

Streamer Launcher for Drone Interception

Related Applications

[001] The present invention claims priority to Singapore patent application no. 10202001202W filed on 10 February 2020, the disclosure of which is incorporated in its entirety.

Field of Invention

[002] The present invention relates to streamer launchers mountable on unmanned aerial vehicles for drone interception. In particular, the invention relates to streamer launchers for generating a streamer cloud so that a target propeller-driven drone flying into the streamer cloud can be brought down non-destructively to the ground.

Background

[003] US patent publication no. 20190285388, by Elta Systems Ltd, describes a drone interceptor system. However, there is no disclosure on construction of the streamer cannons.

[004] Most known streamer cannons or confetti cannons use compressed air or spring forces to eject streamers/confetti. Other cannons eject a net to catch the target drone.

[005] These known streamer or confetti cannons may not be suitable for use on an interceptor UAV; there is a need to provide a light-weight and compact streamer launcher specifically mountable and operable on an intercept UAV.

Summary

[006] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[007] The present invention seeks to provide a system for drone interception. In particular, streamer launchers are provided with various embodiments of streamers pushers for ejecting streamers to create streamer clouds in a flight path of a target propeller-driven UAV or drone, as defined in the claims.

[008] In one embodiment, a streamer launcher is provided, which comprises: a cylindrical launch tube made from a light-weight, fire retardant material; wherein the streamer launcher is mountable on an intercept drone, and the streamer launcher is operable to generate a streamer cloud in a flight path of a target propeller-driven drone.

[009] Preferably, the streamer launcher comprises a cartridge case fittable inside an end of the launch tube and a streamers pusher for fitting into the cartridge case. The streamer pusher has a base member and split segments that are pivotally connected to the base member, wherein an outside end-face of the base member has an impeller surface. The split segment may be cylindrical or V-shaped.

[0010] Dynamic interactions of propellant gases on the impeller surface generate a rotation on the streamer pusher. Preferably, the impeller surface has contoured reliefs that are radial; the contoured reliefs may be impeller-like or made of inclined steps.

Brief Description of the Drawings

[0011] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0012] FIG. 1A illustrates a drone interceptor system according to an embodiment of the present invention, whilst FIG. 1B illustrates a streamer launcher according to an embodiment of the drone interceptor system, and FIG. 1C illustrates an exploded view of the streamer launcher;

[0013] FIG. 2 illustrates a streamers pusher according to an embodiment of the streamer launcher;

[0014] FIG. 3 illustrates a streamers pusher with a sabot configuration;

[0015] FIG. 4A illustrates a streamers pusher with a squirrel-cage configuration, whilst FIGs. 4B and 4C illustrate the squirrel-cage walls are pivotable sideways;

[0016] FIG. 5A illustrates a streamers pusher with a petal configuration, whilst FIG. 5B illustrates the petal walls are operable to open outwardly from the base;

[0017] FIGs. 6A-6C and 7A-7C illustrate two streamers pushers with hinged segments; and

[0018] FIGs. 8A-8B illustrate a streamers pusher with an impeller surface resembling a fan blade or airfoil.

Detailed Description

[0019] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the present invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0020] FIG. 1A shows a drone interception system 10 according to an embodiment of the present invention. As shown schematically, the drone interception system 10 is made up of at least an intercept drone 40 and a ground control vehicle or station 30; preferably, the ground control vehicle 30 is unmanned, ie. a UGV or even an unmanned underwater vehicle (UUV); the ground control vehicle/station 30 may, in turn, be controlled directly by a human operator or by a human operator located in a command centre 20. The intercept drone 40, the ground control vehicle/station 30 and the command centre 20 are in wireless communication. A target drone 60 is propeller-driven, for eg., a quadcopter, such as, DJI phantom, Mavic and similar devices; the target drone 60 may be a size of about 30cm or smaller airframe, but the target drone is not so restricted by its size or propeller design.

