A guidance system for an anti-aircraft missile comprising a missile launcher and a sighting device disposed close to the launcher. The sighting device has a sightline which is rotatable about an azimuth axis as well as an elevation axis perpendicular to the azimuth axis and which is intended to be kept continuously pointing at a target towards which the launched missile is to be guided. The launcher is coupled to the sighting device so that the launching direction is always parallel to the direction of the sightline of the sighting device. Further, the system includes means for determining the deviation of the missile from the sightline in two orthogonal directions perpendicular to the sightline and for producing a yaw control signal representing the deviation of the missile in the first direction and a pitch control signal representing the deviation of the missile in the second direction. The missile is provided with rudder or flight control means responsive to the yaw control signal and the pitch control signal for influencing the flight direction of the missile in a yaw plane in response to the yaw control signal and in a pitch plane perpendicular to the yaw plane in response to the pitch control signal. The missile includes also a direction reference gyroscope which defines the yaw plane of the missile as the plane perpendicular to the reference direction of the gyroscope and the pitch plane of the missile as the plane perpendicular to the yaw plane and extending through the longitudinal axis of the missile.

2 Claims, 3 Drawing Figures
GUIDANCE SYSTEM FOR AN ANTI-AIRCRAFT MISSILE

BACKGROUND OF THE INVENTION

The present invention relates to a guided anti-aircraft missile system of the type in which the launcher for the missile is positioned close to a sighting device and is integral with or coupled to this sighting device in such a manner that the missile is launched in a direction substantially parallel to the direction of the sight-line of the sighting device at the instant of launch and in which the launching missile is guided towards the target by keeping the sight-line of the sighting device pointing at the target and determining the deviation of the missile from the sight-line and producing control signals corresponding to this deviation, which control signals are supplied to the rudder or flight control means of the missile, which in response to these control signals influence the direction of flight of the missile so as to cause the missile to fly along the sight-line which is kept pointing at the target. The invention will be described in conjunction with the drawings wherein:

FIG. 1 is a schematic drawing illustrating the basic operation of a guided anti-aircraft missile system; FIG. 2 is a coordinate space figure illustrating the geometric relations discussed herein; and FIG. 3 is a schematic block diagram of a guidance system for an anti-aircraft missile embodying the invention.

FIG. 1 in the accompanying drawings illustrates schematically the basic operation of such a guided anti-aircraft missile system. The drawing shows only very schematically a launcher 1 in the form of a launching tube for the guided missile 2. In the illustrated example the launcher is integral with a sighting device 3, which is assumed in the illustrated system to consist of an optical sight. The assembly consisting of the launcher 1 and the sighting device 3 is mounted on a stand 4, or a similar support in such a manner that the sight-line S of the sighting device 3 can be rotated in elevation as well as in azimuth, while the launching direction of the launcher 1 remains substantially parallel to the sight-line S. The drawing shows how an operator has "caught" a target M by means of the sighting device 3 and in the instant indicated by 1 succeeded in pointing the sight-line S of the sighting device at the target M. In this instant the missile 2 is launched in the direction of the sight-line. After the launching of the missile, the sight operator continues to keep the sight-line S pointing at the target M, which means of course that the direction of the sight-line S will change as the target M moves along its path of flight. By means of special equipment the deviation of the launched missile 2 from the sight-line S is continuously determined and the signals representing this deviation produced. These signals are supplied to rudder or flight control means of the missile 2, which in response to these control signals changes the direction of flight of the missile so that the deviation of the missile from the sight-line is reduced and the missile is caused to fly along the sight-line, which is kept permanently pointing at the target. It is appreciated that in this way the missile is caused to fly in a curved path towards the target.

It is obvious from the foregoing that an anti-aircraft missile system of the type described requires an equipment or a system for determining the deviation of the missile from the sight-line and for producing control signals representing this deviation for the flight control means of the missile. Various types of devices and equipments for this purpose are known in the prior art.

