United States Patent

[11] 3,623,726

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[45] Patented **Nov. 30, 1971**

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[54] **AERIAL TOW DART DEPLOYABLE FROM A TARGET DROVE WITH A BALLISTICALLY ACTUABLE DEPLOYMENT STATION**
9 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **273/105.3,** 89/1 B, 244/138 R, 242/153
[51] **Int. Cl.** **F41j 9/06**
[50] **Field of Search** ..... 242/153; 273/105.3; 89/1.05, 1.5 F, 1.34, 1 B; 60/26.1; 244/3; 102/47

[56] **References Cited**

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ABSTRACT: An aerial tow dart is provided which is towable by a target drone and is deployable from and jettisonable by the drone. The tow dart emits a homing signal for attracting a missile to the dart rather than to the drone, and is deployed such that the drone and tow dart are separated by a distance sufficiently small that both appear as a single target to the gunnery operator firing the missile. In one embodiment, the tow-cable is carried within the tow dart and fed through a pair of snubbing posts within the tow dart for regulating payout of the tow-cable. A ballistically actuable deployment station for each tow dart is mounted on the target drone and is responsive to control signals for initiating operation of the source of homing signals in the tow dart, releasing and deploying the tow dart, and releasing the tow-cable to jettison the tow dart.

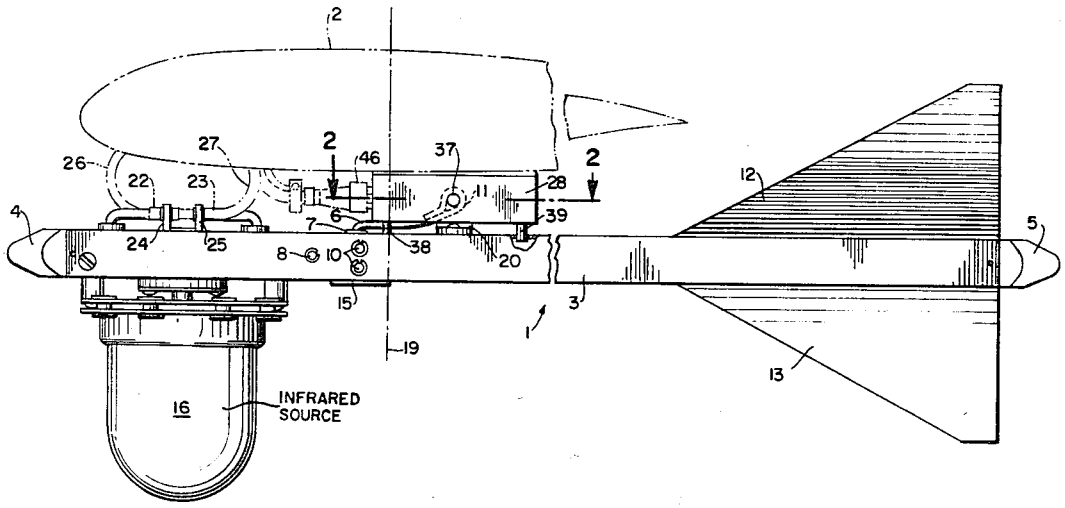

FIG. 1

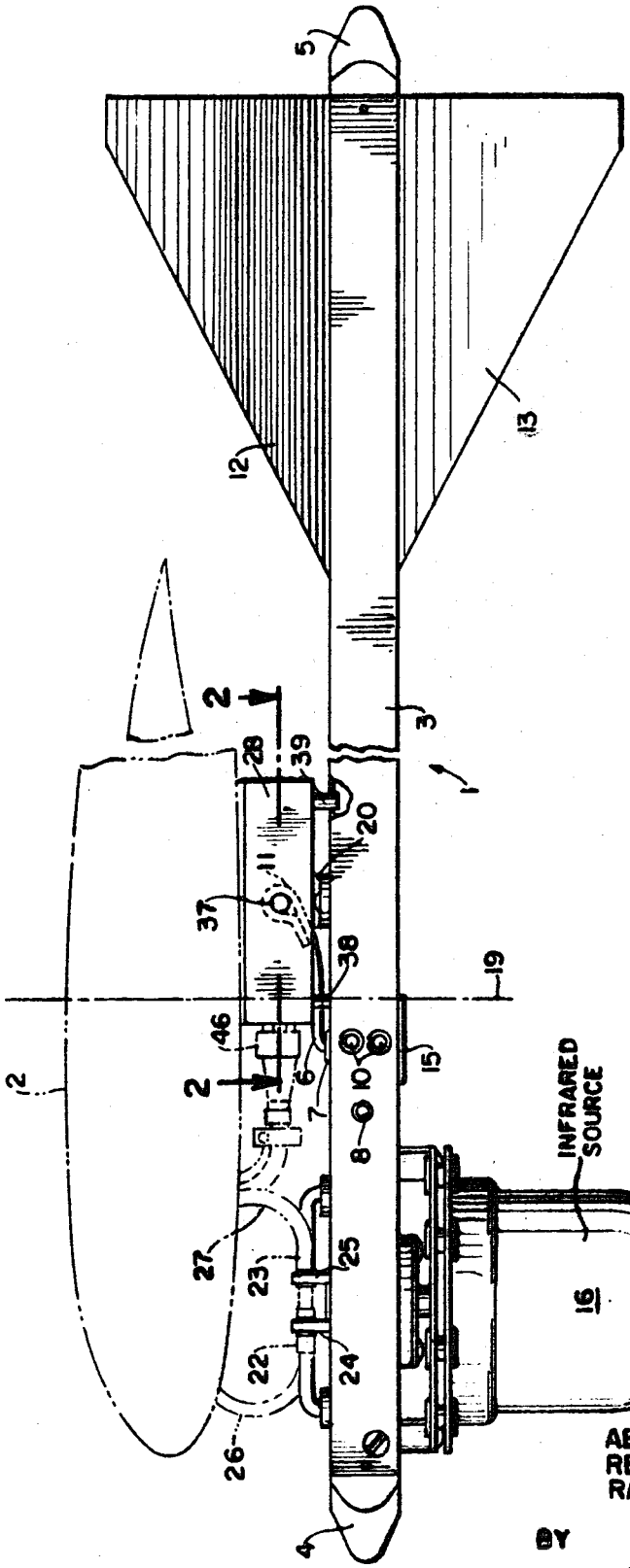

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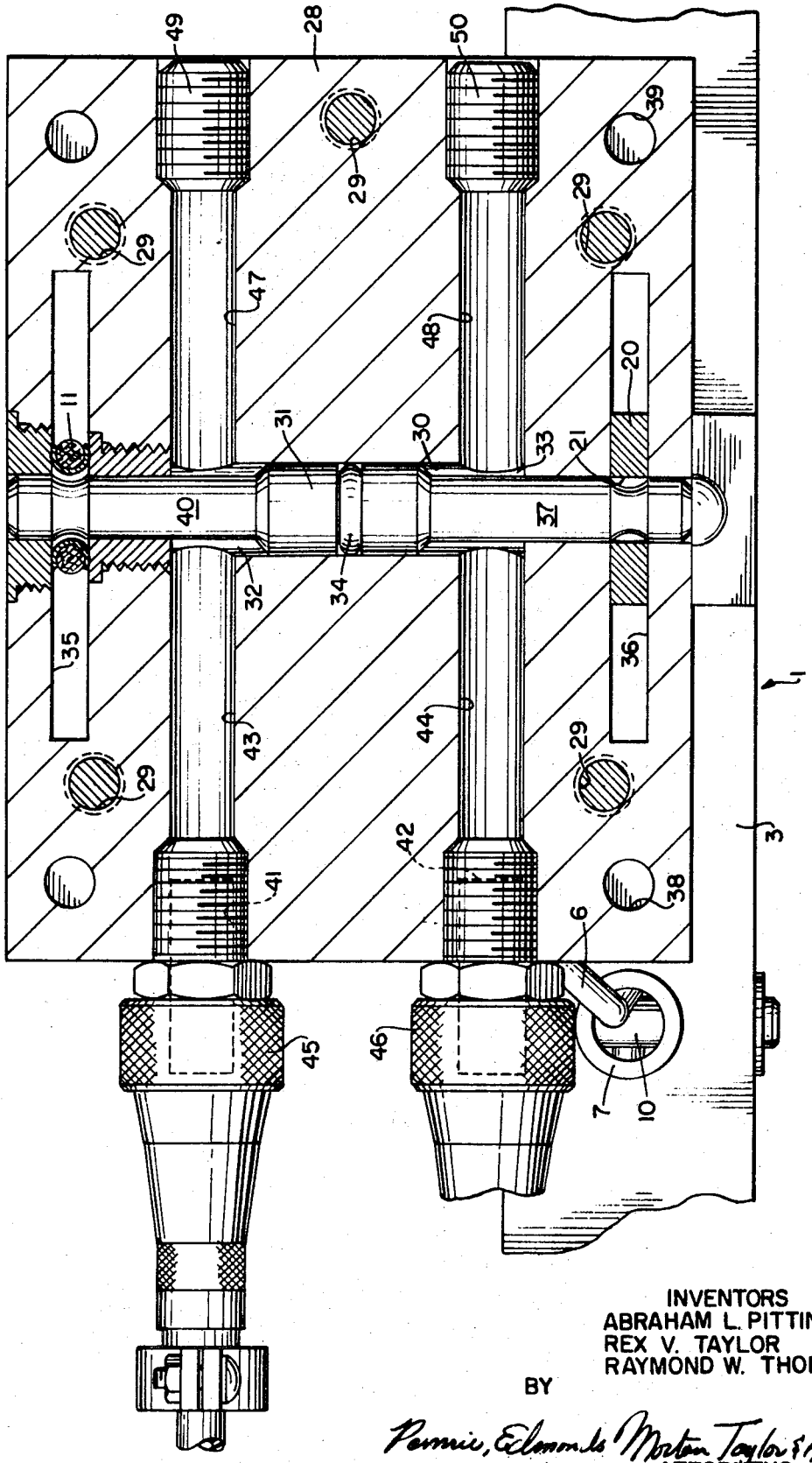
FIG. 2



