

Description

The invention relates to a method in accordance with the definition of the species of claim 1.

Such a method is known from US-A-3 695 555 for an end-phase-guidable artillery projectile or from GB-A-1 605 007 for a projectile in the type of construction of a target-seeking torpedo. However, the invention relates more especially to end-phase-guidable projectiles as are known as submunition from DEFENSE ELECTRONICS, June 1984 issue, page 102.

In control technology respects the simplest conditions for the manoeuvrability of such a projectile emerge if associated with a crossed pair of tail control surfaces is a likewise crossed pair of gliding wings which are considerably larger relative to the control surfaces. Since the firing or launching respectively of the projectiles for constructional reasons cannot be effected with extended control surfaces and gliding surfaces, on the other hand a calibre limitation for the design of the projectile and the space requirement for the warhead and the target-seeking control mechanisms do not make the necessary space for the swinging-in of large gliding wings available, whilst the desirable large aerodynamic gliding wing performance is not achievable with only small gliding wings, one has to be content, in the case of projectiles of the type preferably contemplated for the present invention, with horizontal gliding wings.

As explained in more detail below with reference to Fig. 1, on account of the lack of vertically aligned gliding surfaces the manoeuvrability in the yaw direction (thus in lateral swivelling of the longitudinal axis of the projectile) out of an actually afforded flight attitude is extremely restricted. For homing in on a laterally distant target, therefore, a swivelling of the lift vector out of the vertical in the direction of the target at a distance laterally ahead is necessary, which calls for a correspondingly severe rolling motion of the projectile about its longitudinal axis. However, because such a projectile does not represent a flow-dynamically symmetrical body, each variation of the roll position has repercussions on other aerodynamic influences and thus undesired repercussions on the flight behaviour. These repercussions are non-linear, and more especially severe in the case of large angles of roll; which calls for large adjustment expenditure for the control of the individual flight-critical components, in order to be able to carry out a predetermined manoeuvre in a flight-stable manner. However, upon the transition from rapid gliding-flight motion into a steep descent path for homing in on an acquired target particularly severe course manoeuvres are necessary, which can easily lead out of the stable flight behaviour; so that the projectile motion then no longer responds to the control and the target can be missed.

In recognition of these factors the problem underlying the invention is to modify the homing-in method in accordance with the species in such a way that, even with the presence of only one pair of horizontal gliding surfaces on the projectile, severe yaw manoeuvres for the rapid homing in on the target can be carried out, without running the risk that the flight behaviour thereby becomes unstable, the projectile can thus no longer, or at any rate no longer in the desirable time behaviour, be steered into the target.

This problem is solved, in the case of a method of the type in accordance with the species, essentially in that the measures in accordance with the characterising part of claim 1 are taken; i.e. the resulting aerodynamic wing force is swivelled in the sense of a minimising of the angle of roll in the yaw target direction.

This solution is based on the realisation that the lateral homing in on a target out of the search gliding flight path is anyway bound up with a descent motion; that it is thus not absolutely necessary to maintain the upwardly directed vector of the lift afforded during the gliding flight path also still upon the transverse-inclination yaw control. Instead, by correspondingly oppositely-directed control of the horizontal tail control surfaces the gliding-surface incident flow is so deflected that an aerodynamic negative lift takes effect on the projectile. The then still necessary transverse inclination (rolling motion) for the yaw steering of the flight direction onto the target to be taken aim at is small, more especially very much smaller than upon the swivelling of a maintained lift vector. Thus, despite severe yaw manoeuvres only slight angles of roll are necessary; and since lesser angles of roll have only very slight repercussions on the flight and control behaviour of the projectile, the manoeuvring thereof is less critical, thus the expenditure for the necessary adjustment and control mechanisms of a projectile which is also manoeuvrable in the end phase of the descent is considerably less. What is advantageous in the case of the solution in accordance with the invention is, in addition to this, the fact that the transition from the gliding flight path into the descent path can as a result of transition from lift to negative lift commence very much more steeply. This is of importance more especially in the case of high horizontal closing speed to the target, in order not to fly beyond the position of the target and therefore to miss this, if severe turning manoeuvres are not possible.

On the other hand, a transition from lift to negative lift is not effected or is merely delayed, thus at any rate initially the lift is maintained, if either the target to be homed in on has anyway already been discerned almost ahead, thus at only a small yaw angle, or else if, with too early change-over to negative lift, the danger exists that the now pancaking flight path is no longer sufficient for bridging a target distance which is still great.

