June 2, 1964 R. I. NORMAN ETAL 3,135,511

TOWED TARGET

Filed Feb. 27, 1961 4 Sheets-Sheet 1

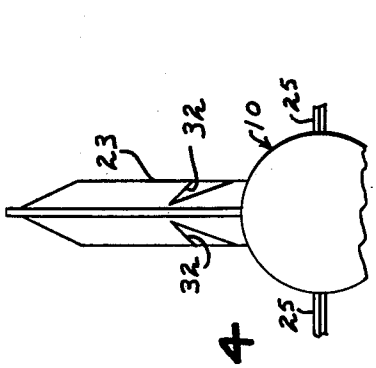
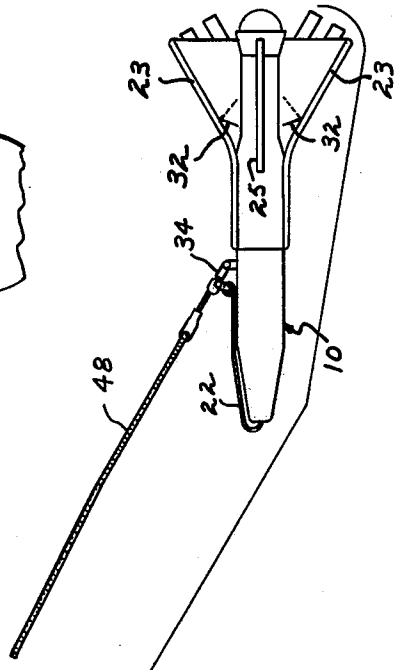


FIG. 4



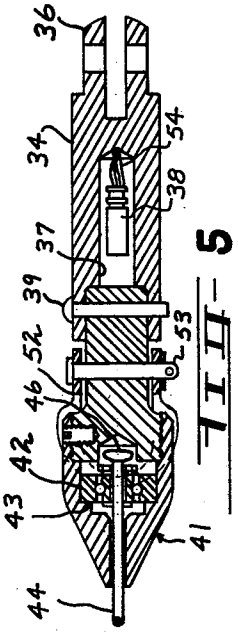


FIG. 5

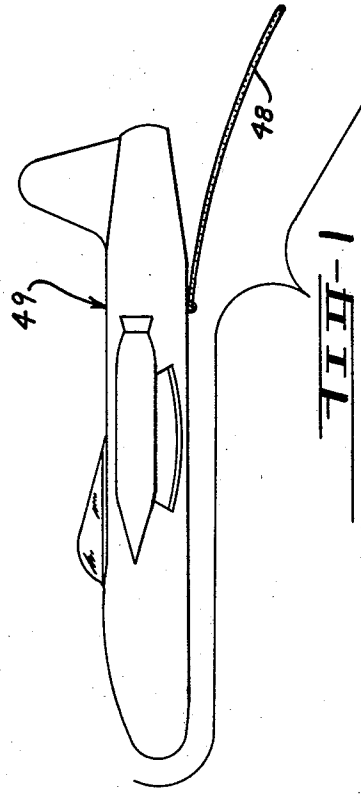


FIG. 1

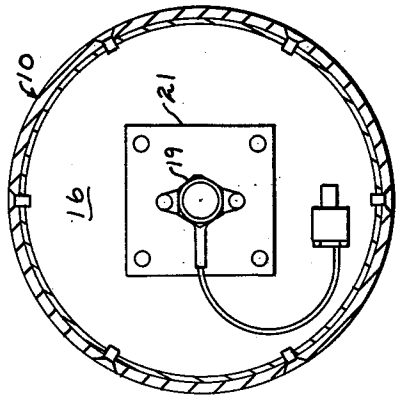


FIG. 3

INVENTORS
Robert I. Norman
BY Norman F. Meullen
Jennings, Carter & Thompson
Attorneys

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Filed Feb. 27, 1961 4 Sheets-Sheet 2