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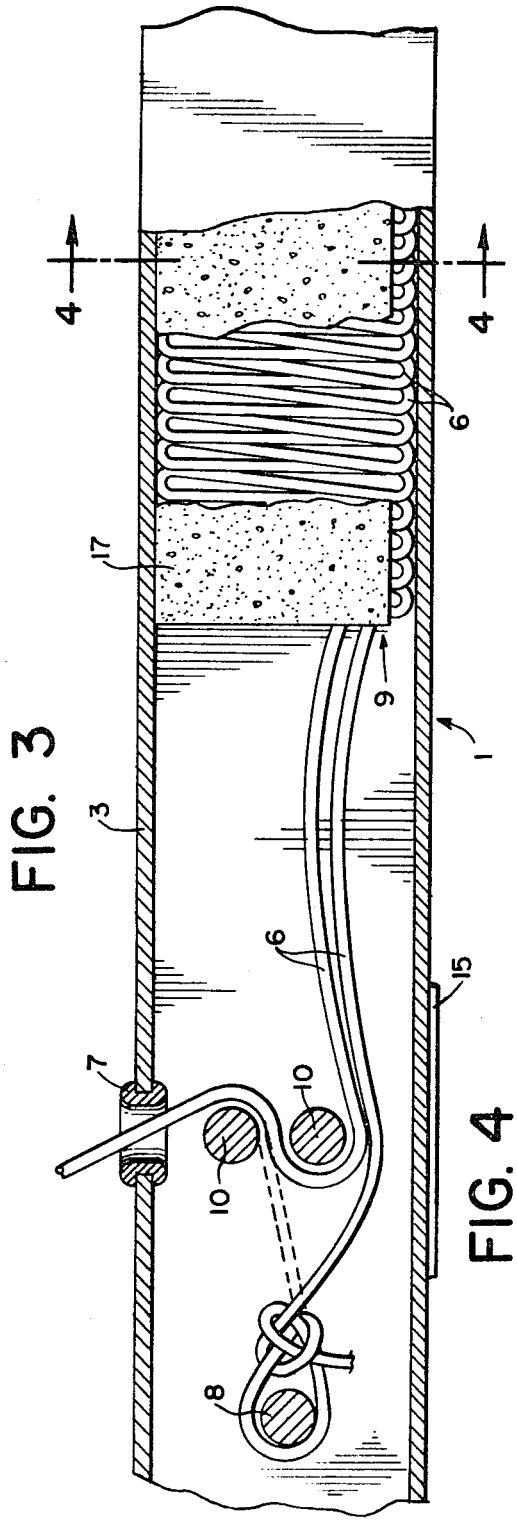

