Jan. 28, 1958 L. W. SEELEY 2,821,396

AERIAL TOW TARGET

Filed Oct. 26, 1955 2 Sheets-Sheet 1

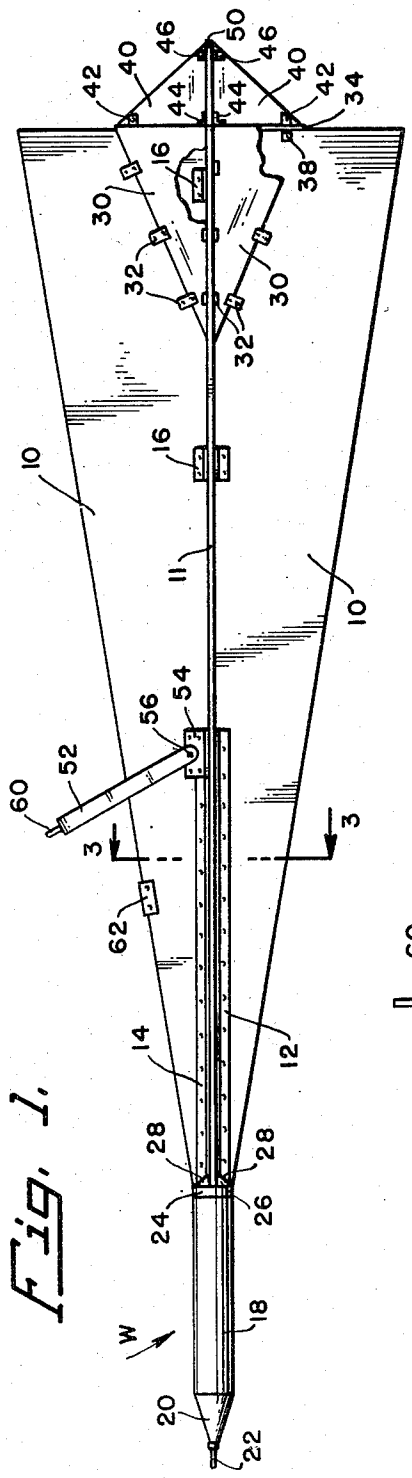


Fig. 1.

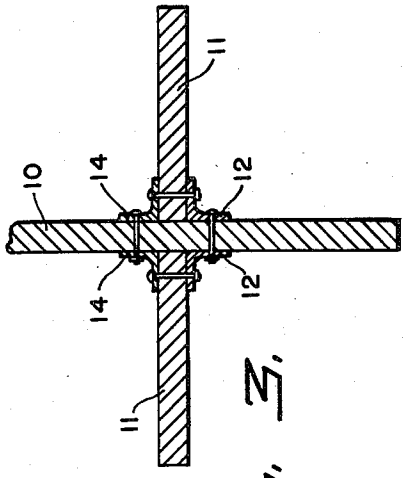


Fig. 3.

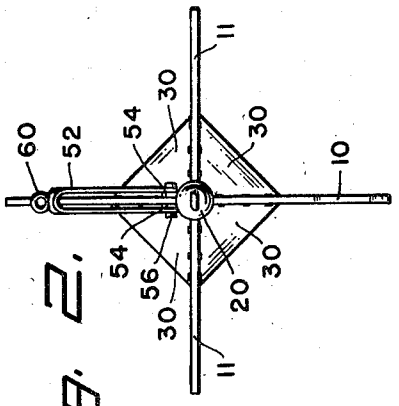


Fig. 2.

INVENTOR.
LEONARD W. SEELEY
BY G. D. O'Brien
V. C. Muller
ATTORNEYS

Jan. 28, 1958 L. W. SEELEY 2,821,396

AERIAL TOW TARGET

Filed Oct. 26, 1955 2 Sheets-Sheet 2

Fig. 4.