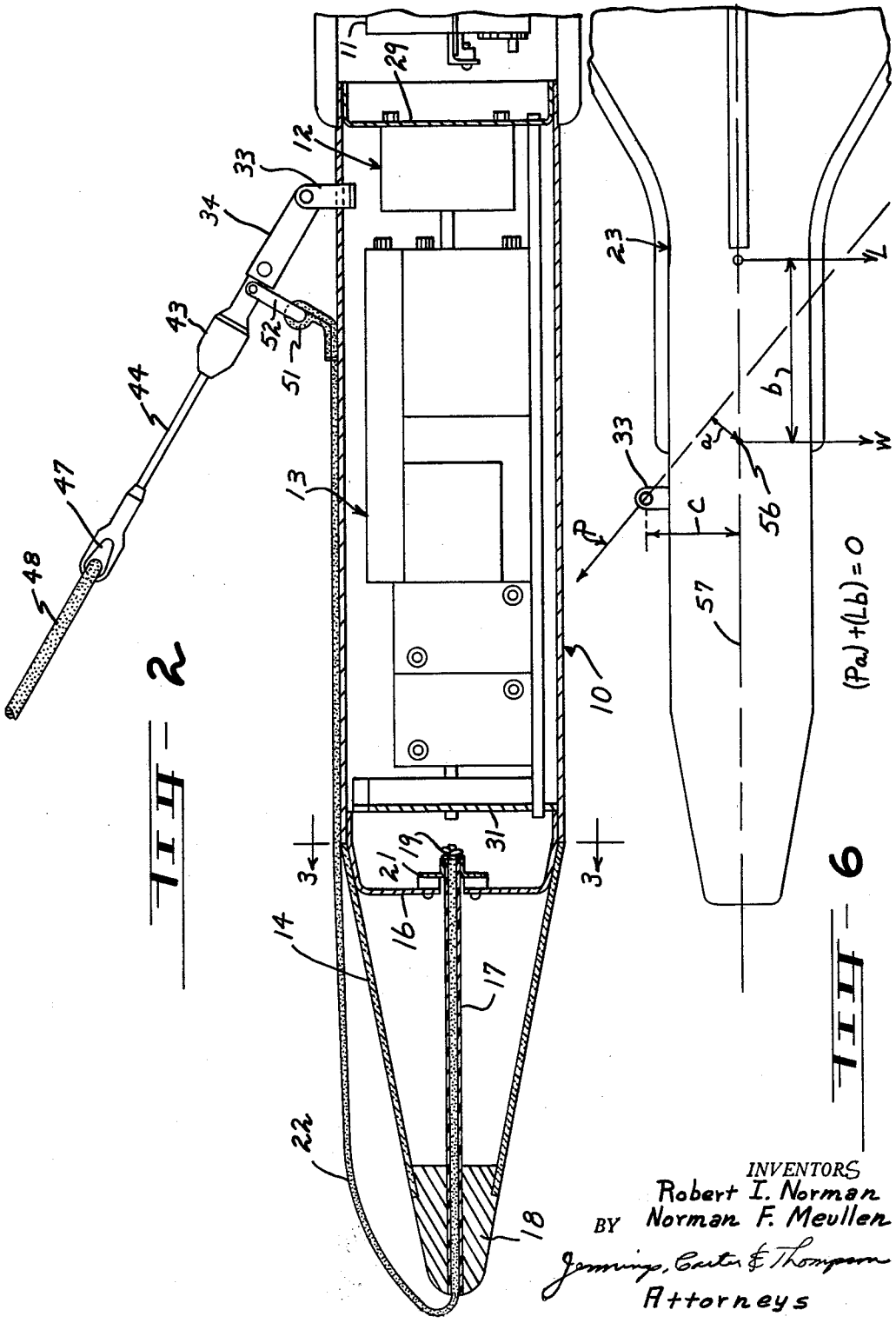


FIG. 2

FIG. 6

INVENTORS
Robert I. Norman
Norman F. Meullen
BY Jennings, Carter & Thompson
Attorneys

