

SEEKER-FUZE SUBMUNITION

The invention relates to a submunition for combatting armoured target objects in a target area.

- 5 A submunition of such a kind, known as a terminally-guidable projectile, for the carrier rocket system MLRS III, is for example described in the journal DEFENSE ELECTRONICS, June 1984, page 102.

- 10 What is disadvantageous about this kind of submunition is the need for great technological expenditure and thus high cost by reason of the use of a seeker head which is movable relative to the submunition structure, in order, after ejection of the submunition from the carrier, to acquire, in the subsequent free-flight phase by strip-shaped scanning of the terrain transversely
15 to the flight direction, a target object that is to be combatted, and then to home in thereon in the continuous guidance procedure.

- 20 Known from DE-OS 33 23 685 is a submunition, similar to said kind, which is ejected over the target area from its carrier, in order then to drop, suspended from the parachute, in decelerated fall into the target area and in so doing to scan this spirally for a target object that is to be combatted; and which has a parachute glide path control for the approach in a specific displacement direction to the target object detected. The
25 requisite equipment determining the direction and end-phase control of the submunition movement is, however, similarly very expensive and complex.

- 30 In addition to this, the effect of a submunition descending on the parachute is restricted, because a glide path control of the parachute yields only a limited manoeuvrability and because finally the dropping movement decelerated by the parachute both assists defence possibilities against the submunition by firing from the target object, and causes drifting out of the target area
35 by reason of air currents close to the ground.

In recognition of these factors, the problem underlying the invention is to design a submunition of said kind in such a way that, despite technologically more modest equipment compared with the terminally-guidable form of submunition, it still yields a
5 good performance (effect in the target).

To solve this problem there is provided in accordance with the present invention a manoeuvrable seeker-fuze submunition, for combatting armoured target objects in a target area, constructed
10 as a dropped projectile comprising a fixed sensor for detecting a target, and comprising a steering system for causing a gyrating or spirally wobbling movement during steep diving down into the target area as well as for end-phase course correction under guidance from the sensor for direct approach flight to a detected
15 target object; wherein the steering system is discontinuously-working and can be transiently deflected or actuated in accordance with the instantaneous target displacement direction relative to the projectile longitudinal axis; and wherein the sensors view is divided into zones and the sensor is arranged to make a zonal
20 evaluation, related to the effective direction of the steering system, of the displacement detected of the target object relative to the projectile longitudinal axis, and to actuate the steering system to bring the target object into a predetermined one of said zones.

25 Thus, the approach of the submunition, delivered by a carrier, to the target area is effected almost in free fall and thus most rapidly even from a great initial height, which reduces defence possibilities and risks of drift and makes possible the
30 rapid search of the target area along a long path, thus of a large scanning region; with transition from a scanning movement of the projectile, gyrating or spirally wobbling so that at least part of its longitudinal axis moves in an arcuate manner, (without the submunition necessarily turning or rotating about said axis) down
35 into the target area, into a terminally-corrected target-homing glide path upon detection of a target, to be combatted, by means of a sensor incorporated rigidly into the structure of the



submunition. Thus, more especially the expenditure for a swingable seeker head, for direction findings in a space-fast system of coordinates, for a braking parachute and for continuously-working target-tracking control systems is obviated.

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Instead, a direct functional coupling between the target-displacement evaluation and the aerodynamic steering system for the transition of the submunition out of its descent movement (in the manner of an object in an aeronautical spin) into the target-homing glide path can be provided; in which respect a zonal evaluation of the target displacement out of a reference zone of the sensors view (i.e. its antenna characteristic) makes possible a three position form of operation of the steering system, simple in apparatus respects, and thus an uncomplicatedly working control.

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Transverse impulse transmitters can be provided for the steering system. More advantageously, however, aerodynamic control surfaces, e.g. control flaps, are usable, which can at the same time perform gliding-wing or guiding-fin functions upon the direct homing-in on the target.

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The steering system preferably has two orthogonally orientated pairs of said control surfaces, of which at least the surfaces of one pair are also deflectable in opposite directions.