FIG. 3

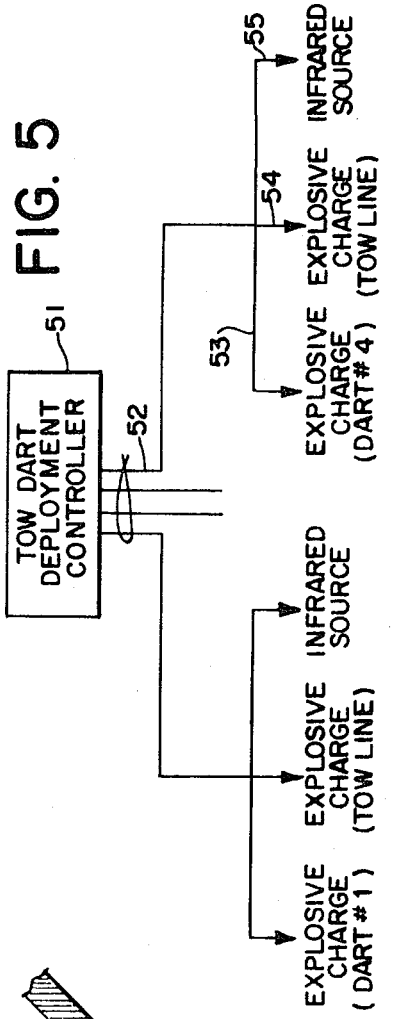

FIG. 5

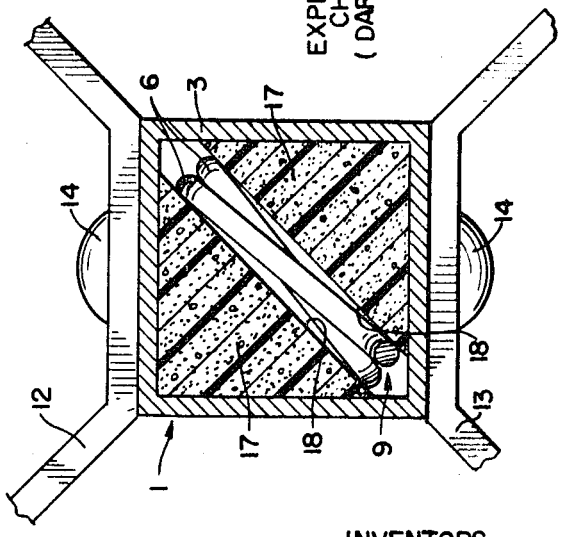

FIG. 4

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AERIAL TOW DART DEPLOYABLE FROM A TARGET DROVE WITH A BALLISTICALLY ACTUABLE DEPLOYMENT STATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to aerial targets particularly useful for gunnery practice which include an unmanned target drone and one or more tow darts deployable and towable by the drone and capable of attracting homing missiles to the tow dart rather than to the drone, so that only the tow dart is destroyed.

2. History of the Prior Art

Both ground-to-air and air-to-air gunnery practice are commonly carried out by firing at an aerial target which simulates an airplane in flight. Commonly, such aerial target is an aerodynamic body, or tow dart towed at a length of up to several miles from a manned airplane and provided in some cases with a radar reflector, infrared source or other generator of homing signals capable of attracting a missile in a manner similar to the way in which it would be attracted to an airplane under combat conditions. In order not to have to use a manned tow airplane for target practice, radio controlled target drones are often used for target practice. However, since the purpose of the target practice is to destroy the drone, this type of practice is highly expensive. Drone towed darts have been suggested previously, but the control of the usual tow-cable reel carried by the drone in order to deploy and control the dart necessitates the use of a heavy and complex drone. Additionally, control of the tow-cable reel requires extra radio channels in the drone's receiving equipment. Further, it has not been feasible to provide target drones with more than one or two tow darts or other targets and still obtain satisfactory performance, since duplication of the heavy deployment and reeling equipment would be necessary for each such dart, severely limiting the drone's flight characteristics. Finally, as noted above, all previous tow darts and other targets have been towed at lengths of up to several miles behind the tow plane, primarily in order to protect the tow plane against the possibility of being hit by a missile. The existence of a double target, that is, the tow plane and the dart, is somewhat confusing to the gunnery operator, and also necessitates carrying the substantial weight of a long tow-cable. A long tow-cable necessarily drastically restricts the maneuverability of the drone.

SUMMARY OF THE INVENTION

In accordance with the invention, a tow dart is provided which is light in weight and is capable of being carried by and deployed from a target drone at a distance sufficiently small that the target drone and tow dart appear as a single target through the visual sighting mechanism used by the gunnery operator in firing at the target.

In accordance with a particularly advantageous embodiment of the invention, the tow-cable is stored in and carried by the tow dart, thereby avoiding the necessity for heavy and complex reeling equipment in the drone. According to one feature of the invention, one ballistically actuable tow dart deployment station corresponding to each dart to be carried is mounted on the drone. Each such tow dart station is capable of engaging a tow dart and also of engaging the end of the tow-cable protruding from the tow dart, and is responsive to control signals for releasing and deploying the dart and for jettisoning the dart by releasing the tow-cable. An additional electrical connection may be provided between each tow dart and the target drone for controlling the firing of a homing signal emitter in the dart.

By this means a propeller driven drone flying at between 250 and 400 miles per hour may easily carry four tow darts, deploying and jettisoning them in sequence as each one is hit.

According to one feature of the invention, upon release by the deployment station, payout of the tow-cable is controlled by a pair of snubbing posts which regulate payout to effect smooth deployment of the tow dart without breaking the tow-cable or perturbing the flight of the drone.

