Feb. 23, 1954 LA VERNE R. PHILPOTT 2,670,158

AXIS CONTROL FOR GUIDED MISSILES

Filed June 18, 1947 4 Sheets-Sheet 1

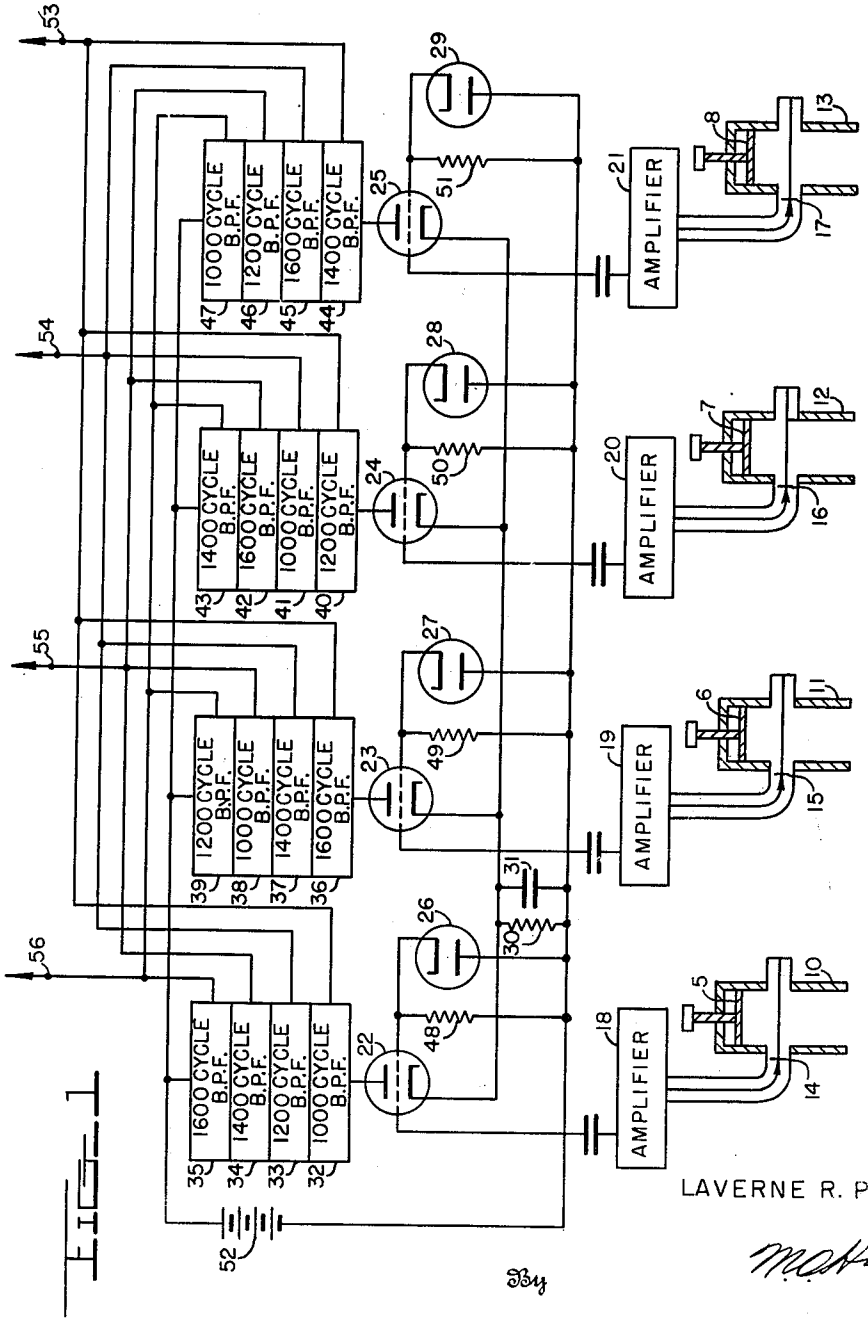


FIG. 1

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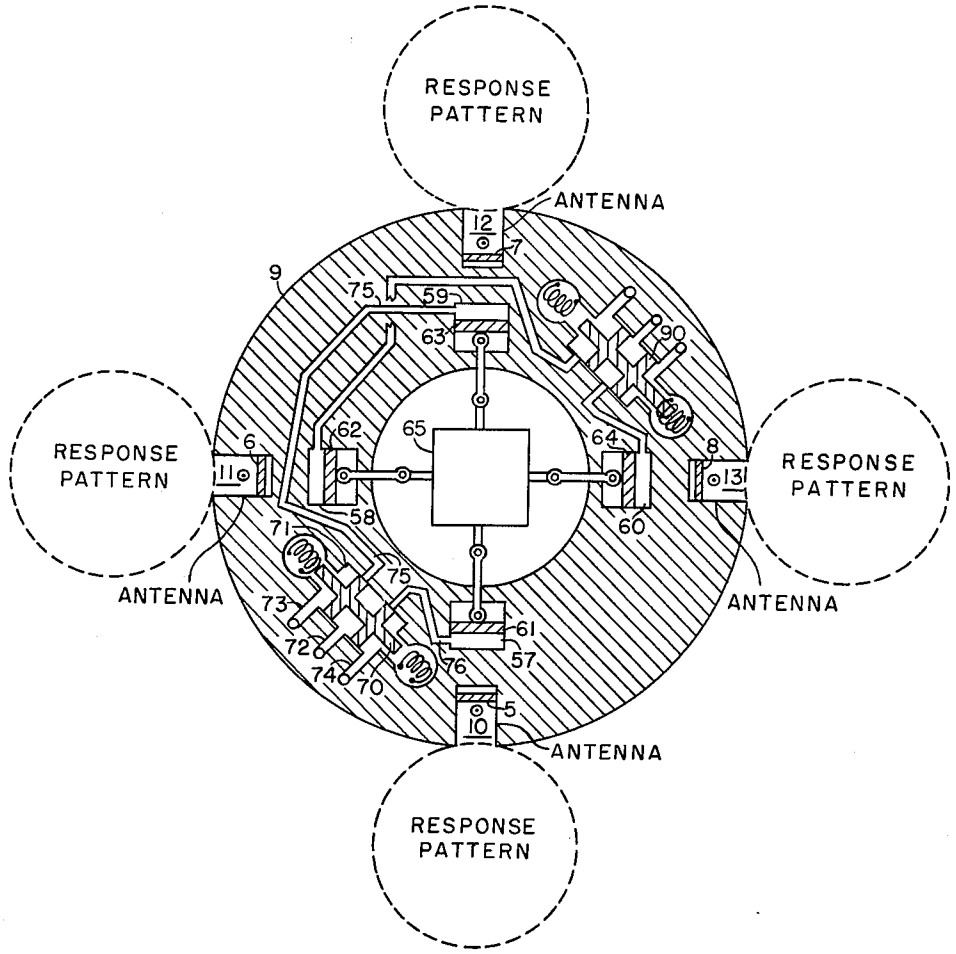
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Feb. 23, 1954 LA VERNE R. PHILPOTT 2,670,158

