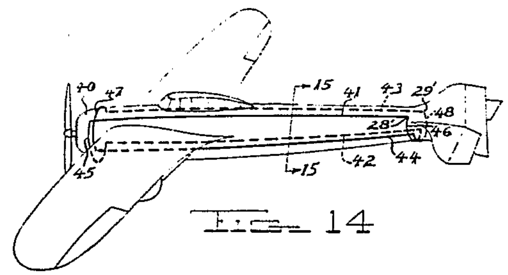

FIG. 14

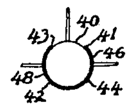

FIG. 15

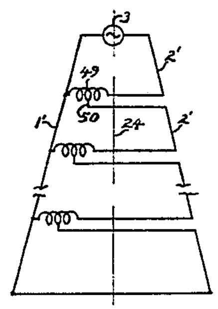

FIG. 16

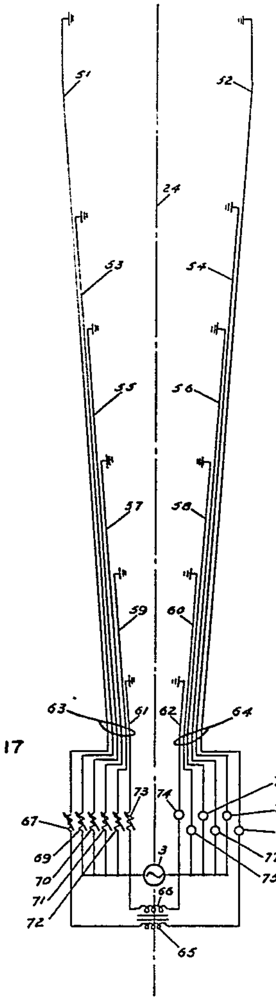

FIG. 17