[0021] In one embodiment, the intercept drone 40 is equipped with a radar or lidar ranging and detecting device. It is possible that the intercept drone 40 is also equipped with an optical camera or video camera for taking photographs or videos, for example, of a target drone 60 that may be near or have entered into a restricted territory or airspace. The

intercept drone 40 is also equipped with a streamer launcher 100. In use, when a target drone 60 has intruded into the restricted territory and a decision is made, for eg., at the command centre 20 or by an AI identification algorithm built into the drone interception system 10, to bring down the target drone 60, the intercept drone 40 is flown close to the target drone 60 to within striking range of the streamer launcher 100; once the intercept drone 40 is positioned and orientated with respect to the target drone 60 after considering environmental factors (such as, wind velocity and direction, etc.), the streamer launcher 100 is activated to generate a streamer cloud 105 into a flight path of the target drone 60. In the streamer cloud, a plurality of streamers 102 of predetermined lengths and strengths are suspended in the flight path for a predetermined period of time. Rotation of propellers of the target drone 60 creates suction forces, and as a result, some of the streamers 102 are sucked by the rotating propellers and due to the lengths of the streamers, some of the streamers 102 become entangled with the propellers; as a result, the entangled propellers are no longer effective or controllable, thus causing the target drone 60 to fall non-destructively to the ground.

[0022] In positioning and orientating the intercept drone 40 with respect to the target drone 60, the radar or lidar or a camera ranging and detecting device 50 is employed. The camera may also be employed, for eg., for visual feedback to the operator at the command centre 20. In addition, the ground control vehicle/station 30 may also be equipped with long-range radar or lidar to detect any incoming drone that may enter the restricted territory; it is also possible that the ground control vehicle/station 30 is also equipped with an optical system and associated electronics to allow visual detection and monitoring of such incoming drones. AI identification algorithms 101 built in the intercept drone 40, the ground control vehicle 30 or the command centre 20 may be employed to identify the target drones 60, for eg. as friends, foes or recreational.

[0023] As shown in FIGs. 1B and 1C, the streamer launcher 100 is made up of substantially a cartridge case 170 fitted into an end of a launch tube 110 and a streamers pusher 120 fitted inside the cartridge case 170; the streamers pusher 120 is loosely fitted inside the launch tube 110 so that the streamers pusher 120 can be ejected along the inside of the launch tube 110. Preferably, the cartridge case 170 is of the 40mm projectile, low-velocity type. An interior of the streamers pusher 120 is hollow and, in use, is packed in an orderly manner with a plurality of coiled-up streamers 102. The launch tube 110 may be

substantially 10-30 cm longer, but is not so restricted by its length. The length of the launch tube 110 affects the throw or ejection distance of the streamers pusher 120 from the launch tube. Preferably, the launch tube 110 is made of a light-weight, high-density plastic or acrylic, with fiberglass or carbon fiber reinforcement; aluminium composites; or other light-weight, fire-retardant materials, or combinations of such materials. Similarly, the streamers pusher 120 is also made up of one or more composites of such light-weight materials. A cover disc 116, for eg., a piece of cardboard, is used to keep the pack of streamers 102 inside the interior of the streamers pusher 120 after manufacturing. After a manufacturing process, the streamers pusher 120, together with the packed streamers 102, is fitted inside the cartridge case 170 as a sub-assembly.

[0024] Also as seen in FIGs. 1B and 1C, the base of the cartridge case 170 is secured removeably to the inside diameter at one end of the launch tube 110. A propellant case 185 containing propellant 180 is fitted into a closed end of the cartridge case 170, to which an electric igniter 190 is provided to set off the propellant 180 when called for. Depending on the design of the propellant case 185, a lead cup may be formed as a thin brass cup-shaped container to store the propellant 180. The opposite or open end of the launch tube 110 is protected by a dust cap 112; the dust cap 112 also serves to keep moisture or fluid from contaminating the launch tube 110, for eg., when the streamer launcher 100 is not in use or is in storage or transit.

[0025] FIGs. 2 show the streamers pusher 120 has a base member 150 and split wall segments 132 connected to the base member 150 to form a hollow, cylindrical cup 130. An exterior end-face of the base member 150 has a surface formed with a plurality of curved radiating impeller blades; this contoured surface now referred to as impeller surface 160. The split cylindrical cup 130 may be made up of 2-5 longitudinal cylindrical segments 132, which are snapped onto or hinged to the base member 150 so that the cylindrical segments 132 are operable to open up as the streamers pusher 120 is ejected out of the launch tube 110. The cylindrical segments 132 making up the split wall of the streamers pusher 120 are configured in three ways, namely, sabot, squirrel-cage and petals configurations 120, 120a-120c, as shown respectively in FIGs. 3, 4A-4C, 5A-5B and 6A-6C; in addition, FIGs. 7A-7C and 8A-8B show other configurations with segments that are folded and hinged; the following description will describe these configurations:

[0026] FIG. 3 shows the cylindrical segments 132 of the streamers pusher sabot configuration 120 are snapped onto the base member 150 by means of a tongue-groove mechanism 140 (with the tongue labelled 134 and the groove labelled 152); once the streamer pusher 120 is ejected out of the launch tube 110, centrifugal and drag forces cause the cylindrical segments 132 to open outwardly and to dislodge or disconnect from the base member 150, thereby releasing the pack of streamers 102 to form a streamer cloud 105; as the streamer pusher 120 is made of light-weight material, falling of the cylindrical segments 132 and the base member 150 does not pose any danger to human, animals and plants or property on the ground.

[0027] FIGs. 4A-4C show the cylindrical segments 132a of the streamer pusher squirrel-cage configuration 120a are pivoted to the base member 150a; once the streamers pusher 120a is ejected out of the launch tube 110, centrifugal and drag forces cause the cylindrical segments 132a to pivot sideways and to open outwardly, thereby releasing the pack of streamers 102 to form a streamer cloud 105. A pin 134 extending from the base member 150a for the associated cylindrical segments 132a to pivot can be short, ie. the pin 134 need not extend the entire length of the cylindrical segment; in another embodiment, the pin 134 can extend the entire length of the cylindrical segment 132a.

[0028] FIGs. 5A and 5B show the cylindrical segments 132b of the streamers pusher petals configuration 120b are pivoted to the base member 150b and are arranged to open outwardly by centrifugal forces; the pivot is configured by a hinge mechanism 140b; by opening outwardly, the pack of streamers 102 are released to form a streamer cloud 105.

[0029] FIGs. 6A-6C show the cylindrical segments 132c of the streamers pusher 120c are pivoted to the base member 150c by means of a hinge mechanism 140c; as illustrated, the hinge mechanism 140c is configured with clevises and accompanying pins. Like the above embodiments, the cylindrical segments 132c open outwardly when the streamers pusher 120c is ejected out of the launch tube 110 under influence of centrifugal forces or drag forces.

[0030] FIGs. 7A-7C show a streamers pusher 120d with hinged segments 132d. These segments 132d are V-shaped and form a solid core at a longitudinal centre when folded in. The streamers 102 are kept in the space of each V-shaped segment 132d. As shown, the V-shaped segments 132d are hinged to the base member 150d by means of hinged

mechanisms 140d, each hinge being made with clevises and an accompanying pin. Torsion springs 142 are provided about the associated pin to assist the hinged segments 132d to open up when the streamers pusher 120d is ejected out of the launch tube 110.

[0031] As seen from FIGs. 6A-6C and 7A-7C, the outside faces of the base members 150c,150d are formed with contoured reliefs 160c,160d; these contoured reliefs 160c,160d are formed by inclined radial steps, which function like the impeller-like surfaces in the above embodiments; these countered surfaces 160c,160d are now referred to as impeller surfaces 160,160d for congruence; these impeller surface 160c,160d also interact with dynamic expanding propellant gases to turn or rotate the streamer pushers 120c,120d as the pushers are being ejected out of the launch tube 110 to create centrifugal forces.

[0032] FIGs. 8A-8B show a streamers pusher 120e according to yet another embodiment. The streamers pusher 120e is a variation of the above streamers pusher 120d, except that the impeller surface 160e is formed with radial contoured surfaces which resemble a fan blade or airfoil. The impeller surface 160e also interacts with dynamic expanding propellant gases to turn or rotate the streamer pusher 120e as it is being ejected out of the launch tube 110 to create centrifugal forces.

[0033] The streamer pushers 120,120a-120e are provided for ease of and orderly packing of the streamers 102. The streamers 102 are rolled-up, packed and compressed into the streamers pushers 120,120a-120e before the streamers pushers are being inserted into the 40mm cartridge case 170. The streamers pushers 120,120a-120e serve to contain or hold the packed and compressed streamers 102 in place. The compressed streamers 102 can be loaded layer by layer into the streamers pushers 120,120a-120e with the help of some tools; after the interior or spaces of the streamers pushers 120,120a-120e are filled up with the streamers 102, each loaded streamers pusher is inserted as a whole and seated in the cartridge case 170. In use, after the electric igniter 190 is ignited, the propellant 180 inside the propellant case 185 burns and generates high-pressure gases, which are released to eject the streamers pushers 120,120a-120e out of the associated cartridge cases 170 and the launch tubes 110 towards the target drone 60. As each of the streamers pusher 120,120a-120d has been ejected out of the launch tube 110, the cylindrical segments 132,132a-132c of the split wall opened up or V-shaped segments 132d opened up and remained in the opened position due to drag forces (and not go back to the cup or cylinder shape or home

position); drag forces also cause the streamers pushers 120,120a-120e to descend down slowly and safely to the ground.