AXIS CONTROL FOR GUIDED MISSILES

Filed June 18, 1947 4 Sheets-Sheet 2

FIG. 2



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Feb. 23, 1954 LA VERNE R. PHILPOTT 2,670,158

AXIS CONTROL FOR GUIDED MISSILES

Filed June 18, 1947 4 Sheets-Sheet 3

FIG. 3

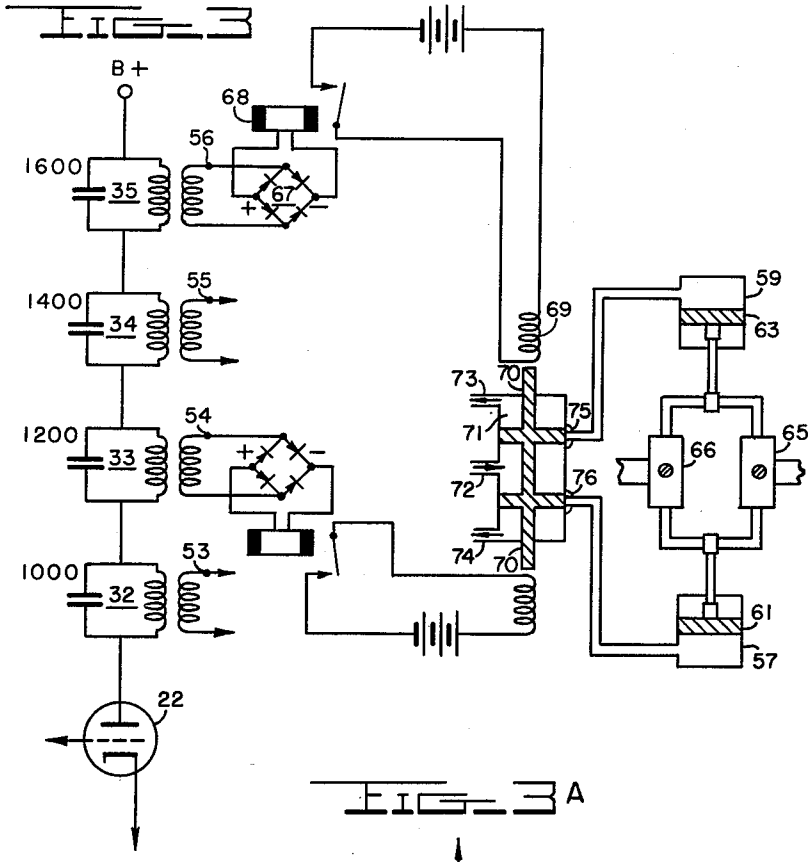
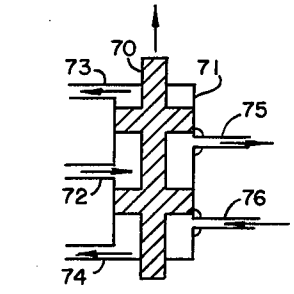