June 2, 1964 R. I. NORMAN ETAL 3,135,511

TOWED TARGET

Filed Feb. 27, 1961 4 Sheets-Sheet 3

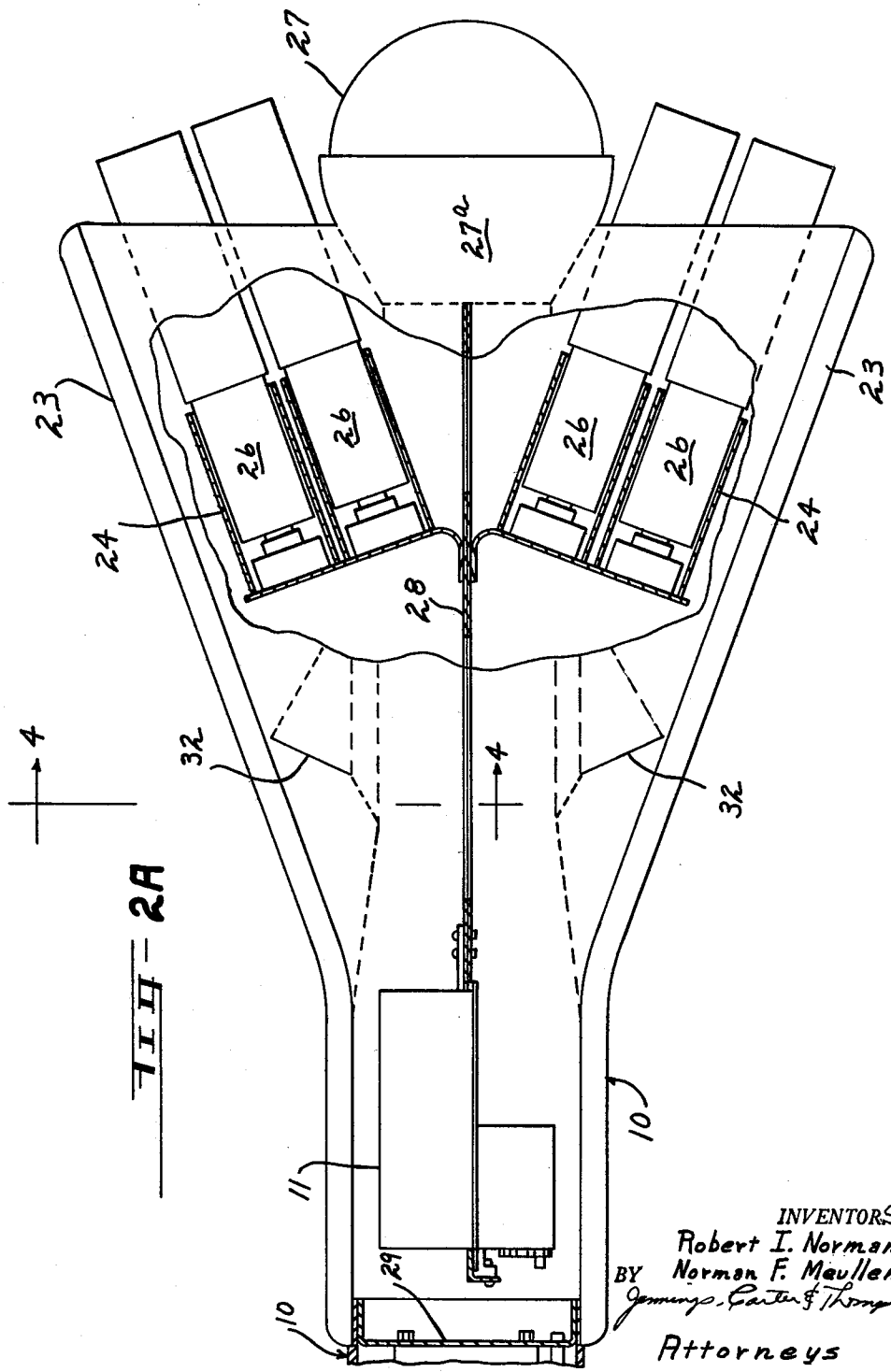


FIG. 2A

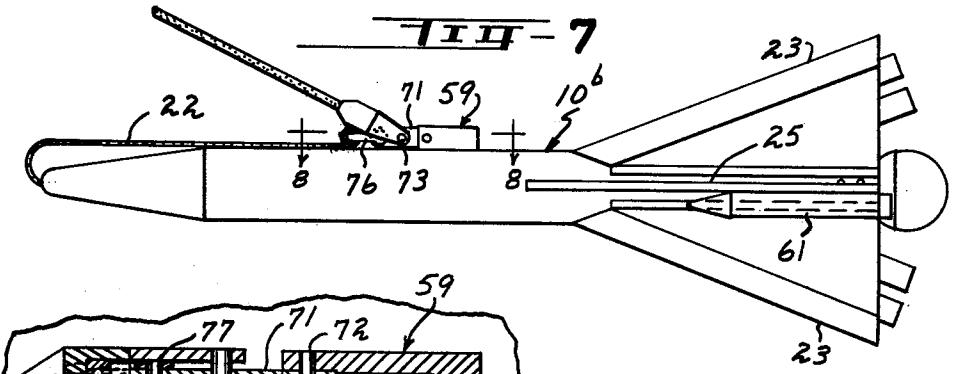
INVENTORS
Robert I. Norman
Norman F. Meullen
