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(54) **Method of compensating for target location changes when firing ballistic missiles**

(57) Changes in the location of targets when firing ballistic missiles from firing devices aligned with respect to a particular target position can be compensated for without the need to realign the firing devices by establishing trajectory correction values which take into account the relation between the firing direction of the firing device and the expected position of the target when a missile fired in the firing direction will reach the position the firing direction was set for the missile to reach. These correction values are introduced before or at firing into an electronic storage means of the missile and after a predetermined time of flight cause the trajectory of the missile to be altered so that it is redirected towards the target's expected position by release of signals from the electronic storage means to trajectory adjusting means of the missile, such as fins, auxiliary rockets or jet-deflecting devices.

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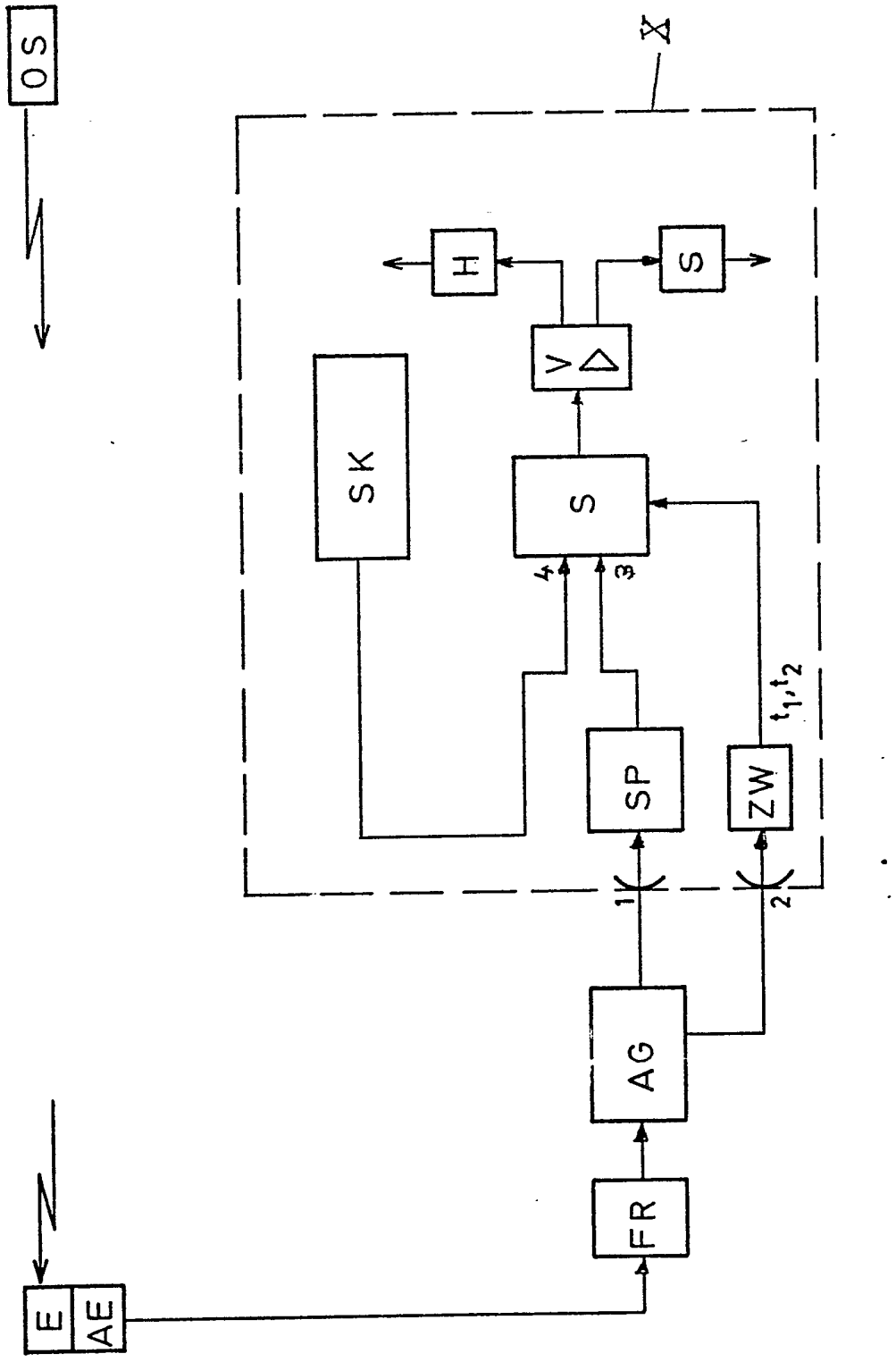