DESCRIPTION OF THE DRAWINGS

Specific embodiments of the invention will be described in conjunction with the annexed drawings, in which:

FIG. 1 is a side view of the wing of a target drone showing a tow dart deployment station and an underslung tow dart carried thereby;

FIG. 2 is a sectional view along line 2—2 of FIG. 1 showing the tow dart deployment mechanism;

FIG. 3 is an elevational view of part of a tow dart, with a portion of the body of the dart broken away, showing the tow-cable storage and payout apparatus;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3; and

FIG. 5 is a schematic diagram of a tow dart deployment controller provided within the body of the target drone for controlling firing of the infrared emitter carried by each tow dart, release and deployment of the tow darts, and jettisoning of the tow darts.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a tow dart suspended beneath the wing 2 (shown in phantom line) of a target drone. The tow dart is formed of a longitudinally extending hollow metal body 3 rectangular in cross section, the forward end of which is capped with a nose member 4 and rear end of which is capped with a tail member 5. A tow-cable 6 (see FIG. 3) is stored within the body and extends through a tow-aperture 7 provided in the upper surface of the body. The tow-cable is fastened at one end within the body to a mounting post 8 and extends therefrom to a hollow storage chamber 9 which is constituted by a portion of the body of the dart. The other end of the tow-cable 6 extends from the storage chamber 9, around the lower one of a pair of snubbing posts 10, between the snubbing posts 10 and then out of the body through tow-aperture 7. The tow end of the tow-cable terminates in a loop 11. A set of four radially extending fins (see FIG. 4) is mounted on the after portion of the body for aerodynamically stabilizing the tow dart in flight, which fins are formed by a pair of opposed fin members 12 and 13 which are fastened to the body by rivets 14. A removable cover plate 15 permits access to the interior of the body immediately below snubbing posts 10 for fastening or adjusting the tow-cable.

A source 16 of infrared radiation is mounted on the underside of the forward portion of tow dart body 3 for emitting infrared radiation in order to attract a missile provided with an infrared homing device. Infrared source 16 per se forms no part of this invention, and any such source compatible with the tow dart in its size, weight and shape characteristics may be used. In order to assure that missiles fired at the drone/target combination are attracted to the target rather that the drone, the infrared source must emit radiation substantially greater than that emitted by the drone itself. An example of such an infrared source, which utilizes a chemical reaction to generate heat is shown in the U.S. Pat. No. 2,933,317 issued Apr. 19, 1960. Alternatively, any other source of the particular homing signal utilized by the missile being fired may be carried by the tow dart.

As shown in FIG. 3, the major portion of the tow-cable is stored in storage chamber 9 in the form of a continuous figure-eight pattern which is held between a pair of resilient storage pads 17, forming opposing cooperative surfaces 18 for holding the stored tow-cable in position. The storage pads may be made of any light and somewhat resilient material, such as styrofoam, and are exteriorly shaped to cooperate with the body of the tow dart forming storage chamber 9.

By this means, the tow-cable may readily be placed in the storage chamber by first laying it in the continuous figure-eight pattern shown, upon one of the opposing surfaces 18 of a

storage pad (for example while the latter is held horizontally externally of the dart), then placing the opposing surface **18** of the other storage pad down upon the coiled tow-cable and inserting the sandwich so formed into the body of the tow dart. Dashed line **19** in FIG. **1** denotes the center of gravity of the tow dart, including infrared source **16**. Tow-aperture **7** is located forward of the center of gravity, assuring the aerodynamic stability of the dart in flight. A member **20** extends upwardly from the body at a point slightly aft of its center of gravity, which mounting member is provided with a laterally extending hole **21** (FIG. **2**) for engaging the tow dart with a tow dart deployment station mounted on the drone. The position of this mounting member is slightly aft of the tow dart's center of gravity. The dart is thereby rendered nose-heavy upon release from the drone, tending to dampen any tendency of the dart to flutter or vibrate while it is being towed. A pair of flexibly mounted electrical breakaway connectors **22** and **23** extend upwardly from the tow dart body and may be flexed at right angles, as shown in FIG. **1**, and held in spring brackets **24**, **25** provided on the upper surface of body **3**. The breakaway connectors are connectable to matching connectors **26** and **27** (shown in phantom line) provided on cables which extend from the wing **2** of the drone approximately above the connectors **22** and **23** when the tow dart is carried by the drone. The breakaway connectors, which are standard items and form no part per se of the present invention, readily slip away from their respective matching connectors carried by the drone when the latter is deployed. Breakaway connectors **22** and **23** are connected through the dart body to infrared source **16** for the purpose of igniting the latter immediately before deployment of the dart, as will be explained later.

FIG. **2** is a sectional view of a tow dart deployment station, one of which is mounted on the wing of the drone corresponding to each dart to be carried. The body **28** of the tow dart deployment station shown in FIG. **2** is provided with mounting holes **29** for attachment to the drone wing. A pressure cylinder **30** extends transversely within the body, and a piston **31** is slidably disposed within cylinder **30** and is capable of being pressure-actuated towards the second end portion **33** of cylinder **30** due to pressure in the first end portion **32** thereof, and is capable of being pressure-actuated towards the first end portion **32** of the cylinder due to pressure in the second end portion **33** thereof. An O-ring **34** is carried by the piston to assure an adequate pressure seal. A tow-cable receiving slot **35** is provided opposite one end of piston **31** and tow dart engagement slot **36** is provided opposite the other end of the piston. Tow dart engagement slot **36** is engaged by corresponding engagement member **20** of the tow dart such that a first stud **37** extending from piston **31** is capable of engaging the hole **21** in engagement member **20** to lock the tow dart in position. When thus locked, positioning members **38** and **39** which extend downwardly from deployment station **28** contact indentations in the upper surfact of tow dart body **3**, thereby rigidly locking the tow dart in position beneath the deployment station. Piston **31** additionally carries a second stud **40** which extends through tow cable receiving slot **35** to securely fasten loop **11** in the end of the tow cable to the deployment station.