BY Jennings, Carter & Thompson
Attorneys

June 2, 1964 R. I. NORMAN ETAL 3,135,511

TOWED TARGET

Filed Feb. 27, 1961 4 Sheets-Sheet 4

Fig. 7



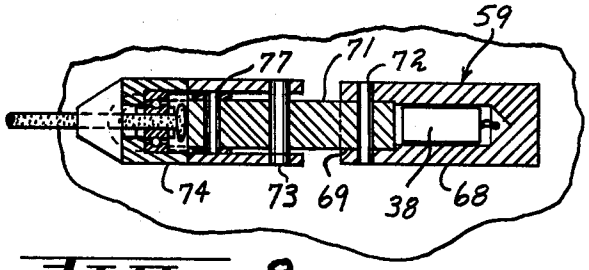
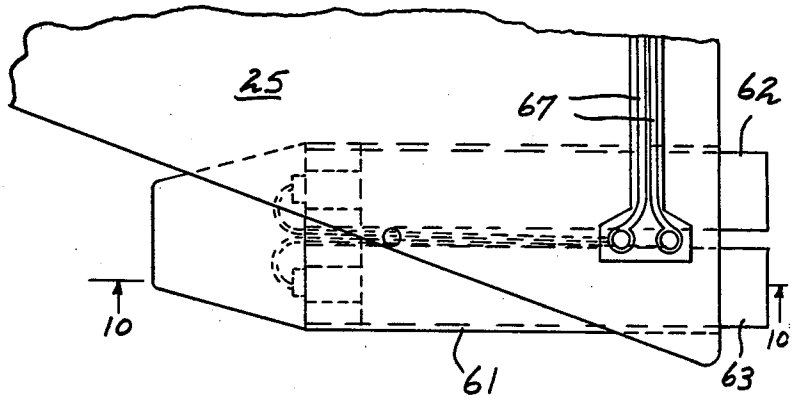