FIG. 3A



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AXIS CONTROL FOR GUIDED MISSILES

Filed June 18, 1947 4 Sheets-Sheet 4

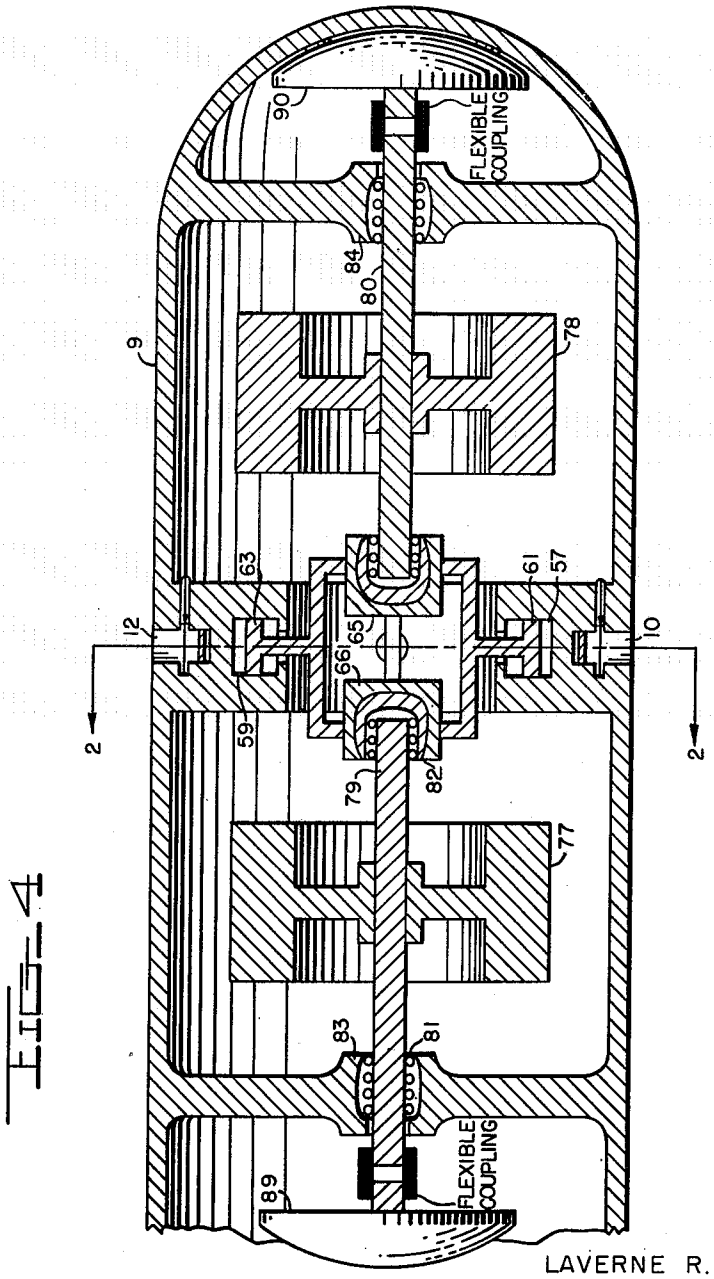


FIG. 4

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UNITED STATES PATENT OFFICE

2,670,158

AXIS CONTROL FOR GUIDED MISSILES

La Verne R. Philpott, Washington, D. C.

Application June 18, 1947, Serial No. 755,272

6 Claims. (Cl. 244—77)

(Granted under Title 35, U. S. Code (1952), sec. 266)

1

This invention relates to guided missiles, and more particularly to a novel radio control system therefor.

It is an object of this invention to provide a system for guiding a missile despite the fact that the missile may be spinning while in flight.

It is a further object of this invention to provide a system for correcting the course of a missile in either one direction at a time or, alternatively, in any combination of two unopposed directions, whichever is desired.

Another object of this invention is to provide a radio control system for guiding the course of a missile while it is in flight, and at the same time frustrate any attempts by unfriendly sources to jam the system and thus confuse the missile as to the direction of its flight.

Other objects and advantages of the invention will be apparent from the following detailed description when taken in conjunction with the accompanying drawings which illustrate a preferred embodiment of the invention, and in which:

Fig. 1 is a schematic diagram of the electrical circuits comprising the invention,

Fig. 2 is a transverse cross sectional view of a typical missile, wherein certain mechanical features of the invention are illustrated,

Fig. 3 is a diagram showing the relationship between the electrical circuits of Fig. 1 and the mechanical features shown in Fig. 2,

Fig. 3A is a partial view of Fig. 3 showing a different operating condition, and

Fig. 4 is a partial longitudinal view showing in cross-section certain of the mechanical features illustrated in Fig. 2.