First and second ballistic chambers **41** and **42** are provided in the body of station **28** and communicate through respective bores **43** and **44** with the first and second end portions of cylinder **30**. An explosive squib, indicated in dashed lines, is capable of being inserted in each of the ballistic chambers **41** and **42**, each chamber being sealed at its open end by a connecting plug (**45** and **46**) which makes electrical contact with the respective squib. When an electrical current passes through either of the connecting plugs, and thereby, through the squib with which it is in contact, the squib is ignited to generate a gas which pressurized the corresponding end portion of cylinder **30** through its respective connecting bore **43** or **44**. As shown more clearly in FIG. **1** electrical connectors **45** and **46** are attached to cables extending downwardly from wing **2** of the target drone.

Adjustment bores **47** and **48** communicate with respective cylinder end portions **32** and **33**, and are provided with movable slugs **49** and **50** respectively for adjusting the total volume to be pressurized by each squib, thereby adjusting the response of piston **31** to the firing of the squibs.

To deploy each tow dart, first the squib in ballistic chamber **42** is fired to actuate piston **31** towards the first cylinder end portion **32**, thereby disengaging stud **37** from upstanding engagement member **20** and permitting the tow dart to fall away from the deployment station due to gravity and the surrounding air flow. After a hit has been scored on the dart or its infrared source has burnt out, the squib in ballistic chamber **41** is fired to actuate piston **31** towards the second portion **33** of the cylinder, thereby disengaging stud **40** from loop **11** of the tow-cable and permitting the cable and the dart to fall away from the drone.

In order to cycle each of the tow darts carried by the drone through a complete deployment cycle, the drone is provided with a tow dart deployment controller **51** (FIG. **5**) which is capable of sequentially generating the control signals necessary to cycle each of the darts. In the embodiment shown controller **51** includes a stepping switch responsive to a single channel radio control signal for sequentially energizing each of the controller output lines. These output lines are divided into four groups of three lines each, each group of output lines being combined in multiconductor cable (e.g. cable **52**) which extends through the wing **2** of the drone to a particular tow dart mounting station. Cable **52** includes wires (or leads) **53**, **54** and **55** which actuate tow dart No. **4** (for purposes of description, the dart shown in FIG. **1**). Lead **55** is connected from the drone power supply through one of cables **26** and **27** extending from the drone wing to one of the breakaway connectors **22** or **23**, which conveys current through the infrared source **16** and back through the other of the breakaway connectors to the ground terminal of the target drone power supply. Lead **54** is connected through the drone wing to connector **45** for actuating the squib in ballistic chamber **41** to release the tow line. Lead **53** is connected through the drone wing to electrical connector **46** for actuating the squib in ballistic chamber **42**, thereby releasing the tow dart. It will thus be seen that the stepping switch within deployment controller **51** steps sequentially through the three electrical leads corresponding to each of the successive tow darts. With respect to station **4**, (illustrated in FIG. **1**), first lead **55** is energized (i.e. connected to the target drone power supply) to ignite the infrared source **16**. Immediately thereafter, lead **53** is energized to explode the squib in ballistic chamber **42** releasing the tow dart from its deployment station. Finally, after the infrared source is spend (presumably the tow dart has been hit by a missile), electrical lead **54** is energized to explode to squib in ballistic chamber **41**, releasing the tow to jettison the dart. In this manner, each tow dart carried by the drone is cycled in turn through ignition, deployment and jettison.

The tow cable (which in the embodiment shown is about one-eighth inch diameter nylon line) if no braking action were provided, would upon release of the dart payout rapidly as the dart is carried aft of the drone by air resistance and downwardly by gravity. This would produce an uncontrolled movement of the dart during deployment and an abrupt tension in the tow line after the dart became fully deployed, snapping the tow-cable and/or violently perturbing the flight of the drone. It is therefore important that payout of the tow-cable be controlled at a fairly constant rate slow enough to avoid the last mentioned undesirable effects. Payout is controlled by snubbing posts **10** which are disposed parallel to each other in the tow dart body and which are spaced apart a distance slightly greater then the diameter of the tow-cable. As shown in FIG. **3**, tow-cable **6** extends around and between snubbing posts **10** through an angle, and it can be seen that the greater this angle, the higher will be the braking effect on the tow-cable. The particular configuration, diameter, spacing and orientation of snubbing posts **10** in any particular tow dart will depend upon the speed of the drone, the weight and the

aerodynamic characteristics of the dart, the flexibility and diameter of the cable, the tension required to remove the cable from between storage pads **9**, and other factors which will be apparent to one skilled in the art.