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The sensor for acquisition of a target object that is to be combatted can work actively or passively, in the infra-red region or in the millimetre-wave region, as known 'per se' for submunition seeker fuzes. For the simple evaluation of the target-object displacement from the longitudinal axis, in other words from the instantaneous orientation of the submunition, the sensors view or antenna characteristic in the target area is subdivided into separately evaluable zones. The directional displacement of the target object sighted at out of the longitudinal axis of the submunition can, however, also be

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determined by zonal evaluation at a multi-element antenna sensor, as is known as such in the form of electronically swingable mechanically stationary millimetre-wave antennae, instead of an infra-red sensor.

5 In particular the invention provides a manoeuvrable seeker-fuze submunition, for combatting armoured target objects in a target area, which can be produced technologically in a less complex and thereby more economical manner than end-phase-guidable
10 submunition rockets equipped with swivel seeker heads, but which yields a higher effect in the target than is achievable by means of a seeker-fuze submunition of a kind which incorporates a fixed sensor, is arranged to drop suspended from a parachute gyratingly into the target area and, even with expensively complex end-phase-
15 correction, has only a relatively restricted search region and is easy to combat and can easily be driven out of the target area by ground winds; the submunition of the invention being a diving-flight projectile having a fixed sensor for the control of an aerodynamic steering system (preferably in a three-position manner
20 of operation) by means of which, upon dropping from a great height above the target area the projectile is initially controlled into a wobbling movement with the longitudinal axis incided or inclined relative to the vertical for the large-area-spiral scanning of the target area; and on detection of a target object, the projectile
25 is changed-over to approximately line-of-sight target homing, in which zonal evaluation detects the movement of the target object out of the central zone of the sensor's scan, in order by way of pulse-length control to carry out, if needed, course corrections (preferably including a proportional hit-point-aim shifting) upon
30 homing-in on a moving target object.

Further developments and features, and alternatives thereto, and advantages of the invention will become apparent from the following description of a preferred example of an embodiment and
35 use of submunition in accordance with the present invention, which embodiment is described with reference to the accompanying



diagrammatic drawings which are restricted to show that which is essential in a highly abstracted manner and are not true to scale. In the drawings:-

FIGURE 1 shows the kinematics of a submunition in several consecutive operational phases;

5 FIGURE 2 shows a highly simplified example of a submunition shown in FIGURE 1; and

FIGURE 3 shows a division of the cross-sectional surface area of a sensor's view or antenna characteristic for the derivation of control information for a discontinuously end-phase-correctable
10 submunition in accordance with FIGURE 2.

By means of a carrier 1 a number of submunitions 2 is delivered over a target area 3, in which armoured target objects have been discovered or can be expected. The carrier 1 may be an
15 artillery projectile or shell, a rocket or an aircraft. Preferably, however, within the framework of the present invention, a carrier 1 is used which is a munitions container which is released from an aircraft and which then automatically continues flying as far as over the target area. The submunitions
20 2 thereof are preferably projectiles which are profiled in a flow-favourable manner, so that these fly, with low drag in an aerodynamically stable manner which can also be influenced by means of simple steering systems 5, so that the missiles can be controlled, without any problems, in their flight path,
25 particularly for end-phase homing-in on the detected target object 4.

Each submunition 2 is, after ejection from its carrier 1, to descend substantially in nose-dive, in other words along a mean
30 path approximately parallel to the perpendicular line 6, into the target area 3. To this extent it is basically immaterial in what orientation the submunitions 2 are arranged in the carrier 1 with respect to its substantially horizontal flight direction or respectively are ejected therefrom.

Since it is, however, - as will be explained in yet more detail hereinafter - expedient to initiate the nose-dive descent from the greatest possible height above the target area 3, it is advantageous, as taken into account in FIGURE 1, to arrange the projectile-shaped submunitions 2 parallel to the flight direction 7 of their carrier 1 and to eject them with such an incidence of their steering systems 5 that in a first functional phase I initially a submunition movement parallel to the flight direction 7 of the carrier 1 occurs; from which then a transition into a second functional phase II of further aerodynamic ascent ensues. When equilibrium between the gravitational force and the dynamic lift forces occurs, the path curve 8 of the submunition 2, flying on in an inertia-dictated manner after ejection from the carrier, has reached its apogee from which, with appropriate constructional setting-up of the centre-of-gravity of the submunition with respect to the dynamic point of application of its steering system 5, it changes round into the third functional phase III of the steep drop down into the target area 3. In the drawing it is not taken into account that, more especially in the case of a great initial velocity in the first phase, it can be expedient to abridge the flight path, parallel to the ground, as far as the transition into the third phase by aerodynamic braking means such as a parachute, a balloon or flaps.