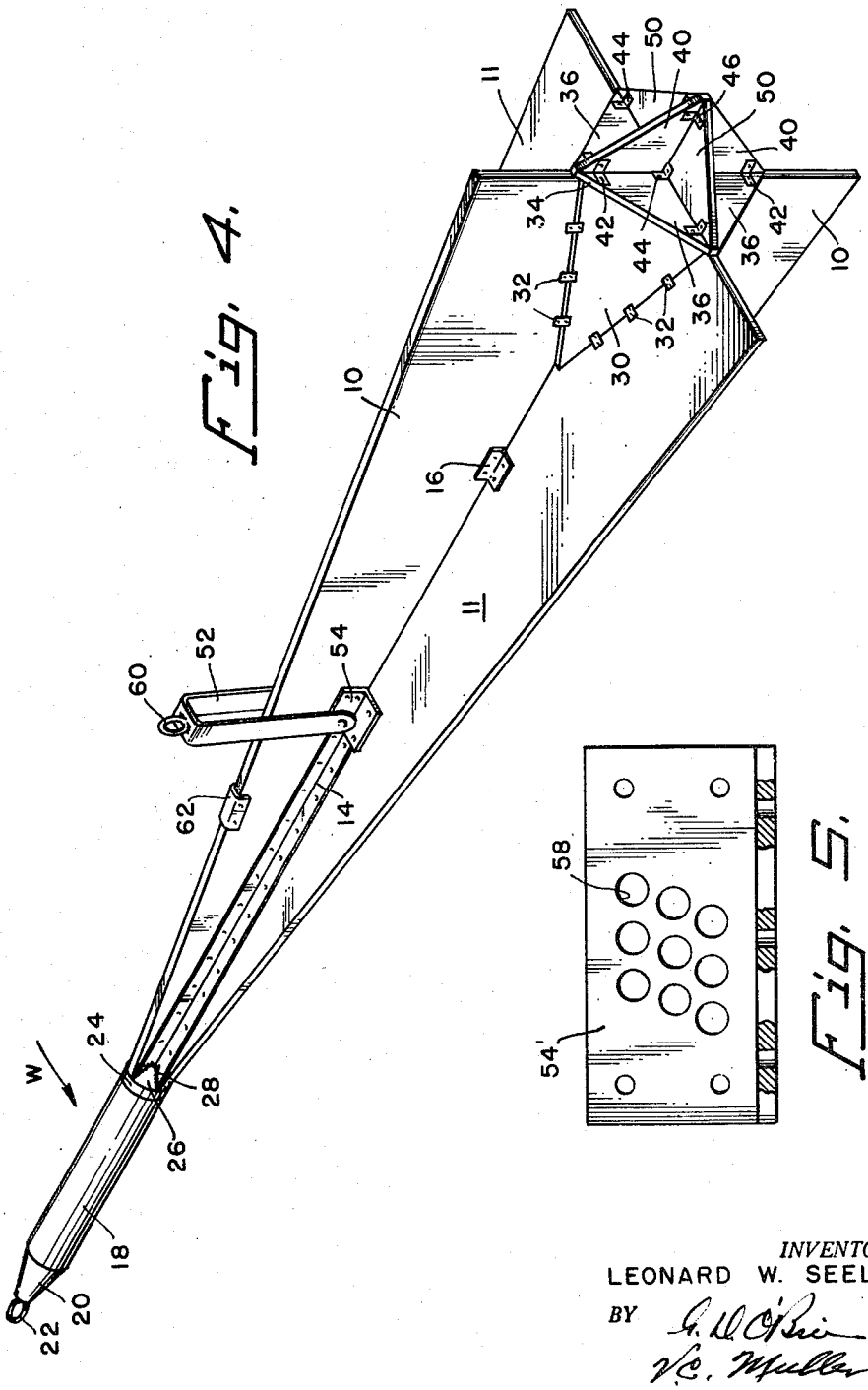


Fig. 5.

INVENTOR.
LEONARD W. SEELEY
BY G. W. O'Brien
V. C. Mueller
ATTORNEYS

United States Patent Office 2,821,396
Patented Jan. 28, 1958

2,821,396

AERIAL TOW TARGET

Leonard W. Seeley, China Lake, Calif., assignor to the United States of America as represented by the Secretary of the Navy

Application October 26, 1955, Serial No. 543,043

8 Claims. (Cl. 273—105.3)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to aerial tow targets of the type used for the training of aviation personnel and for the evaluation of the operation of guided missile control systems and aircraft fire control systems. More specifically, this invention relates to aerial tow targets suitable for use at high speeds which realistically approach the speeds of modern aircraft.