A simple system for this purpose comprises an optical sight through which the operator can observe the target as well as the launched missile and which is provided with an hairline cross or similar reticle means visible within the field of view of the sight, which indicate on the one hand the sight-line, whereby the sight operator can keep the sight-line pointing at the moving target, and on the other hand two orthogonal directions perpendicular to the sight-line, normally the horizontal and vertical directions, whereby the sight operator can assess the deviation of the missile from the sight-line in these two directions. Further, two signal generators are provided, which can be actuated by means of a control lever or a similar member manually operated by the sight operator to produce two control signals corresponding to the deviations of the missile from the sight-line in the horizontal and vertical directions, respectively, as estimated by the sight operator. These two control signals are transmitted to the missile over a suitable signal communication path, for instance wires, a radio link or a laser link, for the control of the flight control means of the missile.

There exist also automatically operating systems similar to the one described above, in which the sighting device comprises photo detectors and optical means for projecting an image of the missile or of a light source on the missile upon these photo detectors; the optical means and the photo detectors being arranged to cooperate in such a manner that signals representing the deviation of the missile from the sight-line in the horizontal and vertical directions, respectively, may be derived from the output signals of the photo detectors. Systems of this kind are described for instance in the U.S. patent specifications Nos. 2,930,894 and 2,942,118.

More sophisticated systems for the same purpose are the so-called beam-riding guidance systems, in which the sighting device is associated with a radiation transmitter which emits an electromagnetic guidance beam in the direction of the sight-line. This guidance beam is produced in such a manner that in a plane perpendicular to the central axis of the beam, that is perpendicular to the sight-line, the beam produces a predetermined pattern of radiation, which pattern also very often moves in a predetermined manner relative to the sight-line. On the missile there is provided a radiation detector which receives the radiation from the guidance beam and produces an electric output signal, which due to the particular radiation pattern of the guidance beam and the predetermined motion of this radiation pattern relative to the sight-line is dependent of the position of the missile relative to the sight-line and from which signal processing circuits can derive signals representing the deviations of the missile from the sight-line in two orthogonal directions, generally the horizontal and vertical directions, respectively. These signals can be used for the guidance of the missile. The guidance beam in such a system can consist of a radio-frequency radiation, a radar-frequency radiation or a light-frequency radiation, in which latter case the beam often consists of a laser radiation. Beamriding guidance systems of various types are described for instance in the U.S. patent specifications Nos. 3,025,024, 3,398,918 and 3,513,315.
It is appreciated that irrespective of the type of system used for determining the deviation of the missile from the sight-line and for producing signals representing this deviation for controlling the flight of the missile, the deviation of the missile will be determined in two preselected, orthogonal directions relative to the sight-line, generally in the horizontal and vertical directions. If the signals representing the horizontal and the vertical deviations, respectively, of the missile from the sight-line are to be used in the missile for controlling the flight of the missile, the flight control means within the missile must obviously know which directions actually are the horizontal and the vertical directions, respectively. This can be obtained by means of a gyroscope mounted in the missile, which always indicates the true vertical direction and thus also the horizontal plane perpendicular thereto, in which case the flight control means of the missile are arranged to influence the flight direction of the missile in the horizontal plane in response to the control signal representing the deviation of the missile from the sight-line in the horizontal direction and to influence the flight direction of the missile in the vertical plane through the longitudinal axis of the missile in response to the control signal representing the deviation of the missile in vertical direction from the sight-line.

As in an anti-aircraft missile system of the type described in the foregoing the missile is launched in the direction of the sight-line pointing at the target and thus generally at an elevation angle, which obviously will vary from one launch to another, one must for indicating the true vertical direction in the launched missile use a so-called vertical-seeking gyroscope, that is a gyroscopic device which when released at the launching of the missile automatically moves to the true vertical direction and continues to indicate this vertical direction irrespective of the movements of the missile in space. Alternatively it would be possible to use a conventional direction reference gyroscope, which before the launching of the missile, that is when the missile is disposed in the launcher coupled to the sighting device, is rotated by servomotors controlled in response to the rotation of the sighting device and the launcher during the target catching and tracking phase before the launching of the missile in such a manner that the reference direction of the gyroscope is always kept vertical as long as the missile is positioned in the launcher. Consequently, at the launching of the missile the gyro will be released with its reference direction vertical and will therefore continue to indicate this true vertical direction in the launched missile.