A swing-in into the diving position is detectable on board the submunition 2 with the necessary accuracy by means of simple apparatus, for instance through a pendulum system for determining the inclination of the submunition longitudinal axis 10 or by the cessation of the reaction force of a mass relative to the structure of the submunition 2 upon transition into the free fall. By means of a pre-programmed control 11 containing for example such a measuring system (see FIGURE 2), now the steering system 5 is changed over in such a way that in a fourth functional phase IV in actual fact no free fall directly along the perpendicular line 6 occurs, but the submunition longitudinal axis 10 experiences, relative to this, a slight incidence along with controlling into a



swivel movement. The submunition 2 thus described during its fourth functional phase in the movement of its longitudinal axis 10 approximately the generatrix of a conical surface and thereby does not descend linearly, but in a helically wobbling rotary motion, into the target area 5.

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As a result of this aerodynamically caused precessive descent motion, the target-seeking sensor 12 describes, with its strongly bunched antenna characteristic 13, in the targetry area 3 a sequence of ranged side-by-side arcs 14 which narrow spirally with the approach of the submunition 2 to the target area. These arcs lie all the more tightly close to one another, for the most gapless possible scanning of the target area 3 for a target object 4 that is to be combatted, the less is the wobble deflection of the submunition 2, in other words the less is its incidence relative to the perpendicular 6; and the region of the spirally scanned target area 3 has, by reason of the geometric factors with a given angle of incidence, an all the greater initial radius in the target area 3, the greater is the onset height of this wobbling target-seeking motion of the submunition 2 over the target area 3, which is why the highest possible apogee 9 is to be striven after.

During this spirally narrowing scanning of the target area 3 by means of the sensor's view or antenna characteristic 13 during the fourth functional phase, upon detection of a target object 4 that is to be combatted the detection signal processing means 15, connected subsequent to the sensor 12, initiates by way of the control 11 a re-orientation of the dynamic effect of the steering system 5 to the effect that the submunition 2 in a fifth functional phase V is deflected out of the wobbling motion into a gliding direction in which, in a sixth functional phase VI, it homes-in on the just detected target object 4 directly, in other words orientated along or parallel to the direction of the view or antenna characteristic 13 upon detection of the target object 4.

In the simplified representation of the functional cycle sketch

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shown in FIGURE 1 it is not taken into account that, on account of the finite time requirement for the change-over, in the fifth functional phase it can be expedient transiently to enlarge the detection angle of the view or characteristic 13 or respectively additionally to allow a superimposed wobbling motion of the submunition 2 so that the detected target object 4 is not lost again. Equally it is not expressed in the drawings that the submunition 2 in the sixth (and seventh) phase naturally needs a lift to compensate for the earth's attraction, in other words in actual fact moves along with transverse displacement relative to the line of sight to the target. A possible incidence of the longitudinal axis 10 relative to the direct direction of sight can readily be taken into consideration in the signal processing 15.

By reason of flow-dynamic transverse influences on the submunition 2 and/or by reason of proper motions of the target object 4 homed-in on, in the sixth functional phase the target can move relative to the longitudinal axis 10 of the submunition 2 into a shifted relative position of the target object 4'. This movement out of the centre zone of the view or antenna characteristic 13 is detected, by means of the sensor 12 and of the signal processing 15 connected subsequent to it, directionwise (in structure-fast coordinates) and converted by way of the control 11 as well as the steering system 5 during a seventh functional phase VII into a discontinuous control for the end-phase course correction, for again accurate approaching of the shifted target object 4' in an eighth functional phase VIII. In the simplified sketch FIGURE 1 it is not taken into account that further such functional phases VII-VIII can follow, in order to carry out repeated end-phase corrections upon the homing-in on the target object 4'.