In the specific embodiment illustrated herein, the length of the tow dart is about 32 inches and its body is 1 inch square. Each of the fins is approximately 1½ inches long and extends 4 inches radially from the body of the dart. Tow-aperture **7** is about one-half inch forward of the center of gravity **19**, and upstanding mounting member **20** is located approximately 1½ inches aft of the center of gravity, the latter being about 8 inches aft of the nose of the tow dart. Infrared source **16** weighs about 3 pounds while the remainder of the dart weighs about 1¼ pounds carrying 35 feet of tow cable. Upon deployment of the dart, the static tension in the tow cable is approximately 10 pounds and the dynamic tension during deployment is controlled to approximately 5 pounds by snubbing posts **10**, effecting the desired smooth deployment.

Infrared source **16** is carried externally of the body of the tow dart in the embodiment shown; for tow speeds higher than about 350–400 miles per hour, it is desirable to provide the infrared (or other) homing source within the body of the dart in order to substantially reduce aerodynamic drag. Such source can be conveniently mounted in the tail end of the dart, and the various parameters and weight distribution modified in accordance with the above teachings.

Although for reasons explained above it is desirable to maintain a small separation distance between the drone and the tow dart when in flight, it will be clear that certain features of this invention are applicable to tow darts deployed on longer cables as well as darts towed by manned aircraft. At about 250 knots, the tow dart described above is offset approximately 25 feet aft and 10 feet below the target drone. Excellent performance has been obtained for such a tow dart on (for example) a MQM–33A target drone; performance of the drone carrying four darts is effected by less than 5 percent. Virtually the only ground recycling necessary between flights is replacement of the spent squibs, centering of the piston **30** and connection of the new darts their respective tow-cables and breakaway connectors.

It will be appreciated by those skilled in the art that modifications of the above described embodiments may be made within the scope and spirit of the invention, which is to be limited only in accordance with the following claims.

What is claimed is:

1. A ballistically actuable tow dart deployment station mountable on a target drone for carrying a tow dart, deploying such tow dart on a tow-cable, and releasing such tow dart, in response to electrical control signals, comprising:

a body member capable of being mounted on a target drone and forming a pressure cylinder therein including first and second end portions;

a piston slideably disposed within said cylinder between said end portions, said piston being actuable toward said first end portion in response to pressure in the second end portion and actuable towards said second end portion in response to pressure in the first end portion;

tow dart engaging means formed on said body capable of engaging a cooperating engagement member of a tow dart and responsive to movement of said piston toward the first cylinder end portion to disengage such engagement member therefrom; and

tow-cable engaging means formed on said body capable of engaging the tow-cable of such tow dart and responsive to movement of said piston toward the second cylinder end portion to disengage the tow-cable therefrom.

2. A ballistically actuable tow dart deployment station as defined in claim **1** wherein said tow dart engagement mounting member is an upstanding member having a hole therein and said tow-cable includes a loop at its end;

said tow dart engaging means including a slot in said body member for receiving said upstanding member therein and a first stud connected to said piston for extending through the hole in the upstanding member to firmly engage the tow dart, whereby movement of the piston toward said first cylinder end portion displaces the first stud from said hole to release the tow dart; and

said tow-cable engaging means including a slot in said body member for cooperating with said tow-cable loop and a second stud connected to said piston for extending through said loop, whereby movement of said pistons towards said second cylinder end portion displaces the second stud from said loop to release the tow-cable.

3. A ballistically actuable tow dart deployment station as defined in claim **2** including first and second ballistic chambers communicating respectively with said first and second cylinder ends, each capable of holding an electrically actuable explosive squib for generating pressure in the cylinder end portion with which it communicates; and

electrical ignition contacts in each of said first and second ballistic chambers for igniting a squib contained therein, whereby ignition of such first squib effects release of such tow-cable and ignition of such second squib effects release of such tow dart.

4. An aerial target for permitting a gunnery operator to engage in simulated gunnery practice with a homing-type missile that is attracted to a particular homing signal and which is aimed through a visual sighting mechanism, comprising:

a self-powered target drone;

at least one tow dart deployment station mounted on the target drone for carrying and deploying a tow dart; and

a tow dart cooperable with said station for being carried thereby and deployed therefrom and including a source of such homing signals stronger than any such homing signals emitted by the target drone, said target drone and tow dart being separated upon deployment by a distance sufficiently small that the target drone and tow dart appear as a single target through such visual sighting mechanism.