In accordance with the present invention, piloting of a missile is accomplished by means of radio energy pulses, for example radar pulses, which are modulated with audio frequencies. In this system, it is contemplated that the value of the audio frequency which will modulate the pulse will depend on whether it is desired to guide the missile either to the right or left, or up or down. The modulated pulses will be received by antennas arranged, for example, one to each quadrant of the transverse cross section of the missile, each antenna having pick up properties which are, in general, confined to its respective quadrant. It is then contemplated that the modulated signals received from each quadrant will be applied to an electronic blocking circuit which is discriminatory in its action in that it functions in such a manner as to permit only the pulse signals received from the quadrant most directly in line with the guiding source, and thus having the maximum power at its peak of any of the signals received, to pass. In this manner, the spinning of the missile while it is in flight does not interrupt the control of the missile, since

2

the controlling signal is not received by a single predetermined antenna on the missile but by the antenna viewed, at a particular instant, most directly by the guiding source, this antenna giving way to another antenna as the missile spins approximately 90°. The system further contemplates that the audio frequency signal will then be applied to actuate a gyroscopic "space anchor."

Referring, now, to Fig. 1 of the accompanying drawings, a schematic diagram is shown of the electrical circuits constituting the control system in the missile. This embodiment comprises quadrant antennas 10 through 13, inclusive, which may be, for instance, either of the dipole type or of the wave guide type having pick up properties which allow each antenna to receive signals from almost any direction within 45° on each side of the axis of the antenna. Said antennas, as shown, are arranged to be tuned by movable plungers 5 through 8, respectively.

Thus if, as in Fig. 2 which is a sectional view of the missile which illustrates the disposition of the antennas and their response patterns, the antennas 10 through 13, inclusive, are spaced at equal distance around a transverse cross sectional perimeter of the missile such that each antenna is able to receive signals in its own quadrant, an antenna system will result which will permit signals from all directions to be picked up by at least one and perhaps two antennas. It will be seen that each antenna is designed to have response characteristics only to signals from such a direction as will reach it without having to pass through the missile first. Thus a signal which impinges on antenna 10 in Fig. 2 will not be received by antenna 12. Otherwise, a signal received by both antennas 10 and 12 would impart equal and opposite actuating impulses to the gyroscopic control mechanism, as hereinafter described, with no resultant force being given thereto.

Referring again to Fig. 1, after being intercepted by one of the antennas 10 through 13, the signals are detected by a corresponding one of the detectors 14 through 17, respectively, which may be crystal detectors. The signals which as aforementioned may be radar pulse signals, are modulated in amplitude, in repetition rate, or in any other suitable manner, by audio frequencies. A different value of audio frequency may exist as the intelligence signal for each quadrant; thus, for example, a modulating frequency of 1000 cycles may impart a force to the missile such as to cause it to turn to the left with respect to its present course, 1200 cycles will cause it to turn to the right, 1400 cycle will cause it to turn skyward and 1600 cycles to turn earthward.

If there is no modulation, the missile will continue to travel in its present course.

Associated with each detector, 14 through 17, is a corresponding amplifier 18 through 21, arranged to amplify the output of their respective detectors to a suitable working level. The output of each amplifier is in turn connected to the control grid of a respective triode, 22 through 25, which comprise the blocking circuit of the invention. Considering only the blocking circuit for the signals intercepted by the antenna 10, with the understanding that the other blocking circuits perform in a similar manner, it will be noted that this circuit consists of a triode 22, a diode 26, a cathode resistance 30 and bypass condenser 31. One side of the cathode resistance 30 and condenser 31 is connected to the cathode of the tube 22, as well as to the cathodes of the other tubes 23, 24, and 25 comprising the blocking circuits, and the other side is connected to the negative terminal of a suitable power supply 52. The diode 26 is connected such that its cathode is tied to the grid of the triode 22 and its plate is joined to the negative terminal of the power supply 52. A resistance 48 is placed in parallel with the diode 26 and provides a grid return for tube 22. The output from the blocking circuit is taken from the plate of the triode 22, and introduced to a series of audio frequency filters, whereby the modulation component impressed on the received signal may be selectively applied to an appropriate control mechanism as hereinafter described.

For the purpose of explaining the action of the blocking circuits, consider a pulse signal which is introduced to the grid of the triode 22 and is of such a magnitude as to cause plate current to flow. This current will produce a voltage across the cathode resistance 30 and the by-pass condenser 31 and thus will tend to place the cathode of the tube 22 as well as tubes 23 through 25, inclusive, at a positive potential with respect to the normal grid bias. The function of the condenser 31 is to smooth this biasing potential and to maintain it at a substantially constant value until the arrival of the next pulse. Therefore, the next pulse applied to any of the triodes in the blocking circuits must be of such an amplitude as to overcome the bias developed across cathode resistance 30 and capacitance 31 before it may impart any control over the direction of the missile. Accordingly, only those signals received by the antenna or antennas most directly in line with the source will be able to impart directivity.