However, gyroscopic devices of the types described above for indicating the true vertical direction in the launched missile are comparatively complicated, wherefore it would be highly desired to make it possible to use more simple gyroscope devices in the missile. It is appreciated that one wishes to make the components and equipment in the missile as simple and cheap as possible equipments order to minimize the dimensions and the weight of the missile and also to reduce the costs of the missile, which constitutes the consumption part of the anti-aircraft system.

SUMMARY OF THE INVENTION

A primary object of the present invention is therefore to provide an improved guidance system for an anti-aircraft missile of the general type described in the foregoing, which makes it possible to use a more simple gyroscope device as a directional reference within the missile.

According to the invention one uses within the missile a simple direction reference gyroscope which before the launching of the missile, that is when the missile is positioned in the launcher coupled to the sighting device, is kept locked in the missile with its reference direction perpendicular to the longitudinal axis of the missile, that is also perpendicular to the direction of launching and thus to the sight-line, and lying in a plane parallel to the plane defined by the sight-line and the azimuth or yaw axis of the sight-line, that is in the vertical plane through the longitudinal axis of the missile if it is assumed that the sighting device is disposed with the yaw axis of the sight-line vertical. When the missile is launched, the gyroscope is released in this position and will consequently during the subsequent flight of the missile keep its reference direction parallel to the direction it had at the launching of the missile. The rudder or flight control means of the missile are then, as conventional, arranged to influence the direction of flight of the missile in the reference plane perpendicular to the reference direction of the gyroscope, in the following called the yaw plane, in response to a yaw control signal and to influence the direction of flight of the missile in the plane through the longitudinal axis of the missile perpendicular to the yaw plane, in the following called the pitch plane, in response to a pitch control signal. It is realized that the yaw plane of the missile will always remain parallel to the reference plane which is perpendicular to the reference direction of the gyroscope at the instant of launch and which was parallel to the sight-line and the yaw axis of the sight-line at the instant of launch.

It is realized that the use of a gyroscope device of the simple type described above in the missile will give cause to serious difficulties in the guidance of the missile, if one, as conventional, determines the deviation of the missile from the sight-line in the horizontal and vertical directions and produces a yaw control signal representing the deviation of the missile from the sight-line in the horizontal direction and a pitch control signal representing the deviation of the missile from the sight-line in the vertical direction. The reasons for these difficulties are that during the guidance of the launched missile towards the moving target the sight-line will obviously be rotated, generally both in azimuth and in elevation, away from its direction at the instant of launch. This rotation of the sight-line causes that the horizontal direction relative to the sight-line will diverge more and more from the yaw control plane of the missile as determined by the gyroscope in the missile. The same is true also for the vertical direction relative to the sight-line, which will also diverge from the pitch control plane of the missile as determined by the gyroscope in the missile. Therefore, signals representing the deviations of the missile from the sight-line in the horizontal and the vertical directions, respectively, can not be used for controlling the flight of the missile in the yaw plane and the pitch plane, respectively, as determined by the gyroscope in the missile, as this would give as a result that the missile would be forced to move in a helical flight path about the sight-line; and this helical flight path might in the unfavourable case become divergent so that the missile is removed more and more...
from the sight-line instead of being brought closer to
the sight-line.

The geometric relations discussed above are illus-
trated in FIG. 2 in the accompanying drawings.