5. An aerial target as defined in claim **4** wherein the distance between said drone and said tow dart when the latter is deployed is less than about 100 feet and said source of homing signals is a source of infrared radiation greater than any infrared radiation emitted by the target drone.

6. An aerial target as defined in claim **4** wherein said tow dart contains a tow-cable, said tow dart deployment station includes release means for cooperating with the tow dart and the tow-cable, and said target drone includes tow dart controller means for sequentially controlling the tow dart station to (a) release and deploy the tow dart, and (b) jettison the tow cart by releasing the tow cable.

7. A ballistically actuable tow dart deployment station mountable on a target drone for carrying a tow dart, deploying such tow dart on a tow-cable, and releasing such tow dart, in response to electrical control signals, comprising:

a body member capable of being mounted on a target drone, and including tow dart engaging means capable of engaging a cooperating engagement member of a tow dart and tow-cable engaging means capable of engaging the tow-cable of such tow dart;

first means included in said body member responsive to a control signal for actuating said tow dart engaging means to release such engagement member therefrom; and

second means included in said body member responsive to a second control signal for actuating said tow-cable engaging means to disengage such tow-cable therefrom.

8. The combination of a ballistically actuable tow dart deployment station mountable on a target drone, and a tow dart for use therewith, said deployment station being capable of carrying such tow dart, deploying it on a two-cable, and releasing it, in response to electrical control signals, comprising:

a body member capable of being mounted on a target drone and forming a pressure cylinder therein including first and second end portions;

a piston slideably disposed within said cylinder between said end portions, said piston being actuable toward said first end portion in response to pressure in the second end portion and actuable towards said seconded portion in response to pressure in the first end portion;

tow dart engaging means formed on said body capable of engaging a cooperating engagement member of a tow dart and responsive to movement of said piston toward the first cylinder end portion to disengage such engagement member therefrom;

tow-cable engaging means formed on said body capable of engaging the tow-cable of such tow dart and responsive to movement of said piston toward the second cylinder end portion to disengage the tow-cable therefrom;

a longitudinally extending body having a nose end and a tail end and a towing aperture and forming a hollow storage chamber within at least a portion of said tow dart body, the center of gravity of said tow dart being at a point between the nose and tail ends thereof;

a tow-cable stored within said storage chamber, one end thereof being anchored to the tow dart body and the other end thereof extending through said towing aperture, said tow-cable being stored in said chamber in such manner that it can be withdrawn through the towing aperture by applying tension to its end extending through the towing aperture;

fins extending from said tow dart body for aerodynamically stabilizing the tow dart in flight when towed by the tow cable;

means carried by said tow dart for attracting missiles thereto rather than to such target drone; and

said cooperating engagement member comprising an upstanding member on said tow dart body; said tow-cable including a loop at its end extending through the tow aperture for cooperating with said tow-cable engaging means.

9. The combination of a ballistically actuable tow dart deployment station mountable on a target drone, and a tow dart for use therewith, said deployment station being capable of carrying such tow dart, deploying it on a tow-cable, and releasing it, in response to electrical control signals, and comprising:

a body member capable of being mounted on a target drone, and including tow dart engaging means capable of engaging a cooperating engagement member of a tow dart and tow-cable engaging means capable of engaging the tow-cable of such tow dart;

first means included in said body member responsive to a control signal for actuating said tow dart engaging means to release such engagement member therefrom;

second means included in said body member responsive to a second control signal for actuating said tow-cable engaging means to disengage such tow-cable therefrom;

a longitudinally extending body having a nose end and a tail end and a towing aperture and forming a hollow storage chamber within at least a portion of said tow dart body, the center of gravity of said tow dart being at a point between the nose and tail ends thereof;

a tow-cable stored within said storage chamber, one end thereof being anchored to the tow dart body and the other end thereof extending through said towing aperture, said tow-cable being stored in said chamber in such manner that it can be withdrawn through the towing aperture by applying tension to its end extending through the towing apertures;

fins extending from said tow dart body for aerodynamically stabilizing the tow dart in flight when towed by the tow-cable;

means carried by said tow dart for attracting missiles thereto rather than to such target drone; and

said cooperating engagement member comprising an upstanding member on said tow dart body; said tow-cable including a loop at its end extending through the tow aperture for cooperating with said tow-cable engaging means.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,623,726 Dated November 30, 1971

Inventor(s) Abraham L. Pittinger et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title of invention "FROM A TARGET DROVE" should read -- FROM A TARGET DRONE --. Column 4, line 51, "spend" should read -- spent --. Column 5, line 6, "is 1 inch square" should read -- is 7 inches square --. Column 6, line 49, "tow cart" should read -- tow dart --.

Signed and sealed this 4th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

ORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334