It is apparent, however, that the missile may be so positioned with respect to the control station that two antennas will pick up one control signal, for example a signal having the modulation frequency for turning the missile to the right. Thus, as shown in Fig. 2, for a signal which arrives from the guiding source in such a direction that its field strength at antenna 10 is of the same order of magnitude as at antenna 11, both of these signals will be allowed to pass through the blocking circuit and both signals will contribute towards actuating the gyroscopic space anchor so as to turn the missile to the right. It may be seen that modulation signals may be applied simultaneously so as to turn the missile in two directions at the same time—i. e., to the right and upward—but these directions may not be diametrically opposed to each other as, for example, to the right and to the left.

Referring again to Fig. 1, the diode 26 is reverse connected to short out any signals on the grid of the triode 22 that are negative with respect to the low voltage side of the resistance 30 and thus it serves to maintain the positive potential on the resistance 30.

The pulse outputs from the blocking circuits are then taken from the plates of the triodes, and are applied to a series of filters associated therewith. In the case of triode 22, the filters are shown at 32 through 35, it being understood that a somewhat similar filter series is associated with each of the other triodes 23, 24, and 25 in the blocking circuits. In each filter series there are four filters, one for each modulation frequency used in guiding the missile. The filters in each series serve to channelize the audio frequency modulation picked up by its antenna to the proper mechanical means for turning the missile in the desired direction. Filters 32 through 35, inclusive, comprise the filter unit associated with the first blocking circuit connected to antenna 10, filters 36 through 39, inclusive, 40 through 43, inclusive, and 44 through 47 inclusive, serve to channelize correctly the signals from antennas 11, 12, and 13, respectively. Thus, assuming that the audio frequencies have values of 1000, 1200, 1400, and 1600 cycles per second, the filters for the first series may be arranged such that filter 32 might respond to only 1000 cycles, filter 33 to only 1200 cycles, filter 34 to only 1400 cycles, and filter 35 to only 1600 cycles. Then, in the second series, filters 36, 37, 38, and 39 might serve to respond only to 1600, 1400, 1000 and 1200 respectively. Likewise, filter units 40, 41, 42, and 43 might serve to channelize audio frequencies of 1200, 1000, 1600, and 1400 respectively, and filter units 44, 45, 46, 47 to channelize 1400, 1600, 1200, and 1000 cycles respectively.

From the drawing it will be noted that the output of the 1000 cycle pass filter 32 associated with antenna 10 is brought out to a lead 53 which connects to a suitable control mechanism hereinafter described for applying a turning force in one direction to the missile. The output of the other 1000 cycle pass filters associated with the other antennas are brought out to distinct leads, 55, 54, and 56 respectively which connect to similar control mechanism. This is done for the reason that the turning force applied by the mechanism connected to lead 53 in response to a modulation frequency must be at right angles to that derived from antenna 11 since the latter antenna is located on the missile at right angles to antenna 10 and before it can come into play the missile must spin or rotate 90° about its axis. Similarly the 1000 cycle note from antenna 12 which is displaced mechanically 180° from antenna 10 must operate to apply a force 180° out of phase with that from antenna 10 since the missile must be turned in the same direction regardless of which antenna receives the signal.

In following the staggered interconnections of the filters it will be seen that the outputs of filters 32, 36, 40, and 44 in respect to antennas 10, 11, 12, and 13 are all joined to lead 53. Through lead 53 said filter outputs are introduced to a mechanism hereinafter described in connection with Fig. 3, which will apply a force in a specific direction to the gyroscopic "space anchor" so as to cause the missile to change its direction. Similarly, the outputs from the filters 33, 37, 41, and 45 are brought together and introduced through the lead 54 to a similar mechanism which will apply a force to the gyroscopic "space anchor" in a direction that will be opposite to that applied above. Likewise, the out-

puts from the filters 34, 38, 42, and 46 and the units 35, 39, 43, and 47 are brought together to two common terminals and are introduced through the leads 55 and 56, respectively, to two mechanisms similar to those described above which will produce forces on the "space anchor" perpendicular to those produced above but opposite in direction with respect to each other. It will thus be seen that the actuating signals are able to turn the missile in four directions, each of which is either at an angle of 90°, 180°, or 270° with respect to the others.