Fig. 8

Fig. 9



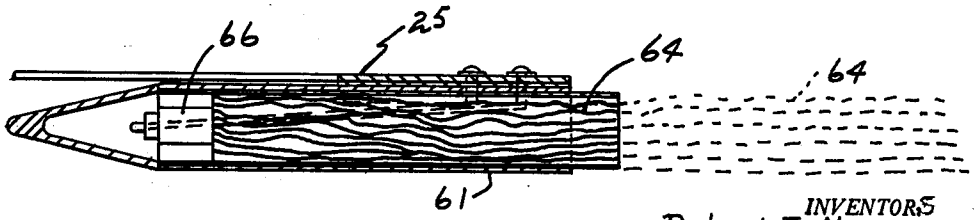


Fig. 10

INVENTORS
Robert I. Norman
BY Norman F. Maullen
Jennings, Carter & Thompson
Attorneys

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3,135,511

TOWED TARGET

Robert I. Norman and Norman F. Meullen, Birmingham, Ala., assignors to The Hayes Corporation, a corporation of Alabama

Filed Feb. 27, 1961, Ser. No. 91,763
6 Claims. (Cl. 273—105.3)

Our invention relates to towed targets for aerial purposes, and more particularly to such target which simulates a self-propelled target such as a jet aircraft, thereby to afford practice in detecting and intercepting such aircraft or similar object.

Our invention also relates particularly to the provision of a target having the features hereinafter set forth and which shall be capable of effective towing both at subsonic and supersonic speeds.

An object of our invention is to provide a towed target of the character designated which shall be stable in flight at subsonic and supersonic speeds, that is, one which has minimum tendency to roll, yaw or pitch, and to accomplish such stability in a predetermined range of lift to drag ratio.

A more specific object is to provide a target which may be towed from a point of connection located offset from the longitudinal axis of the target body, and in such position relative to the effective lift and center of gravity as aerodynamically to stabilize the target.

Another object is to provide a target which carries one or more means for increasing or decreasing the detectability of the target together with means effective to energize the same upon command from a remotely instituted radio signal, and specifically, if such means is an infra-red flare, to increase the effectiveness of such flare by discharging it at an angle to the longitudinal axis of the target.

Another object of our invention is to provide means for changing the point of connection of the tow cable while the target is in flight, whereby the target may be launched while secured to the towing cable in the oil longitudinal center tow position and recovered while being towed from some other position. Further, we propose to use such in-flight shifting of tow positions to keep the target trimmed for the desired type of flight after expending a load, to cause the target to change its altitude relative to the towing aircraft, etc.

Another object is to provide improved means for housing infra-red sources such as flares in the stabilizing surfaces provided on the target as distinguished from housing the flares in the body of the target, together with means to cool the surfaces when the flares are ignited.

A still further object is to provide, in combination with one specific tow connection, an antenna for the radio carried by the target which is in the form of a tube, through which tube passes a non-metallic flexible tow member, and the nose of the target being of non-metallic material, whereby the function of the antenna is not impaired and the tow member is securely fastened to a suitable part of the target body structure.

Yet another object of our invention is to provide a target which in general is aerodynamically trimmed by attaching the tow cable in such position relative to the center of gravity and the center of lift, as thereby to eliminate the necessity for trimming the target by tabs, peculiarly shaped airfoil sections, and the like, all to the end that our target shall fly properly, both at subsonic and supersonic speeds.

A target illustrating features of our invention is shown in the accompanying drawings, forming a part of this application, in which:

FIG. 1 is a diagrammatic view showing our improved target being towed by an aircraft, the scale of the target relative to the aircraft being increased;

FIG. 2 is a vertical sectional view, partly in elevation showing the front of the target, the towing cable being attached at a position to stabilize the target;

FIG. 2*a* is in effect a continuation of the view of FIG. 2 and showing the rear of the target with certain parts broken away and in section;

FIG. 3 is a detail sectional view taken generally along line 3—3 of FIG. 2;

FIG. 4 is a fragmental detail view taken generally along line 4—4 of FIG. 2*a* and drawn to a reduced scale;

FIG. 5 is a vertical sectional view through the swivel tow connection and the explosive discharge or squib means for disconnecting the swivel tow connection from the point where it is shown connected in FIG. 2;

FIG. 6 is a diagrammatic view illustrating the forces involved in our improved target and the directions thereof;