Realistic evaluation of guided missile control systems and of fire control systems for high-speed aircraft, as well as effective training of fighter pilots and aviation gunners have long been handicapped by the lack of suitable high-speed aerial targets. The aerial tow targets available for such purposes were usually in the nature of cloth banners and sleeves, and some use was made of winged glider-type craft. The cloth banners and sleeves are inherently high drag devices which precludes their being towed to current realistic operational speeds and makes them entirely unsuitable for operation at such speeds. The winged glider-type craft are essentially small airplanes, and as such, are expensive and impose severe operational problems in being launched and recovered. Because the old conventional tow targets could not be used for training or evaluation purposes at speeds realistically approximating those of modern aircraft, considerable effort has been expended in various attempts to provide new aerial tow targets having improved high speed characteristics. Prior to the development of the herein disclosed target, no particularly successful solution had been reached, the greatest difficulties with most proposed designs being instability and/or excessive drag at high speed flight, excessive cost, and susceptibility to destruction.

The present invention is based upon a combination of design features making stable flight possible at speeds up to 450 knots at 30,000 feet pressure altitude. It has been discovered that a dart-shaped target (which inherently has little drag but is unstable in flight if nose-towed) can be suitably towed with great stability at high speeds if a weighted extension is attached to the forward end of the target to shift the over-all center of gravity forward of the aerodynamic center of the target and if the target is towed from the center of gravity instead of at the nose. These discoveries have made it possible to design an aerial tow target which is low in cost, stable in high speed flight, and structurally rugged so that it may often be retrieved and reused (with economical repair if necessary). As a further advantage, the novel tow target which is the subject of this invention particularly lends itself to the inclusion of radar reflecting surfaces thereon, and this provides another important feature of the invention.

It is, therefore, an object of this invention to provide a novel aerial tow target capable of stable high-speed flight.

It is a further object of this invention to provide an

aerial tow target capable of stable high-speed flight and which is rugged in construction and economical in cost and in maintenance.

A still further object of this invention is to provide an aerial tow target of simple, economical construction, the structure being such as to facilitate the ease of incorporating radar reflecting means therein.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a side elevation of an aerial tow target according to this invention, with parts broken away for clarity of illustration;

Fig. 2 is a front elevation of the aerial tow target of Fig. 1;

Fig. 3 is an enlarged section taken along the line 3—3 of Fig. 1, in the direction of the arrows;

Fig. 4 is a perspective view of the tow target of Figs. 1, 2 and 3 taken from the rear of the target to illustrate the radar reflector feature thereof; and

Fig. 5 is a front elevation of an adjustable pivot plate which may be used to form a part of this invention.

Attention is now directed to the drawings, the various figures of which depict a single illustrative example of an aerial tow target according to this invention and in which like reference numerals are used to indicate like parts throughout. The illustrated modification is a four-winged cruciform construction as shown and comprises four similar triangular wings or fins attached at right angles with the bases thereof in a plane (defining the rearward end of the target) with the hypotenuses thereof outwardly disposed so that the wings converge in a point towards the forward end of the target. Such wings may be formed and rigidly attached to one another in any suitable manner. By way of example, for rigidity of structure and ease of manufacture, either the pair of vertical fins or the pair of horizontal fins may be made of a single piece, the other set being attached thereto. In the construction shown in the drawing and as best seen in Fig. 3, the vertical fins or wings comprise a single integral piece **10** in the shape of an isosceles triangle and the horizontal fins or wings **11** comprise a pair of triangular pieces, as shown. Fins **10** and **11** may be rigidly attached to one another in any suitable manner. Thus, a plurality of L-section angle bars may be used to provide means to rigidly assemble the fins. As illustrated, there are provided a pair of lower angle bars **12** of a length to extend from the nose of the assembled target to a point a short distance aft of the calculated center of gravity of the entire assembly (including the weighted forward extension to be described hereinafter) and a pair of upper angle bars **14** of a length to extend from the nose of the target to a point slightly forward of the center of gravity. The angle bars and the fin sections are provided with appropriate bolt holes and are bolted together, as best shown in Fig. 3, with the pair of lower angle bars **12** positioned on opposite sides of the vertical fin **10** and bearing against said vertical fin and on the lower sides of the two lateral horizontal fins **11**, as illustrated. Similarly, upper angle bars **14** are used to complete the assembly, bearing against the opposite side faces of vertical fin **10** and on the upper inboard faces of the horizontal fins **11**. Additional rigidity may be imparted by the similar use of short angle sections **16** at a position about two-thirds of the length of the target from the nose and at a point near the rearward end thereof, as shown in Figs. 1 and 4.