It will now be explained why modulating frequencies of 1000, 1600, 1200, and 1400 cycles from the filter units 32, 36, 40, and 44, respectively, are brought together at the lead 53 and why similar arrangements are made with respect to the leads 54, 55, and 56. Suppose, for example, that it is desired to turn the missile to the left and that the modulating frequency for such a result is 1000 cycles, and assume further that the missile is spinning. If, say, the antenna 10 is most directly aligned with the source emitting the guiding signals; the signal will pass from the antenna 10 through the blocking circuit comprising the tube 22 and through the filter 32, which is designed to pass 1000 cycle signals, to the output terminal 53. A moment later, when the missile has spun around 90°, antenna 11 will receive the signal and the signal will pass through the filter 38 to the output lead 55. It will immediately be observed that the output lead 55 actuates a mechanism producing a force on the missile which is at right angles with the force actuated by the signal from the output lead 53. But the missile has spun 90° in this interval and thus the forces transmitted to the missile will tend to turn the missile in the same direction. Suppose, as another example that it is desired to turn the missile upward and that the modulating frequency is 1600 cycles. If the antenna 11 is positioned such that it will receive the signal from the control source, the signal will pass through the filter unit 36 to the channel 53. A moment later, the missile has spun so that antenna 12 receives the signal. Now filter 42 passes the signal to channel 55. Channels 53 and 55 actuate mechanisms producing forces at right angles to each other but since the missile has spun that same 90° during this interval, the two forces produced one after the other will tend to turn the missile in the same direction, in this case, upward. This same result will occur for other sets of conditions of modulating frequencies and antenna positions with respect to the guiding source and the result will not be affected by the missile spinning in a clockwise or counterclockwise direction. It may be seen that if the modulating frequencies were not staggered in one channel but all of the 1000 cycle signals, for example, from filter units 32, 38, 41, and 47 were connected in one channel, forces in different directions would result when the missile was spinning and thus the missile would not be able to be guided. Thus the problem that may be presented in a system for guiding the course of the missile, where the missile becomes confused as to its orientation because of the missile spinning while in flight, is not presented in the present invention, since a modulating signal having a particular frequency will be introduced to an actuating means which will turn the missile in the desired direction regardless of what antenna intercepts the signal.

The mechanical actuating means for turning the missile in a particular direction is shown more clearly in Figs. 2 and 4. The interconnection between the electrical circuits of Fig. 1 and the mechanical actuating means shown in Figs. 2 and 4 will be described in detail in connection with Fig. 3 and Fig. 3A.

In Fig. 2, which is a transverse cross sectional view of the missile taken through the lines 2—2 of Fig. 4, the antennas and the mechanical actuating means may be seen in cross section. The antennas 10 through 13 are spaced in quadrature about the transverse periphery of the missile body 9. As shown, said antennas consist of holes cut into the missile body a depth of one quarter wave-length of the carrier frequency. This depth may be adjusted by the movable plungers 5 through 8, respectively. This design provides antennas having very little effect on the airfoil of the missile. There are four cylindrical chambers 57 through 60 spaced in quadrature with respect to the transverse cross section within the body of the missile. Four pistons 61 through 64 are located one each in the said four cylinders. Said pistons are mechanically connected, as by connecting rods and yokes to the gyroscopic "space anchor" 65. The mechanical operation of the pistons and the "space anchor" is controlled by the hydraulic valves 70 and 90 as described below in connection with Fig. 3 and Fig. 4. In Fig. 2 the relation of the pistons to each other, to the "space anchor," and to the antennas can be seen.

If a signal is received at any antenna modulated to turn the missile upward, valve 90 will be moved so as to force oil into cylinder 60 and out of cylinder 58 thereby introducing a pressure against piston 64 and removing pressure from piston 62. This change in pressure produces a force to the left upon the pistons 62 and 64 which is transmitted to the "space anchor" 65. Fig. 2 illustrates the leftward force just described.

Fig. 3 shows a mechanical actuating means for transferring the received signals to mechanical energy suitable to produce a piston action similar to that referred to above in connection with Fig. 2. The mechanical actuating means is shown with tube 22 of Fig. 1 and its associated filters 32 through 35. The other tubes 23 through 25 of Fig. 1 are not shown but their connection to the mechanical actuating means is indicated by the terminals 53 through 56 which also appear in Fig. 1. The filters shown are parallel resonant circuits connected in series between the plate of the tube 22 and the plate power supply. When a signal is applied to said tube at a frequency to which one of its associated filters is tuned, the high internal impedance presented by that filter will permit a large signal to be coupled from the inductive branch of said filter. The signal coupled from the filter, after being rectified, may be used to energize a relay arranged to open a pair of valves which change the oil pressure in one of the pairs of opposite cylinders of Fig. 2. Fig. 3 shows only the oil pressure control mechanism for the 1600 cycle filter 35 and the 1200 cycle filter 33. Filters 32 and 34 operate the remaining two opposing pistons 62 and 64 not here shown by identical means.