FIG. 7 is a side elevational view of a towed target embodying features of our construction and showing a different type of tow connection and also showing means carried by one of the horizontal stabilizers for discharging into the air material which will either increase or decrease the in-flight detectability of the target;

FIG. 8 is an enlarged detail sectional view taken generally along line 8—8 of FIG. 7 and showing a modified form of tow connection embodying explosive separable elements;

FIG. 9 is a fragmental plan view of one of the horizontal stabilizing surfaces of the target shown in FIG. 7 and showing the location of pods for carrying the charges or means affecting the detectability of the target; and,

FIG. 10 is a detail sectional view taken generally along line 10—10 of FIG. 9.

Referring now to the drawings for a better understanding of our invention, our improved target comprises generally a tube-like axially elongated body indicated generally by the numeral 10. The body is built to accommodate a radio receiver indicated generally by the numeral 11, an electric switch 12 which may be a switch of the sequence type, and a power supply for the radio indicated at 13 and which may be in the form of a number of storage batteries. As is well understood in this art, the radio receiver 11, upon receipt of a signal of a given frequency connects one set of contacts of the sequence switch to provide energy for carrying out certain operations, such for instance as to fire flares in sequence, or one at a time, as will be hereinafter pointed out. The battery 13 furnishes power both to the radio and for the electric detonation or ignition of the flares.

The nose of the body may be provided with a cone 14 which is made of radio wave permeable material. Secured at its rear end to a forward bulkhead 16 inside the body is a tubular radio antenna 17. The radio antenna is made of metal suitable for the purpose. The tube passes through a nose block 18.

Passing through the antenna and secured at 19 to a bracket 21 on the rear of the bulkhead 16 is a length of flexible material 22. The material 22 may be a nylon rope of sufficient size and strength to carry the pull of the entire target in a manner later to appear.

Adjacent the rear of the body we provide vertical stabilizing fins which preferably are of airfoil section as indicated at 23. It will be noted that the fins 23 are thick enough to accommodate flare holders 24. We provide horizontal stabilizers 25 which may be relatively thin as shown. A plurality of flares 26, of the kind known in the art and which may be electrically ignited, are mounted in the holders. In like manner, at the rear of the body there may be mounted a Luneberg lens in-

dicated at 27. It will be understood that the structural part of the body 10 proper continues rearwardly to the holder 27a for the Luneberg lens, there being internal strengthening members indicated generally by the numeral 28 inside the body. Likewise, a suitable number of other bulkheads such as 29 and 31 are provided for strength purposes and to accommodate mounting the several mechanisms in the body.

It will also be especially noted that the vertical fins or stabilizers are provided with openings 32 along their leading edges. The purpose of such openings is to admit a flow of air through the fins, thus to cool the fins when the flares are ignited. While various forms, shapes and locations for these openings may be devised, we prefer simply to slit the surfaces of the fins on each side as indicated in FIG. 4 and to press inwardly on the metal just forwardly of such slits.

Mounted on the body, and securely tied in with the internal framework thereof is a tow connection 33 to which may be attached a member 34 having a clevis end 36. See FIG. 5. As will later appear, the tow connection 33 is specifically related to the center of gravity of the target and center of lift thereof is offset from the longitudinal center line of the body, all for purposes presently to be explained in detail.

Referring particularly to FIG. 5 it will be seen that the member 34 includes a chamber 37 in which there is a squib 38 of explosive material. Joined to the part 34 by means of a shear rivet 39 is a forward body part 41. The forward body part 41 includes a swivel in the form of a thrust bearing 42, the outer race thereof being mounted in a shouldered, recessed part 43 of the portion 41. A length of cable 44 passes through the inner race of the bearing 42 and may be provided with an enlarged or swaged end 46 to prevent the same from withdrawing from the inner race.