SPECIFICATION

Method of compensating for target location changes when firing ballistic missiles

This invention relates to a method of compensating for target location changes when firing ballistic missiles.

Remotely guided missiles are known whose flight path onto a target is controlled during their flight by radio signal transmission from a separate signal trnasmitter. Furthermore, self-guiding missiles are known which automatically undergo changes in trajectory by comparison of the actual position of the target at any time with the theoretical position of the target according to a programme through use of a flight programme with which they are equipped. The launching or firing direction of these missiles in relation to the target to be attacked is, in such cases, of secondary importance, because of the changes in trajectory which are possible automatically or by remote control during the flight. The cost of equipping and operating missiles of this type is, however, so great that the use of these guided missiles is relatively limited.

Unguided missiles, generally termed ballistic missiles are used in very much larger numbers, on account of their comparatively simple construction. These missiles are launched by means of a launcher or fired by means of a firing device, depending on whether they are rockets or shells. In the interests of succinctness, the term "firing device" or "discharge" is used in the following description, even if the ballistic missile is a rocket, that is, fired from a launcher, as is advantageously the case.

With ballistic missiles, it is necessary to direct the firing device towards the position at the time of firing of the target to be attacked taking into consideration both the required direction and the required range. The need to be constantly re-adjusting the firing device from one firing direction and range into another, the so-called realignment, requires considerable expenditure of time in many cases, especially when using firing devices of a relatively simple construction. Hitherto, this time factor was not in practice a problem since ballistic missiles have so far been used, for example, almost exclusively against stationary targets, or more particularly as weapons for scattering or bursting over an area. In contrast realignment is a characteristic component of the reaction time when using electronic means with modern weapon systems and is not a matter of concern here. It has now become common practice for ballistic missiles to be guided in the final phases of their flight when directed against mobile separate targets and hence the "reaction time" factor, in giving the missiles their initial alignment, has assumed greater importance.

A particular situation in which it is necessary to attempt to obtain a shortest possible reaction time is when targets such as tanks, lorries or ships moving on land or on the water in a more or less regular surface formation are to be attacked. Generally, such targets can only be effectively attacked, even with optimal reconnaissance and using a ballistic missile with final phase guiding, when a reaction time in the range of one or more minutes is achieved.

In another tactical situation, the target objectives successively approach the firing position in "in line" formations. The "in line" formations result from travel taking place along geographically established "deployment routes", such as roads, tracks, bridges or even rivers. In this case, the possible target areas have to be established in advance of the arrival of the targets in the areas in order that a shortest possible reaction time should be achieved. As a general rule, several such alternative deployment or advance routes are potentially available for each firing position. Consequently, it is necessary to allot at least one firing device to each possible route and to direct it on to the predetermined target area on this route. However, should the targets unexpectedly approach the firing position along only one of these routes, the firing devices alloted to the other routes may not be usable in practice on account of the relatively long time involved for their realignment onto a target area on such a route.

The time-wasting realignment of the firing devices is also to be avoided in the following situation. Some artillery systems carry out a missile track following procedure with pilot firings by radar in order to improve subsequently the accuracy of fire with ballistic missiles. A computer extrapolates from the plotted curve the points of impact of the different pilot firings and also the corrective firing commands for the pre-calculated "hits" of several firing devices. By this procedure, the effect of non-ballistic influences, such as wind or temperature, can be largely eliminated. Nevertheless, these correcting firing controls or orders lead to time-wasting realignment of the firing appliances.