The function of the actuating means may be clearly seen by tracing a signal through Fig. 3. Choosing a 1600 cycle signal, the signal will resonate in the 1600 cycle filter 35. The signal energy is then coupled from the filter and fed through a line 56 to a bridge rectifier 67. The rectified signal is then applied to relay 68 which closes a circuit energizing the solenoid 69. The

energy in the solenoid moves a hydraulic valve 70 upward. The hydraulic valve is contained in a valve chamber having three connections leading to an oil reservoir not shown. One of these connections 72 is in the center of the valve chamber and permits oil to be forced into the chamber under pressure. The remaining connections 73 and 74 to the reservoir are located respectively at the top and bottom of said chamber and their function is to discharge oil from the chamber to the reservoir. Another opening 75 in the valve chamber 71 leads to the cylinder 59 of piston 63. Another opening 76 leads to the cylinder 57 of the opposite piston 61. Said last two openings are arranged so that when the valve 70 is in its normal position, both are closed. When valve 70 is moved either up or down, both said openings are opened. If valve 70 is moved upward by solenoid 69, connection 75 is opened to the reservoir input connection 72 and connection 76 is opened to the lower discharge connection 74. Thus oil is forced into the upper cylinder 59, pushing piston 63 downward, thus putting a downward force on the "space anchor" bearings 66 and 65. Said downward force is also transmitted to the lower piston 61 which forces oil out of its cylinder 57 and out the discharge 74 to the reservoir. It should be noted that an upward force is produced on the cylinders equal and opposite to the downward force in the pistons.

The position of the valve 70 for the action just described is shown in Fig. 3A, in which the flow of oil to and from the reservoir is shown by arrows. After the 1600 cycle signal subsides, valve 70 will lower closing connections 75 and 76. The greater pressure in upper cylinder 59 as compared to that in the lower cylinder 57 and hence the downward force on the "space anchor" 65 and 66, will remain until changed by a subsequent movement of the valve 70 responsive to a subsequent signal of 1600 or 1200 cycles. A 1200 cycle signal would, of course, resonate in filter 33, produce a downward movement upon valve 70, and have an opposite effect upon the pressure in cylinders 57 and 59.

Fig. 4, which is a longitudinal cross sectional view of the missile, shows in greater detail the construction of the "space anchor." A pair of cylindrical weights 77 and 78 are rotatably mounted within the missile body on a pair of shafts 79 and 80 respectively. Rotation of said weights is produced by motor means 89 and 90 shown flexibly coupled to shafts 79 and 80 respectively. The weights and their respective shafts are located on either side of the piston housing comprising the cross sectional view of Fig. 2. The shaft 79 of weight 77, shown to the left of the housing, is supported at its ends by bearings 81 and 82. These bearings 81 and 82 have a spherical shape which allows them to turn in any direction inside their respective bearing housings 83 and 66. The left bearing housing 83 is an integral part of the missile body 9. The right bearing housing 66 is mechanically linked to the four pistons of Fig. 2, two of which are not shown in the figure, and responds to movements thereof. The cylindrical weight 77 is rotated about its shaft 79 by motor means 89. It may be given a pressure tending to rotate it about its bearing 83 by forces on the pistons 57, 58, 59, and 60.

The other cylindrical weight 78 on its shaft 80 is mounted in bearing housing 65 and 84 in the same manner as the left weight 77. Said weight 78 is also rotated about its shaft 80 by a motor means 90 but it is rotated in the opposite direction to the left weight 77.

Now if a signal with a 1600 cycle modulation is applied to antenna 10, it has been shown in Fig. 3 that the pistons 63 and 61 and the movable bearing housings 66 and 65 will try to move downward. This downward force will be transmitted through the integral housings 83 and 84 at the opposite end of each rotatable shaft to the missile body, where it is counteracted by the upward force of the cylinder 59. Assuming a direction of rotation for the two weights such that the top of the left weight 77 is coming out of the plane of the paper and the top of the right weight 78 is going into the plane of the paper, then with the downward force from the pistons, each shaft has two tendencies toward rotation, one tendency because of the opposite rotation of the two shafts and the other tendency because of the downward pressure from the piston. From these two tendencies a precession movement will be established in a third direction. This precession movement will produce a tendency for the shafts to rotate about the integral bearing housings 83 and 84 such that the end of shaft 80 within bearing housing 84 will go into the plane of the paper and the end of shaft 79 including bearing housing 83 will come out of the plane of the paper. This tendency of motion cannot be absorbed within the missile and since there is no opposing force, the missile body will be turned in space such that its nose goes into the plane of the paper and its tail comes out of the plane of the paper. The actual change of direction of travel is accomplished by the aerodynamic lift developed on the side of the missile. In the orientation of the drawings the precession described will cause the missile to turn to the left.

The missile will respond similarly to forces upon the other pistons. It should be noted that this system would operate equally well using two pistons and cylinders instead of four. If only two were used the opposing chamber for each piston would be on the connecting rod side of the piston instead of in an oppositely placed piston and cylinder.