As shown in FIG. 2 the forward end of the cable 44 is provided with an eye 47 to which may be attached a tow cable 48 leading to the aircraft 49 as shown in FIG. 1. If desired the cable 48 may lead directly to the swivel connection.

The rear end of the flexible cable 22 may be attached as indicated at 51 to a clevis 52. The clevis 52 is pivotally carried on a pin 53 passing through the part 41.

The explosive charge 38 may be of the electrically ignitnig type, energy being supplied thereto from a suitable source, such as the batteries 13, through wires 54, under control of the sequence switch 31.

Referring particularly now to FIG. 6, it will be seen that the bracket 33 to which the part 34 of the tow member is connected is located forwardly of the center of gravity of the target as a whole which is indicated by the numeral 56. Furthermore, the bracket or tow connection is so located relative to the center of gravity 56 that it is offset a distance *c* from the center line of the target as a whole and which is indicated by the numeral 57. Still further, the position of bracket 33 relative to the center of gravity 56 is such that an extension of the direction of pull exerted by the tow cable 48 is generally displaced from the center of gravity 56 some distance indicated by the small letter *a*. The center of lift L of the target is always rearwardly of the center of gravity 56 some distance indicated by the letter *b*.

With the foregoing in mind and denominating the pull of the cable by the letter P, and the weight or mass of the target by the letter W, it is possible to position tow connection 33 so that the following formula is valid:

$$Pa+Lb=0$$

Stated differently, in view of the fact that the towing connection 33 is offset the distance *c* and since the moments in a vertical plane about the center of gravity 56 are equal and opposite, it will be seen that the target is stabilized about its several axes. Therefore, by a combination of the relative and proper disposition of tow connection 33 relative to the center of gravity and the center of lift, and by offsetting it from the longitudinal center line of the target, the target is stable in all directions. In practice, we finde that the foregoing holds true both for subsonic and supersonic towing and we therefore have provided a target fully capable of towing under those conditions. In fact, a target according to our invention has recently been flown at record speed and has been found to possess all of the improved flight characteristics set forth herein.

In view of the foregoing the operation, construction and advantages of our target may now be more fully explained and understood. As is presently known, military aircraft are equipped with devices for recovering targets of the general nature here involved when the targets are being towed generally from the front, coincident with their longitudinal axes. However, such equipment forming a part of the aircraft can, with minor variations, be altered to permit launching of our improved target. Therefore, one specific object of our invention is attainable, namely, to launch the target with the tow cable effectively connected to the point 33 and, when it is desired to recover the target, to explode the squib 38, shearing rivet 39, thereby effectively connecting the cable 48 to the target through the nylon or other flexible tow member 22. Still further, and as is apparent from our disclosure, it would be quite possible to change from a point 33 to a tow connection similar to 33 forwardly of that shown in our drawings, and subsequently to change from the second such point 33 to the tow connection represented by the member 22. The later operation has advantages where it is desired to keep the target trimmed in response to having discharged a load such as having expended the material in devices such as the flares 26. However, it is to be especially pointed out that the prime advantage of our invention lies in having provided a target which is stable in flight by connecting the tow cable to the point 33, relatively arranged as disclosed.

In FIGS. 7 to 10 we show our improved target which embodies certain additional features. Thus, the target 10b of FIG. 7 is provided with a different type of separable tow cable connector member indicated generally by the numeral 59. Also, beneath the horizontal stabilizer or fin 25 we mount a pod 61 for carrying, for instance, a pair of cylinders 62 and 63. The cylinders 62 and 63 may carry charges of "chaff," indicated at 64. As is known, such "chaff," may consist of small strips of tin or lead foil or the like, proportioned in accordance with the wave length of the radar or other instrumentality which is attempting to detect the path of the target. At the front of each pod is an explosive charge 66 which is connected by leads 67 to the sequencer switch 12 and by that switch connected to a source of power when desired.