Upon impact of the submunition 2 on the target 4', or immediately before this, by means of the sensor 12 or of a separate triggering mechanism (not taken into account in the



drawing), the submunition warhead 16 is detonated, which preferably has at least one jet-forming insert 17 for the destruction of the armouring of the target object 4'.

As indicated in simplified manner in FIGURE 2, the steering system 5 consists for example of a simple flap arrangement. Upon the incidence thereof relative to the direction of the projectile longitudinal axis 10, an appropriate torque about the centre-of-gravity of the submunition 2 is initiated, in order to swing the longitudinal axis 10 out of the instantaneous spatial orientation. After return into the normal position parallel to the longitudinal axis 10, the flaps of the steering system again act as an aerodynamic gliding surface, so that the instantaneously assumed spatial orientation of the submunition longitudinal axis 10 is henceforth maintained as far as possible. However, also (not taken into consideration in the drawing) additionally separate gliding surfaces can be provided for this purpose.

The steering system 5 for the end-phase correction of the flight direction of the submunition 2 upon the approach to the acquired target object 4' can also be realised in some other way, for example by transverse impulse generators for swivelling the projectile longitudinal axis 10 about the centre-of-gravity of the submunition 2. The realisation of the steering system 5 by simple flaps, e.g. two orthogonally orientated pairs of flaps, has the advantage of being able to bring about both a pitching movement of the longitudinal axis 10 - namely by incidence in the same direction - and a rotary motion - namely by flap incidence in opposite directions, and thus, by simple control cycles as a result of superimposition of these influences, being able to control the submunition 2 into the described spinning motion during the fourth functional phase, which is necessary in order, by means of the sensor 12 incorporated rigidly into the structure of the submunition 2, to carry out the spiral target-area scanning along the near-circular arcs 14.

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A particularly simple electromechanical or electrofluid realisation possibility of the functional coupling between the control 11 and the steering system 5 emerges because no continuous operation of the control 11 is required, but a three-point or three-position operation (in other words enabling one deflection position on each side of the neutral or zero position) is sufficient. In the case of this, the steering system 5 is run only briefly into a defined second deflected position and, after performance of the desired manoeuvre of the submunition - in other words swivelling of its longitudinal axis 10 in space - this deflection is revoked again. The severity of the manoeuvre, in other words of the deflection, can then be influenced by a simple pulse length control. If the hinging of the steering system 5 to the structure of the submunition 2 is not arranged so that there is a stable equilibrium position, related to the aerodynamic effect of the incident flow on the flaps, then it is sufficient, by means of the control 11, to cancel a locking of the appropriate flap or flaps in a basic position so that the flap or flaps is or are then transferred, by the aerodynamic effect, into a displaced position or positions. Thereafter, the control 11 again causes a return into the basic position. Conversely, two-point operation with aerodynamically stable hinging of the steering system 5 makes possible the automatic aerodynamic return of the flaps into constructionally preset basic positions, when forces applied by the control 11 for the deflection of the flaps are switched off once more.

The three-point operation of the steering system 5 connected subsequent to the sensor 12 requires only a simple evaluation to recognise and compensate for a movement of the target object 4-4' once acquired and detected as to be combatted. For example, the cross-sectional surface area of the sensor's view or antenna characteristic 13 (FIGURE 3) can be subdivided into as many zones a, surrounding in ring-arc-shaped manner a central zone c, as different incidence directions can be triggered by means of the steering system 5. In the case of the biaxial-orthogonal system 5



shown in FIGURE 2, the flaps of which can be displaced out of the neutral-stationary position in two opposite directions, the four sectorial zones al-ar and al'-ar' in the cross-sectional area of the view or antenna characteristic 13 can be associated with the thereby possible incidence directions. So long as the detected and sighted-at target object 4 is still detected in the central zone c of the characteristic 13, the flight direction (in other words the spatial orientation of the longitudinal axis 10) of the submunition 2 is maintained (sixth functional phase in FIGURE 1). However, if the detected target object 4' shifts into one of the ring zones a of the characteristic 13, a direct hit is no longer guaranteed. Therefore now - directly initiated from the relevant ring zone a (namely ar in the exemplified instance in accordance with FIGURE 3) - by way of the control 11 that displacement or incidence of the steering system 5 is briefly triggered which, through a swivelling of the submunition longitudinal axis 10, precisely cancels this migratory movement in the cross-sectional area of the antenna characteristic 13 once more, thus by an end-phase course correction returns the target object 4', detected in its target movement, again into the central region c of the view or characteristic.