The reference characters used in FIG. 2 have follow-
ing significations; the index o being used to indicate
the values of various quantities at the instant of launch for
the missile:
O is the position or site of the sighting device and the
launcher;
M is the target;
$[x_o, y_o, z_o]$ is a ground-fixed coordinate system having
its origin located in the sighting device and its $z_o$
axis extending downwards and coinciding with the
azimuth yaw axis of the sight-line. For the sake of
simplicity and in order to facilitate the description
it is assumed that the yaw axis of the sight-line is
vertical and that, consequently, also the $z_o$-axis is
vertical, whereby the $x_o$-axis and the $y_o$-axis will lie
in the horizontal plane. It shall be noticed, how-
ever, that the discussions and calculations in the
following are valid and true irrespective of this
assumption, that is irrespective of whether the sight-
ing device is positioned with its yaw exactly vertical
or not;
R is the direction vector from the sighting device to
the target;
$\chi, \gamma$ are the directional angles of the target vector R
in the ground-fixed coordinate system $[x_o, y_o, z_o]$;
$[x_r, y_r, z_r]$ is a sight-fixed coordinate system having
its origin located in the sighting device, its $x_r$-axis
coinciding with the sight-line and its $y_r$-axis lying in
the same plane as the $x_o$ and $y_o$-axes of the ground-
fixed coordinate system, that is in the horizontal
plane with the assumption made above. It shall be
noticed that the sight-line coincides with the target
vector R, as the sight-line is kept permanently
pointing at the target, and that consequently the
$y_r$-axis constitutes the elevation or pitch axis of the
sight-line. Further, it is assumed that the angular
deviation of the missile from the sight-line is small;
A is the plane defined by the sight-line (the target
vector $R_o$) and the elevation or pitch yaw axis of the
sighting device (the $y_{ao}$-axis) at the instant of
launch (indicated by the index o) for the missile;
B is a plane perpendicular to the sight-line (the target
vector R) and containing the $y_r$-axis and the $z_r$-axis
at a later point of time after the launching of the
missile;
$y_{ab}$ is the line of intersection between the planes A
and B;
$\phi$ is the angle between the $y_r$-axis and the intersection
line $y_{ab}$.

It is realized that, when using the above described
simple direction reference gyroscope device in the
missile, the gyroscope will at the instant of launch for
the missile be released in a position with its reference
direction coinciding with the $z_{ao}$-axis and will conse-
quently define the plane A perpendicular thereto as its
reference plane, wherefore the yaw control plane of
the launched missile will always remain parallel to the
plane A during the entire flight of the missile. If then,
as conventional in the prior art, the deviation of the
missile from the sight-line is determined in, respect-
ively, the horizontal and vertical directions, the devia-
tion of the missile from the sight-line at a later point
of time will obviously not be determined in the yaw con-
trol plane A of the missile but instead in the direction
of the horizontal $y_r$-axis, which no longer lies in the
plane A. Consequently, if the deviation of the missile
from the sight-line is determined in a coordinate sys-
tem, which lies in a plane perpendicular to the sight-
line and has a first axis always horizontal and a second
axis always vertical, the azimuth or yaw deviation of
the missile from the sight-line will be determined in the
direction of the $y_r$-axis, whereas on the other hand the
resulting yaw control of the missile will take place in the
direction $y_{ab}$ which lies in the yaw control plane A of
the missile. The corresponding phenomenon will ap-
pear in determining the deviation of the missile in the
vertical direction from the sight-line and in the result-
ing pitch control of the missile. It is appreciated that
this phenomenon will cause an incorrect control of the
flight of the missile, and this error in the control of the
flight of the missile will become the larger the more
sight-line diverges in azimuth and elevation from its
original direction at the instant of launch for the mis-
sile. This incorrect control of the flight of the missile
gives as a result that the missile is caused to fly in a heli-
cal path about the sight-line and if the error, that is the
angular deviation between the $y_r$-direction and the $y_{ao}$
direction, becomes sufficiently large, the helical flight
path of the missile about the sight-line will become di-
vergent, whereby the missile will move away from the
sight-line.