Even if the target at a great instantaneously afforded distance carries out escape movements, it can be advantageous, despite target acquisition, initially still to maintain the lift, thus the glide path, until the distance is sufficiently reduced for optimum transition into a steep descent path. The appropriate change-over criteria can readily be derived from the information such as target distance and line-of-sight inclination or respectively line-of-sight angle-of-rotation speed, which is anyway obtained and evaluated by the seeker head or respectively by the control mechanism, connected subsequently to it, for the collision-course control (proportional navigation in the end-flight phase) on board the projectile.

Additional alternatives and further developments as well as further features and advantages of the invention will become apparent from the further claims and, also taking into account what is set forth in the abstract, from the following description of a preferred example of realisation, shown in the drawings along with a restriction to that which is essential in a severely abstracted manner and not quite true to scale, in exercise of the measures in accordance with the invention.

Fig. 1 shows in side view a projectile, capable of gliding and controllable, with gliding surfaces restricted to the horizontal plane,

Fig. 2 shows in rearward view a projectile in accordance with Fig. 1 upon the homing in on a target acquired laterally ahead, along with representation of the rolling procedure for the swinging-in into the lateral displacement direction in the event of conventional lift control and in the event of negative lift control in accordance with the invention, and

Fig. 3 shows a vertical plane through the gliding flight path of the projectile and the position of the target acquired by it.

The projectile shown in side view in Fig. 1 is equipped with crossed control surfaces 2, 3, thus ones aligned horizontally and vertically in pairs, and with a pair of gliding surfaces 4 which extend only horizontally and which are approximately symmetrical in cross-section. From an oppositely-directed incidence e.g. of the horizontal control surfaces 2 there results a rolling motion 5 about the longitudinal axis 6 of the projectile. Oppositely-directed incidence components of the horizontal control surfaces 2 in the direction shown in a fully solid line in Fig. 1 cause an incident flow 7 of the gliding surfaces 4, from which a lift 8 of the projectile 1, contrary to the force of gravity directed towards the centre of the earth, results; and in the case of which it is thus a matter of the normal mode of operation for a gliding flight, aligned approximately parallel to the target area 15, of the projectile 1. On the other hand, an incidence of both horizontal control surfaces 2 in the angular direction indicated in broken lines in Fig. 1 leads to an incident flow 7' of the gliding surfaces 4,

from which a negative lift 9 of the projectile 1, thus an aerodynamic assistance of the motion component in the direction of the gravitation and thus a steep plunging out of the glide path 13 into a diving descent path 19 (Fig. 3) results. Thus, by way of the incidence of the horizontal control surfaces 2, a pitching motion 10 of the projectile 1 about the transverse axis 11 through a centre of gravity 12 is controllable.

For severe yaw motions 13 about the centre-of-gravity vertical axis 14 the relatively small surface area of the vertical control surfaces 3 and the transverse force resulting from the lateral blowing against of the narrow fuselage of the projectile 1 are not sufficient, since these are not assisted aerodynamically by identically aligned incident-flow surfaces (thus by wings transversely to the horizontal surfaces 4).

For changes of course (yaw motions 13) it is therefore necessary - as is known as such from the conventional aircraft control - to roll the projectile 1 by means of the control surfaces 2 into a transverse inclination, thus to carry out a rolling motion 5, until the horizontal surfaces 4 also have adequate inclination components in the vertical direction; then the incident flow 7, thus the now correspondingly laterally inclined vector of the lift 8, leads to a curving flight controlled substantially again by way of the horizontal control surfaces 2; until the longitudinal axis 6 has assumed the new flight direction and the rolling motion 5 can therefore again be cancelled as far as into the normal horizontal position.