The center of gravity of the dart-shaped target formed as described hereinabove is shifted forwardly to a point

forward of the aerodynamic center by the attachment of a weighted extension W to the forward end of the longitudinal axis of the target. As best illustrated in Fig. 1, the weighted extension is of generally bullet shape comprising a cylindrical rearward portion 18, and a conical nose portion 20 which may be integral or may be a separate piece connected to the cylindrical portion by appropriate means. Nose portion 20 has an eye-bolt 22 conected to the forward end thereof by suitable means (as by screw-threads, not shown). Extension W may be designed to have an appropriate weight and weight distribution in any of a variety of obvious manners, either by casting the extension itself with walls of a desired thickness and material, or by fixing balance weights internally of a thin cylindrical tube forming the extension.

Extension W may be attached to the forward end of the tow target by any suitable means, as for example by detachable attachment (by means not shown) to a coupling member 24 which has rearwardly extending projections 26 which are suitably connected (as by welding at 28) to the angle irons 12 and 14.

The rearward end of the target is provided with fairing strips 30 for bracing the rearward portions of the fins. Such strips 30 may be attached by any suitable means, between adjacent fins in the configuration and position shown, as for example by the use of angle clips 32 and appropriate securing screws or bolts, as illustrated.

The cruciform dart-shaped target described herein is stable, because any departure in attitude from zero lift produces a turning moment about the center of gravity, caused by either positive or negative lift, which must be to the rear of the center of gravity, because of the proponderance of the air foil area in that locality. The turning moment thus produced is a stable one because it tends to restore the dart-shaped target to a condition and attitude of zero lift.

An aft-facing radar-reflecting corner is provided in each quadrant at the aft end of the target by a reflector construction, if desired, an example of a preferred construction of which is shown in the drawings. A rectangular sheet of material 34, of a configuration to substantially match the configuration of the open rear end of the attached fairing strips 30, is provided to form a reflecting surface 36 normal to the axis of the target, fairing strips 30 serving the function of diverting the airstream around the forward surface of sheet 34 to avoid excessive airstream pressures on that surface in flight. Sheet 34 is suitably attached to the tail end of fins 10, 11 by angle clips, as at 38. Four rearwardly extending reflector fins are attached to the rear surface 36 of sheet 34 to provide four reflecting corners at the aft end of the target, as shown (see Figs. 1 and 4). The mode of assembly or attachment is not critical, but in the illustrated example, the two vertical reflector fins are formed by a single piece of material 40 of isosceles triangle shape which is attached to the reflecting surface 36 by angle clips 42 and the horizontal reflector fins are a pair of right triangular pieces 50 which are attached to surface 36 and to appropriate sides of the vertical fins 40 by angle slips 44 and 46 respectively. The surfaces 36 and the reflector fins 40 and 50 are either painted with a conducting silver paint or are metallized by spraying with an aluminum metallizing gun. There are thus provided four corners (in each of the four quadrants) each formed of perpendicular surfaces to most efficiently reflect radar signals.

The target is towed by means of a U-shaped tow bar or yoke 52 which has a tow-line attaching eyelet 60 and which straddles the upper portion of vertical fin 10 and is pivotally attached to opposed attachment plates 54 by a pivot pin 56. Attachment plates 54 are positioned at a point slightly above the approximate center of gravity of the assembly (in the illustrated example this point is at the right end of upper angle bars 14) and are attached

to opposite sides of the vertical fin 10 by appropriate screws, bolts, or rivets passing through plates 54 and through the fin. Pivot pin 56 passes through aligned holes in the plates 54 and the fin to provide pivotal support for the yoke member 52. If desired, a plurality of pivot points may be provided by the expedient of providing attachment plates 54' having plural openings 58 in complementary patterns as shown in Fig. 5 and in providing matching holes in the fin whereby adjustment of the position of the tow bar 52 may be effected by proper placement of pivot pin 56. If desired, an edge guard 62 may be appropriately positioned on the edge of the fin 10 to protect the fin from damage by yoke 52.

The tow target described above may have fins made of a plurality of materials, such as plywood, plastics, etc., being limited only by considerations of bending modulus (strength) and weight. Similarly, the modes of attachment of the parts which could be utilized are purely a matter of choice, the configuration and the point of connection and arrangement of counterweight W and towbar 52 being the only critical aspects.