According to the present invention this problem is
eliminated in that the deviation of the missile from the
sight-line is determined in an orthogonal coordinate
system which lies in a plane perpendicular to the sight-
line with its origin on the sight-line and which at the in-
stant of launch for the missile has a first axis parallel to
the elevation or pitch axis of the sight-line, that is par-
allel to the $y_{ao}$-axis in FIG. 2, but which after the launch-
ing of the missile is rotated through the angle $\phi$ about
the sight-line so that said first axis of the coordinate sys-
tem will always lie in the yaw control plane A of the
missile, that be parallel to the direction $y_{ao}$ in FIG. 2.
It is realized that the angle $\phi$ will vary during the flight
of the missile dependent on the continuous movement
of the sight-line from its direction at the launch and
that, consequently, the coordinate system used for de-
termining the deviation of the missile from the sight-
line must be continuously rotated about the sight-line
during the guidance of the missile towards the target.
The rotation of the coordinate system used for deter-
mining the deviation of the missile from the sight-line
and for producing corresponding yaw and pitch control
signals for the flight control means of the missile can be
accomplished in various ways, primarily depending on
the type of system used for determining the deviation
of the missile from the sight-line. In a simple system
of the type described in the foregoing, in which one uses
an optical sighting device provided with a hairline cross
or similar reticle means visible in the field of view of the
sighting device and signal generators manually oper-
ated by the operator of the sighting device, the inven-
tion may be put into practice in that the hairline cross
or the corresponding reticle means visible in the field of
view of the sighting device is rotated relative to the
sighting device about the sight-line by the angle $\phi$.
However, this will of course mean that the hairline
cross or corresponding reticle means will be tilted by
the angle $\phi$ relative to the horizontal and vertical direc-
tions, respectively, in the field of view of the sighting
device. This may be confusing to the sight operator,
wherefore it may be advantageous to let the hair-line
cross or the corresponding reticle means remain fixed
relative to the sighting device so that it will always in-
dicate the horizontal and vertical directions, respec-
tively, in the field of view, in which case the operator es-

timates in conventional manner the deviation of the
mishile from the sight-line in the horizontal and vertical di-
rections, respectively, and by means of the manually
operated signal generators produces signals representing
the deviations of the missile from the sight-line in the
horizontal and vertical directions, respectively. These
signals are subsequently converted into the de-
sired yaw and pitch control signals, respectively, for the
flight control means of the missile by the use of con-
tventional coordinated transforming circuits, which per-
form the calculations
\[ s = x \cos \phi - y \sin \phi \]
\[ h = x \sin \phi + y \cos \phi \]
where \( s \) is the desired yaw control signal for the flight
control means of the missile, \( h \) is the desired pitch con-


To calculate the angle \( \phi \), this expression is certainly not exact, but for the values of the angles \( \gamma, \gamma_0, \chi, \chi_0 \) occurring in practice it gives values for the angle \( \phi \) which differ very little from the exact values according to the expression (3).

One has arrived at this more simple expression for
calculating the value of the angle \( \phi \) by studying the gen-
eral motions equations for the missile. Using a mis-
sile-fixed coordinate system having its origin in the cen-
ter of gravity of the missile, its \( x \)-axis coinciding with
the longitudinal direction of the missile and positive in the
direction of flight of the missile, its \( y \)-axis positive to the
right and its \( z \)-axis positive downwards and a ground-
parallel coordinate system having its origin in the cen-
ter of gravity of the missile and its axes parallel to the
axes of the ground-fixed coordinate system \([x, y, z]\)
used in FIG. 2 it is possible to formulate the following
relation for the attitude angles of the missile in the


When using a beam-riding guidance system of the
type described in the foregoing invention is most
simply put into practice in that the transmitted guid-
ance beam is rotated by the angle \( \phi \) around its
central axis, which coincides with the sight-line. For radio-
or radar-frequency guidance beams this rotation can be
accomplished by rotation of the transmitter antennas
for the guidance beam, whereas a light-frequency
guidance beam the rotation of the beam can be accom-
plished by means of optical members in the guidance
beam transmitter, as for instance so called dove prisms,
which rotate the optical radiation beam about its cen-
tral axis.