Controlled from the sensor 12, the incidence or displacement of the steering system 5 can now be cancelled again; if it is not from the very start, by reason of given geometric subordinations, linked with a pulse-length time control.

In FIGURE 3 it is further taken into consideration that it can be expedient to define at least one ring-sector-shaped transitional zone b in the view or antenna characteristic 13 between the central zone c and the respectively radially linking outer zone a. The timespan which a target object 4-4' shifting from the central zone c dwells in this intermediate zone b - or which elapses until after exit from the central zone c the entry into an outer ring zone a is ascertained - is a measure of the rate of change of relative direction between the sensor 12

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(incorporated rigidly into the submunition) and the detected target object. Derived from this measurement, the control 11 can then, as known 'per se', trigger an anticipatory or advanced re-orientation of the submunition direction of movement in the seventh functional phase; so that at least approximately a collision course in accordance with proportional navigation for a direct hit arises, and accordingly a direct hit is to be expected even upon rapid fleeing motion of the detected target object 4.

Instead of the ring-sector zone evaluation of the view or sensor characteristic 13 in accordance with FIGURE 3 also ray-shaped, or crossed lobe zone configurations can be provided, the oval cross-sections of which at the base of the target area 3 are evaluated subdivided into distance zones, in order to obtain displacement and migration information for the discontinuous end-phase flight correction of the submunition 2. In the drawing, to simplify the representation, it is also not taken into consideration that the incorporation of the sensor 12 can, in the interests of the target-homing relative to the flight position of the projectile, be such that the direction of the view or characteristic 13 is offset in relation to the missile axis; and that, for the generation of aerodynamic lift and more rapid acquisition of the once detected target object, it can be expedient to equip the submunition 2 with a small cruising engine or booster which (along with the jettisoning or discarding of possible aerodynamic braking means) is started up upon the transition into the sixth functional phase.

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CLAIMS

1. A manoeuvrable seeker-fuze submunition, for combatting armoured target objects in a target area, constructed as a dropped
5 projectile comprising a fixed sensor for detecting a target, and comprising a steering system for causing a gyrating or spirally wobbling movement during steep diving down into the target area as well as for end-phase course correction under guidance from the sensor for direct approach flight to a detected target object;
10 wherein the steering system is discontinuously-working and can be transiently deflected or actuated in accordance with the instantaneous target displacement direction relative to the projectile longitudinal axis; and wherein the sensor's view is divided into zones and the sensor is arranged to make a zonal
15 evaluation, related to the effective direction of the steering system, of the displacement of the target object relative to the projectile longitudinal axis, and to actuate the steering system to bring the target object into a predetermined one of said zones.
- 20 2. A submunition as claimed in Claim 1, wherein the steering system comprises aerodynamic control surfaces, each of which is controllable in a three position form of operation from the sensor.
- 25 3. A submunition as claimed in Claim 2, wherein the steering system has two orthogonally orientated pairs of said control surfaces, of which at least the surfaces of one pair are also deflectable in opposite directions.
- 30 4. A submunition as claimed in any preceding Claim 3, arranged to make an additional evaluation of the speed of target movement for an end-phase correction, approximated to steering for a collision with the target, of the flight direction.
- 35 5. A submunition as claimed in any one of Claims 2 to 4, providing pulse-length control for the deflection of the steering system.



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6. A submunition as claimed in any one of the preceding claims, equipped with an aerodynamic braking mechanism which is transiently effective within the functional phases between launch (e.g. carrier ejection) and target-object detection.

5 7. A submunition as claimed in any one of the preceding claims, equipped with a propulsion unit which can be started up upon target-object acquisition.

8. A submunition arranged to operate substantially as
10 hereinbefore described with reference to FIGURE 1 or FIGURES 1 and 3; or constructed substantially as hereinbefore described with reference to FIGURE 2 of the accompanying drawings.

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