From the above it should be obvious that this invention provides economical and rugged tow targets having high speed stability characteristics not previously achieved. Such targets, if proper selection of materials is made, are not of unduly excessive weight and lend themselves to little or easily repairable damage when released and dropped at the end of a tow flight. Thus, a target of plywood made according to the above teachings and having wings of approximately 12 foot length and about 2 foot maximum span weighs about one-hundred pounds with nose extension ballast and is easily repaired when damaged by dropping or by gunfire.

The subject target is towed, as previously described, by a yoke 52 which straddles the wing and is mounted for fore and aft pivotal movement and this arrangement plus the flexibility of the line allows the target to head into the wind. By virtue of the forward position of the center of gravity the target has a tendency to return to and stabilize at zero angle of attack and thus a tendency to find a position of stability in which it develops no lift of its own. The airload against the tow line is thus the only force supporting the target. As a result, in flight, the tow line, usually a nylon rope, curves out and down behind the tow plane and the target travels several hundred feet below. Thus, the tow plane is out of the line of fire when a low-angle off-the-tail attack is made on the target.

Although the illustrated example is of a cruciform arrangement of four wings, three or more wings may be used. Any wing planform may be employed, but the delta shaped wing illustrated herein appears advantageous for the reason that its aerodynamic center is in the immediate vicinity of the half-chord point and hence requires a minimum amount of nose extension counter weight to move the center of gravity forward of the aerodynamic center for stability, thus resulting in a minimum over-all weight for the target.

Obviously, many modifications and variations of this invention are possible in the light of the above teachings. It is therefore to be understood that the invention is not intended to be limited to specific modification herein illustrated and discussed, its scope being rather defined by the appended claims.

What is claimed is:

1. A high-speed aerial tow-target comprising a wing assembly of a plurality of rigid planar wing elements attached to one another so that they extend outwardly from a central axis, said wing assembly having a center of gravity and an aerodynamic center of known locations on said axis, a weighted extension attached to the forward end of the wing assembly at said central axis and extending forwardly thereof, said extension being of such weight and length that the combined wing assembly and extension have a center of gravity which is forward of the

aerodynamic center thereof, a yoke straddling one of said wings, means for pivotally attaching said yoke to said wing assembly adjacent said central axis, and substantially at said last named center of gravity.

2. An aerial tow-target according to claim 1, having radar reflecting means appended to the after end thereof.

3. The aerial tow-target of claim 1, in which the means for attaching said yoke to said wing assembly comprises a plurality of bearing means on said wing assembly in the vicinity of said last named center of gravity, and connecting means selectively engageable with one of said bearing means to privotally attach said yoke thereto.

4. An aerial tow-target according to claim 1, wherein the wing assembly is comprised of four wings, attached to one another to extend radially outwardly from said central axis.

5. An aerial tow-target according to claim 4 wherein the four wings are arranged in a cruciform configuration with each wing perpendicular to the next adjacent wings.

6. An aerial tow-target according to claim 5, wherein the wings are triangular in shape, the rearward edges thereof forming bases of said triangular shapes in a plane perpendicular to that of the central axis and the hypotenuses thereof outwardly extending from said central axis.

7. An aerial tow-target according to claim 6 wherein

the wing assembly is reinforced by substantially triangular fairing strips attached between each set of adjacent wings at the after end thereof, each said triangular strip being attached to the wing assembly with its apex substantially at the line of juncture of adjacent wings and the ends of its base edge positioned at points along the aft end of said adjacent wings, which are spaced from said line of juncture, whereby the wing assembly is rigidified and the wings are braced against vibration and flutter.

8. An aerial tow-target according to claim 6, having radar reflecting means attached thereto aft of said fairing strips whereby the said radar reflecting means is shielded from the air stream by said fairing strips.

References Cited in the file of this patent

UNITED STATES PATENTS

1,408,001	Hauck	Feb. 28, 1922
1,974,656	Nelson	Sept. 25, 1934
2,390,538	Jessen	Dec. 11, 1945
2,419,549	Griesinger	Apr. 29, 1947
2,463,517	Chromak	Mar. 8, 1949

FOREIGN PATENTS

7,466	Great Britain	1913