According to the present invention, there is provided a method of compensating for target location changes when firing a ballistic missile aligned in a firing device with respect to a target position which is no longer to be reached by the target, which comprises establishing trajectory correction values which take into account the relation between the firing direction of the firing device and the expected position of the target when a missile fired in said firing direction will reach the position the firing direction is set for the missile to reach, introducing these correction values into an electronic storage means of the missile before or on firing thereof and causing the trajectory

of the missile to be altered so that it is redirected towards said expected position by release of signals from the electronic storage means to trajectory adjusting means of the missile at a prescribed instant after firing.

The method of this invention enables the afore-mentioned time-wasting realignments of firing devices for ballistic missiles, more particularly missiles for attacking separate moving targets to be avoided and, as a result, the "reaction time" factor can be reduced to a minimum. More particularly, the procedures comprised by the method of this invention make it possible to achieve a controlled influencing of the trajectory as such of ballistic missiles which may be equipped with a final-phase guiding means, without any realignment of the firing device being necessary. In this procedure, the need for realignment is, as it were, shifted from the weapon firing system into the missile, by introducing trajectory or flight path correction values for an aimed subsequent control into the missile immediately prior to or at the time of firing. This subsequent control is obtained without the need to use costly piloting devices for transmission of track-correction signals during the flight and additionally offers a greater functional reliability, since enemy measures for influencing the signal transmission would have no effect.

The method of this invention makes it necessary for the individual missiles to have electronically stored therein, just before or even at the time of firing, the anticipated target coordinates resulting from a prior reconnaissance, so that it is possible, in an extremely short time, to supply to the individual missiles a different instruction in accordance with different required target areas. For example, when the previously indicated "in-line" formation of targets takes place on only one of several possible routes of advance, the firing devices allotted to or trained on the other advance routes quickly become fully effective or alternatively can be utilised without concern for their fundamental misalignment. In addition, when targets ar following one another, the method according to the invention makes it possible to obtain a grouping of the paths or trajectories of several missiles according to height, so as to spread the "hits" the missiles make according to the configuration of the formation to be attacked. If missiles which are steered or guided in the final phase are then being used it is also possible in such a situation to achieve self-governed target selection, so that as far as possible each missile has another specific target assigned to it.

In order to enable the method according to the invention to be carried out, the ballistic missiles are provided with an electronic means which is electrically connected to the firing device before or even at the time of firing and comprises a signal store with a timing mechanism. In addition, the missiles are provided with suitable known flight influencing members, such as fins, auxiliary rockets or jet-deflecting devices, which execute the adjusting steps necessary for changing the trajectory of the missile by effecting lateral deflection and change in height and range as required at an instant in time which is introduced into the timing mechanism. These changes can take place in a single step or even in several steps and so influence the trajectory of the missile that a flight behaviour established prior to firing is produced. With missiles which are controlled or steered in the final phase, these changes have to be complete at the latest when it is time for the locating head to become effective. The delay-free electronic processing and storage of the trajectory-correcting data is preferably effected on a digital basis.

The detection of a recording of its movement, that is its position, speed and direction of movement, to provide data for use in carrying out the method of this invention may in principle be effected by observation, for example, from the firing point, the characteristic data then being introduced manually into an analysing or computing device and processed electronically in the latter or in a firing control calculator to yield correction values, which are then introduced shortly before or at the time of firing, electronically into the information storage unit of the missile. It is, however, preferred to use automatically operating location devices or sensors which, after a target to be attacked has been detected, transmit the movement data in respect thereof, preferably in the form of an electric signal transmitted by radio, without any delay to the evaluating means for further processing. Thus, according to a preferred feature of the invention, one or more locating devices effects detection of a target and recording of its position, speed and direction and radio transmission of corresponding information to an evaluating means associated with a firing control calculator for the firing device, signals received by the evaluating means together with firing control information from the firing control calculator being converted into trajectory correction values and introduced electronically into the missile with substantially no delay prior to or at the time of firing. Target detection may be achieved, for example, by using aircraft equipped with appropriate radar or infra-red observation systems.