For putting the invention into practice it is obviously
necessary to calculate the value of the angle \( \phi \). From
FIG. 2 the following equations can be formulated
for the unitary vectors:
\[ \hat{y}_a \cdot \hat{z}_s = 0 \quad (\hat{y}_a \text{ is perpendicular to the plane } A) \]
\[ \hat{y}_b = \hat{y}_a \cos \phi + \hat{z}_s \sin \phi \]

\[ \tau \phi = \frac{\sin \gamma, \sin (\chi - \chi_0)}{\sin \gamma, \cos (\chi - \chi_0) + \cos \gamma, \gamma_0} \]

This expression (3) for the value of the angle \( \phi \) is
exact and can obviously be calculated in the sighting
device, as all directional angles \( \gamma, \gamma_0, \chi, \chi_0 \) for the
sight-line can be measured at the sighting device by
means of suitable transducers or sensors of a type de-
pending on the design of the sighting device being used.

However, the expression (3) for the value of the
angle \( \phi \) is obviously comparatively complicated and
would require a rather complicated computer for its
calculating. Therefore, it would be preferable to be
able to use a more simple expression for calculating the
value of the angle \( \phi \) so that a smaller and simpler com-
puter could be used in the sighting device for this pur-
pose.

The present invention provides also such a much sim-
er expression for the calculation of the value of the
angle \( \phi \).
Consequently, according to the invention one uses preferably the simple expression (7) given above for calculating the value of the angle $\phi$. It is appreciated that this expression can be calculated by employing very simple computing circuits and that it only requires that the elevation angle $\gamma_e$ of the sight-line at the instant of launch and the variation of the azimuth angle ($\chi - \chi_0$) of the sight-line during the flight of the missile are measured.

The structural design in detail of the guidance system according to the invention has not been described in detail, as it is appreciated that it will be very much dependent on the structural design of the sighting device used and of the system used for determining the deviation of the missile from the sight-line, for instance the beam-riding guidance system being used. The practical design of a guidance system according to the invention should not involve any problems for someone skilled in the art guided by the foregoing description of the invention, in particular if the approximative expression (7) for the value of the angle $\phi$ is used. FIG. 3 shows by way of example and only for illustrative purposes a schematic block diagram of a guidance system for an anti-aircraft missile embodying the invention. The drawing shows the sighting device or instrument 3 and the missile 2. As discussed in the foregoing the sighting instrument can be rotated in azimuth about an azimuth axis $\chi_2$ and in elevation about an elevation axis $\chi_3$. In conventional manner an azimuth angle transducer AT is coupled to the sighting instrument so as to sense the rotation of the sighting instrument about the azimuth axis $\chi_2$ and to produce an output signal representing the rotation angle $\omega$ of the sighting instrument and thus of the sight-line about the azimuth axis. In similar manner an elevation angle transducer ET is coupled to the sighting instrument so as to sense the rotation of the sighting instrument about the elevation axis $\chi_3$, and to produce an output signal representing the rotation angle $\gamma$ of the sighting instrument and thus of the sight-line about the elevation axis $\chi_3$.

By way of example and for illustrative purposes only it is assumed that in the illustrated guidance system the means for determining the deviation of the launched missile from the sight-line of the sighting instrument 3 is of the type described in U.S. pat. No. 3,513,315 (Bofors). Consequently the sighting instrument includes a guidance beam transmitter, which emits in the direction of the sight-line of the sighting instrument an optical guidance beam comprising a pattern of luminous and non-luminous sectors defining a two-axes orthogonal coordinate system perpendicular to the direction of the guidance beam GB and thus the sight-line of the sighting instrument. Further and as described in U.S. pat. No. 3,513,315 the missile 2 includes a photocell PC, for sensing the optical guidance beam and producing a corresponding output signal, which is supplied to a deviation signal generating circuitry DS, which processes the output signal of the photocell and produces a yaw deviation signal representing the deviation of the missile from the sight-line of the sighting instrument in the direction of the one axis of the above-mentioned coordinate system and a pitch deviation signal representing the deviation of the missile from the sight-line in the direction of the second axis of said coordinate system.