The representation sequence in Fig. 2 at the top corresponds to this conventional manoeuvre of a transverse inclination for the performance of fairly large lateral changes in course. At the instant shown top left in Fig. 2 (to which the representation in Fig. 3 corresponds) the projectile 1 shown in rearward view acquired from its instantaneous glide path 18 over the target area 15 by means of its swivellable seeker head 16 (Fig. 1) laterally ahead a target 17 to be combatted. Whereas, for homing in on the target 17, the pitching motion 10 in the horizontal plane (in accordance with the representation in Fig. 1) is effected by the control of the horizontal control surfaces 2 - preferably in the interests of the steepest possible target approach with delayed pitching motion 10, as shown further in more detail in GB-A-2 134 632 of the applicant -, upon conventional transverse-inclination manoeuvre the lateral course correction in accordance with the upper representation in Fig. 2 requires a rolling motion 5 amounting to almost 180°; in order namely in the course of the target approach to swivel the vector of the lift 8, still directed perpendicularly upwards on the glide path 18, in the direction of the target 17 to be homed in on, as indicated by the arrow for the swivelled lift 8' in Fig. 2 to the right back (beyond the plane of the representation of the projectile 1 top left).

If, on the other hand, for homing in on the target the horizontal control surfaces 2 are changed over to negative lift, as expressed in the case of the lower manoeuvre representation in Fig. 2, for the yaw motion out of the instantaneous glide path 18 it needs an oppositely-directed transverse inclination, thus an oppositely-directed rolling motion 5' of the projectile 1. Since now the decisive acceleration component for the approach to the target 17, namely the negative lift 9, already has the correct alignment, the counter angle of roll 5' necessary - as also emerges from the symbolic representation in Fig. 2 - is perforce considerably less than the angle of roll 5 in the case of the conventional transverse inclination during maintenance of the lift 8. However, the reduced necessary angle of the rolling motion 5' means, as mentioned in the preamble, a better manoeuvring behaviour of the projectile 1 and thus a better controllable and yet also more rapid transition from the glide path 18 into the descent path 19; which is important more especially when the horizontal target distance 20 (transversely to the plane of representation of Fig. 2; see Fig. 3) upon target acquisition and change-over to negative lift 9 is still relatively slight, thus out of high gliding-flight speed of the projectile 1 hard yawing manoeuvres become necessary for changing the flight direction towards the target 17.

On the other hand, it is advantageous upon target acquisition at any rate initially still to maintain the incidence of the horizontal control surfaces 2 for lift (thus in the control mechanism 21, carried by the seeker head 16, for the incidence of the horizontal control surfaces 2 still not immediately to change over to negative-lift transverse inclination), when the target distance 20 is still very great or respectively by reason of an escape movement 22 of the target 17 is not reduced or at any rate reduced only relatively little. This is because in these cases for a later steepest possible (thus in munition technology respects the most effective possible) descent path 19 initially a continuation of the rapid gliding flight in the path 18, to reduce the target distance 20, is still desirable.

However, the flying-body motion along the glide path 18 needs an aerodynamic lift 3 to compensate for the gravitation. The projectile 1 would thus pancake out of an initial glide path 18 and be able to reach the target 17 only in a shallow approach or no longer at all, if - despite afforded target acquisition by means of the seeker head 16 - the horizontal distance 20 for the desired course of the descent path 19 to be taken under negative lift 9 is still too great.

Likewise a change-over to negative lift is not necessary, or respectively necessary only in the very last phase of the descent path 19 - thus severely delayed -, when the acquired target (in accordance with Fig. 3) is almost in the vertical plane through the instantaneous glide path 18, thus only a slight yaw course correction and accordingly only

a slight rolling motion 5 with maintained vectorial direction of the lift 8 is necessary.



Patent claims

1. A method for homing in on a target (17) located laterally ahead out of the gliding flight path of a projectile (1) equipped with a seeker head (16), with control surfaces (2, 3) and with horizontal gliding surfaces (4), along with performance of a rolling motion for the yaw manoeuvre, characterised in that for the transition from the gliding flight path into a yaw-manoeuvre descent path (19) the control surfaces are changed over, along with oppositely-directed rolling motion (5'), from lift to negative lift (9).

2. A method according to Claim 1, characterised in that the change over to negative lift is effected only when or respectively not until the target-displacement yaw angle along with negative lift necessitates an angle of roll for the yaw manoeuvre which is amountwise at any rate not substantially greater than during maintenance of the gliding flight lift.

3. A method according to Claim 1 or 2, characterised in that the change over to negative lift is effected only when or respectively not until a predetermined horizontal target distance (20) is fallen below.

4. A method according to one of the preceding claims, characterised in that the change over to negative lift is effected only when or respectively not until a predetermined vertical target distance is not yet fallen below.