[0034] When the streamers pusher 120,120a-120e is being ejected down the launch tube 110 by gases generated from the burnt propellant 180, the gas flow acting on the impeller surface 160,160c-160e at the base member 150,150a-150e causes the streamers pusher 120,120a-120e and its content of packed streamers 102 to turn or rotate (ie. the streamers pusher need not spin like a conventional member to achieve a long trajectory). Upon leaving the launch tube 110, the split wall 130,130a-130c of the streamer pusher 120,120a-120e flips open and pushes the streamers 102 forward or the V-shaped segments 132d of the streamer pusher 120d,120e open up and push the streamers forward, thus releasing the compressed streamers 102, as the streamers are no longer contained or confined by the streamer pusher. The rotation (generated by air flow around or over the impeller surface 160,160c-160e) allows the streamers 102 to spread out both radially and forwardly in the direction of trajectory upon leaving the launch tube 110; this creates a wide and effective dispersion of the streamers 102 (both forward and sideways) to form a streamer cloud 105 in the flight path of the target drone 60.

[0035] In one embodiment, when the intercept drone 40 is ready in position and orientation, the electric igniter 190 is activated to set off the propellant 180 disposed inside the propellant case 185; the resultant expansion of gases from burning of the propellant 180 ejects the streamers pusher 120,120a-120e from the inside the cartridge case 170 and the launch tube 110; as the streamers pusher 120,120a-120e is ejected out of the launch tube 110, a flow of gases around the periphery of the streamers pusher causes the propellant gases to flow over the impeller surface 160,160c-160e located at the base 150,150a-150d of the streamers pusher; it is also possible that as the streamer pusher 120,120a-120e is travelling along the inside of the launch tube 110 during ejection, the expanding propellant gases flow over the impeller surface 160,160c-160e; as a result of the dynamic flow of gases interacting with the impeller surface 160,160c-160e, the streamer pusher 120,120a-120e is caused to turn or rotate as it is being ejected along the inside the launch tube 110. Once the streamers pusher is ejected out of the launch tube 110, drag forces decelerate the streamers pusher; together with centrifugal forces, wall segments 132,132a-132c or V-shaped segments 132d of the streamers pusher open up and the pack of streamers 102 are thrown outwardly and along a trajectory; dynamic drag forces also act of each streamer

102, resulting in the streamers 102 becoming dispersed along the trajectory and generating a streamer cloud 105 in the flight path of the target drone 60. With this invention, the target drone 60 can be brought down to the ground by some of the streamers becoming entangled with one or more of the propellers.

[0036] Preferably, the streamers 102 are made of high-strength thin films, such as, Mylar, OOP, PVC, Polyimide, paper, fabrics (synthetic or natural) and so on. If the streamer material is absorbent, the material is preferably coated for waterproofing to allow the streamers 102 to be used in wet weather or winter condition. The streamers 102 are being rolled up and compacted into the streamer pusher 120, 120a-120e in an orderly manner, and upon release, the streamers 102 would uncoil themselves and become useful to entangle with the propellers of the target drone.

[0037] Preferably, the cartridge case 170 is removeably connected to the internal diameter of the launch tube 110, for eg., by means of screws 172; catch-and-groove mechanism for twist to lock or unlock; threaded connection; or other similar type of removeable attach-disconnect joining mechanism; these removeably quick attach-disconnect mechanisms allow quick replacement of the cartridge case 170 sub-assembly in the field, ie. sub-assemblies complete with the streamers pusher 120, 120a-120e and the packed streamers 102. This facilitates quick deployment of the streamer launcher 100 and the drone intercept system 10 in the field.

[0038] While specific embodiments have been described and illustrated, it is understood that many changes, modifications and variations disclosed in the text description and drawings and combinations thereof could be made to the present invention without departing from the scope of the present invention.