However, detection of targets is preferably effected using location sensors which can be positioned in the ground or anchored in water. Such sensors are already in use and preferably operate in accordance with acoustic or optical principles. However, they may also respond, for example, to variations in a magnetic field, or operate using radar or infra-red signals. These latter types of sensor, however,

are additionally provided with an energy supply for them to operate and to transmit signals by radio to the evaluating unit. The location sensors can be laid on the ground or in water for example from the air by means of rockets. Laying make take place in a battle zone or immediately ahead of it. However, where the tactical situation makes this possible, positioning by hand or from a vehicle is preferred, since it is very easy in this case to determine the exact position of the sensors in relation to the location of the firing device. In the event of the location sensors being air-distributed, such a determination of the position can be subsequently carried out, as a result of the various sensors emitting test signals. The differences in the signals received will make it possible to establish the position of the sensors in relation to one another and to the at least one firing device at the intended firing point.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example only, to the accompanying drawing which shows schematically the operations involved in carrying out the method of this invention.

Referring to the drawing, the signals of a tracking sensor OS are radio-transmitted to a receiver E, decoded in an evaluating unit AE, fed into a firing control calculator FR and processed into firing commands. The commands are introduced into the firing device AG from which they are transmitted through connection 1 to signal storage means SP of missiles.

On firing the missile, a timer ZW is set in operation through connection 2. This opens input 3 to a switch S on expiration of a time t_1 after firing, so that trajectory correction values are fed into the signal storage means can be passed on through an amplifier V to an adjusting device for the operation of fins, jet guidance units etc. The drawing indicates the adjusting device to comprise two adjusting motors H and M which influence the respective fins, not shown, for effecting changes in trajectory with respect to height and lateral direction of the missile. Normally, the time interval t_1 is set to expire after the end of the driven phase of the missile. The switch S, in the case of a missile with final phase guidance by means of a tracking head SK, operates to switch from input 3 to input 4 after reaching a time t_2 after expiry of time interval t_1 so that the signal from the tracking head can effect, via the amplifier V, the operation of the adjusting device.

The missile travels ballistically until expiry of time t_1. As a result of carrying out of the method of this invention, during the time t_2-t_1, certain trajectory corrections, that is controlled auxiliary guidance, can br performed as a result of information which has been fed to the missile at the time of firing thereof. After expiry of time t_2, when the final phase before striking the target is about to begin, the tracking head SK of the final phase guidance system takes over the correction of the missile trajectory in conventional manner.

The components shown in the broken lined rectangle X of the drawings are housed in the missile. Conventional electronic equipment and circuitry for the various components shown in the diagram may be used.

CLAIMS

1. A method of compensating for target location changes when firing a ballistic missile aligned in a firing device with respect to a target position which is no longer to be reached by the target, which comprises establishing trajectory correction values which take into account the relation between the firing direction of the firing device and the expected position of the target when a missile fired in said firing direction will reach the position the firing device is set for the missile to reach, introducing these correction values into an electronic storage menas of the missile before or on firing thereof and causing the trajectory of the missile to be altered so that it is redirected towards said expected position by release of signals from the electronic storage means to trajectory adjusting means of the missile at a prescribed instant after firing.

2. A method as claimed in Claim 1, wherein the missile is equipped with fired phase steering and the said prescribed instant after firing is before said final flight phase commences.

3. A method as claimed in Claim 1 or 2, which is applied to a plurality of missiles aligned in firing devices to attack a plurality of targets successively approaching a firing position in a number of in-line formations along a number of routes, not all of which routes are being travelled over by the targets, whereby all of the missiles are directed towards targets on the route or routes being travelled over.

4. A method as claimed in any one of the preceding claims, wherein one or more locating devices effects detection of a target and recording of its position, speed and direction and radio transmission of corresponding information to an evaluating means associated with a firing control calculator for the firing device, signals received by the evaluating means together with firing control information from the firing control calculator being converted into trajectory correction values and introduced electronically into the missile with substantially no delay prior to or at the time of firing.

5. A method a claimed in Claim 4, wherein a said locating device is positioned on the ground or anchored in water.

6. A method as claimed in Claim 5 or 6, wherein a said locating device is positioned on

the ground or anchored in water in an intended battle zone or in front of the battle zone.

7. A method as claimed in Claim 5 or 6, wherein the locating device is an acoustic or optical sensor.

8. A method as claimed in Claim 1 of compensating for target location changes, when firing a ballistic missile, substantially as hereinbefore described with respect to the accompanying drawing.

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