The output signals from the deviation signal generating circuitry DS, which signals represent the deviations of the missile from the sight-line of the sighting instrument in the axis-directions of the coordinate system defined by the guidance beam, are supplied to the flight control means FC of the missile, which process said signals and operate the steering means of the missile, as for instance rudder or steering wings, in response to the deviation signals so as to steer the missile in a yaw control plane and a pitch control plane in a direction reducing the deviation of the missile from the sight-line. By way of example and for illustrative purposes only it can be appreciated that these flight control means FC are of the type described in the U.S. pat. No. 3,708,139. The flight control means receive information about the attitude of the missile relative to the yaw and pitch control planes from the attitude sensing direction reference gyro RG mounted in the missile. As discussed in the foregoing, this direction reference gyro RG has a locked position in the missile before the launching of the missile (when the missile is still located in the launcher) which position is such that the reference direction of the gyro is perpendicular to the plane which is parallel to the elevation axis of the sighting instrument and the launching direction of the missile launcher. At the launching of the missile the gyro is released in said position and will subsequently during the flight of the missile continuously define a plane extending through the longitudinal axis of the missile perpendicularly to the reference direction of the gyro as the yaw control plane for the flight control means and a plane extending through the longitudinal axis of the missile perpendicularly to said yaw control plane as the pitch control plane for the flight control means and provide the flight control means with an attitude signal representing the attitude of the missile relative to said yaw and pitch control planes.

As previously discussed, the above-mentioned orthogonal coordinate system of the guidance beam shall be rotated by the angle $\phi$ during the flight of the missile so as to "match" the orientation of the yaw and pitch control planes defined by the direction reference gyro in the missile 2. For this purpose the sighting instrument 3 is provided with a coordinate rotator CR. If, as assumed above, the guidance beam transmitter BT is of the type described in U.S. pat. No. 3,513,315, this coordinate rotator may preferably rotate the reticle means in the guidance beam transmitter BT, which produces the coordinate system determining pattern of the emitted optical guidance beam. The coordinate rotator is responsive to a signal representing the value of the coordinate rotation angle $\tau$ from an angle $\phi$ calculator, which as inputs receives the angles $\omega$ and $\gamma$ from the azimuth angle transducer and the elevation angle transducer, respectively, and calculates the value of the angle $\phi$ in accordance with the expressions given in the foregoing for the angle $\phi$.

We claim:

1. In a guidance system for an anti-aircraft missile adapted to be launched from a launching device, comprising a sighting device disposed close to said launching device and having a sight-line movable about an azimuth axis and an elevation axis perpendicular to the azimuth axis and intended to be kept pointing at a target during the guidance of a launched missile towards the target, said launching device being coupled to said sighting device so as to have its launching direction substantially parallel to the direction of said sight-line at the instant of launching the missile; means for deter-
to define a plane perpendicular to its reference direction as said yaw control plane for said flight control means, and that after the launching of the missile said coordinate system is rotated about the sight-line through an angle \( \phi \) in response to the movements of the sight-line of the sighting device, the value of said angle \( \phi \) corresponding at least approximately to the expression

\[
\tan \phi = \frac{\sin \gamma_0 \sin (\chi - \chi_0)}{\sin \gamma_0 \sin (\chi - \chi_0) + \cos \gamma_0}
\]

where \( \chi \) is the directional angle of the sight-line about its azimuth axis, \( \chi_0 \) is the value of the angle \( \chi \) at the instant of launch, \( \gamma \) is the directional angle of the sight-line about its elevation axis and \( \gamma_0 \) is the value of the angle \( \gamma \) at the instant of launch.

2. A guidance system as claimed in claim 1, wherein the value of the angle \( \phi \) is determined by the expression

\[
\phi = (\chi - \chi_0) \sin \gamma_0
\]
as an approximation to the expression

\[
\tan \phi = \frac{\sin \gamma_0 \sin (\lambda - \lambda_0)}{\sin \gamma_0 \cos (\lambda - \lambda_0) + \cos \gamma_0}
\]

* * * * *