While certain preferred embodiments of this invention have been described, it is realized that many modifications and variations of this invention may be made and no limitations upon this invention are intended other than may be imposed by the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a radio control system having a modulated carrier wave, means for guiding a spinning missile in response to the modulation characteristic impressed on said carrier wave, comprising, a plurality of directive antennas spaced circumferentially about the periphery of said missile to provide adjacent response patterns, control means operative to impart an up, down, right, or left turning movement to said missile in accord with and responsive to the modulation characteristic of the received signal, a separate receiving channel connecting the output of each of said antennas to said control means, each of said channels being operative to control the action of said control means in response to the modulation

characteristic of said received signal, and means interconnecting said receiving channels operative responsive to the channel receiving the strongest incoming signal, to render the remaining channels temporarily inoperative.

2. In a radio control system having a modulated carrier wave, means for guiding a spinning missile in response to the modulation characteristic impressed on said carrier wave comprising, at least four directive antennas circumferentially spaced about the periphery of said missile to provide adjacent response patterns, control means including four signal input channels operative to impart an up, down, right, or left turning movement to said missile in accord with and responsive to the modulation characteristic of the received signal, a receiving channel means for each antenna, each of said receiving channel means including a series of filter circuits operatively connecting its respective antenna to each input channel of said control means, said filter circuits being operative to selectively transfer the energy of the received signal to the input channels of said control means in accordance with the modulation characteristic of said received signals, and means interconnecting said receiving channels operative responsive to the channel receiving the strongest incoming signal, to render the remaining channels temporarily inoperative.

3. In a radio control system having a modulated carrier wave, means for guiding a spinning missile in response to the modulation characteristic impressed on said carrier wave comprising, at least four directive antennas circumferentially spaced about the periphery of said missile to provide adjacent response patterns, control means including four signal input channels operative to impart an up, down, right, or left turning movement to said missile in accord with and responsive to the modulation characteristic of the received signal, a receiving channel means for each antenna, each of said receiving channel means including an amplifier means and a series of filter circuits operatively connecting its respective antenna to each input channel of said control means, said filter circuits being operative to selectively transfer the energy of the received signal to the input channels of said control means in accordance with the modulation characteristic of said received signals, and signal integrating means common to said receiving channel means, said signal integrating means being operative responsive to signals received at any said receiving channel means to temporarily increase the bias upon all said amplifier means rendering said receiving channel means unresponsive to smaller signals.

4. A radio-controlled missile comprising a pair of weights rotating in counterrelation and in axial alignment with respect to one another and with respect to the axis of the missile, the opposite ends of said weights being pivotally journalled to walls of said missile, the adjacent ends of said weights being pivotally journalled to at least one pair of yokes carried respectively by at least one pair of pistons arranged in space quadrature relation, said pistons being operative upon application of a displacing force thereto, to produce a misaligning force upon said weights in a selectable direction so as to produce a selectable turning movement to said missile, separate control means operatively connected to each of said pistons to control the displacing force thereon, a directive antenna system arranged one antenna to each quadrant of the transverse periphery of the missile, a separate receiving channel means interconnecting each of said antennas to each of said control means, said receiving channel means operative to transfer a control signal to said control means to effect a displacing force upon said pistons responsive to and in accordance with the modulation characteristic of an incoming radio signal.

5. A guided missile comprising, a pair of weights rotating in counterrelation and in axial alignment with respect to one another and with respect to the axis of the missile, the opposite ends of said weights being pivotally journalled to walls of said missile, the adjacent ends of said weights being pivotally journalled to at least one pair of yokes carried respectively by at least one pair of pistons arranged in space quadrature relation, hydraulic control means operatively connected to each of said pistons for selectably applying a displacing force to said pistons and their associated yokes, said pistons being operative upon application of a displacing force thereto, to produce a misaligning force upon said weights in a selectable direction so as to produce a selectable turning movement to said missile, a directive antenna system arranged one antenna to each quadrant of the transverse periphery of the missile, a separate receiving channel means interconnecting each of said antennas to each of said control means, said receiving channel means operative to transfer a control signal to said control means to effect a displacing force upon said pistons responsive to and in accordance with the modulation characteristic of an incoming radio signal.

6. A guided missile comprising, a pair of weights rotating in counterrelation and in axial alignment with respect to one another and with respect to the axis of the missile, the opposite ends of said weights being pivotally journalled to walls of said missile, the adjacent ends of said weights being pivotally journalled to at least one pair of yokes carried respectively by at least one pair of pistons arranged in space quadrature relation, electric valve operated hydraulic control means for selectively introducing oil under pressure to said pistons whereby a force may be imparted thereto and to their associated yokes, said pistons being operative upon application of a force thereto, to produce a misaligning force upon said weights in a selectable direction so as to produce a selectable turning movement to said missile, a directive antenna system arranged one antenna to each quadrant of the transverse periphery of the missile, a separate receiving channel means interconnecting each of said antennas to each of said control means, said receiving channel means operative to transfer a control signal to said control means to effect a displacing force upon said pistons responsive to and in accordance with the modulation characteristic of an incoming radio signal.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
887,443	Thayer	May 12, 1908

FOREIGN PATENTS

Number	Country	Date
184,526	Great Britain	July 31, 1922
388,230	France	May 26, 1908