The breakaway tow connection 59 of FIGS. 7 and 8 embodies a cylinder 68 which is secured to the body of the target 10b, thus to tow from the same approximate point as the bracket 33 in the other figures. Inside the cylinder is an explosive charge 38, identical with that already described and which may be selectively connected to a source of energy to explode the same.

Passing into the member 68 through a slot 69 therein is a connector member 71. A shear rivet 72 secures the member 71 to the member 68.

The member 71 is connected by a rivet 73 to the clevis end of a cable connector 74. The flexible cable 22 is connected to a clevis 76 in turn connected by a rivet or pin 77 to the member 71. The tow cable is connected to the inner race of a thrust bearing housed in part 77 as already described, thus to form a swivel.

The operation of the member 59 is substantially as described in connection with the connector of FIG. 5. That is, when the charge 38 explodes, the part 71 is moved outwardly to shear the rivet 72. The end of the member 71 that originally was in the cylinder 68 thus

occupies the space between the clevis end of the member 74, the link or clevis 76 tied to the end of the cable 22 pivoting about the rivet 73 to occupy the rearward position.

In connection with the pods 62 and 63, it is apparent that they may contain flares, chaff, or may house other means which might either increase or decrease the detectability of the target.

In operation, the target is launched from the towing aircraft 49 with the body member 34 connected to 33. Upon receiving the proper signal from the aircraft or other source, the radio receiver 11 operates the switch 12, thus to fire one or more of the flares 26 or discharge the "chaff" from tubes 62 or 63. Subsequent signals from the radio receiver fire others of the flares 26 or other devices at the commmand of the operator as is well known in the art. A still further signal from the operator sequences the switch 12 to a position to supply energy through the leads 54 to the squib 38, thus to shear rivet 39 and effectively connect the tow cable to the target along its longitudinal axis for recovery into the aircraft 49.

It is further to be noted that the flares 26 are directed upwardly and downwardly, in a generally vertical plane, relative to the longitudinal axis of the target. This has the peculiar advantage of distributing a stream or streams of infra-red energy at an angle to the path of the target, whereby the tracking mechanism has a better "view" or exposure to such streams or paths of infra-red energy. It will also be noted that this better "view" is afforded when the tracking instrumentality is approaching the towed target from generally the same altitude. Our improved target thus distinguishes over those types in which the flares are fired directly rearwardly in that we obtain a broader field of influence, directed at a more efficient angle than is the case with those targets which fire their infra-red sources immediately rearwardly of their directions of flight. Likewise, the advantage of cooling the surfaces of the fins 23 upon firing of the flares are that we prevent damage to such surfaces which has been known to occur with some prior art targets. Still further, by having the infra-red sources in or on the vertical fins or stabilizers themselves as distinguished from the body proper, we shorten the overall length of the target, reduce the structural complications, and decrease the cost of construction of the target as a whole.

In view of the foregoing, it will be apparent that we have devised an improved towed target for aerial purposes. In actual practice, our target has been found to be extremely stable in flight, in all directions, both at subsonic and supersonic speeds. It is readily adaptable to recovery with present launching and recovery equipment without extensive changes therein. By providing the antenna for the radio in tube form and by utilizing the flexible member 22 of radio wave permeable material, we have simplified the adaptation of the antenna to a target which may be towed from its nose position, coincident with the axial center line.

While we have shown our invention in but two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and we desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What we claim is:

1. In a target adapted to be towed at the end of a single tow line by an airplane, an elongated tubular shaped body, airfoils adjacent the rear end of the body, a tow line connection on the body offset from the longitudinal center line of the body, a second tow line connection located at another position on the body, a tow line connected to the first named connection, and means to transfer the point of tow from the first named connection to the second named one while the target is connected solely by said tow line to an airplane and trailing the airplane in flight.

2. A target as defined in claim 1 in which the second tow connection is adjacent the front of the body and located substantially coincident with the longitudinal center line of the body.

3. A towable target as defined in claim 1 in which the tow line is attached to the target through a swivel at the first named towing connection, and in which the means to change the first to the second towing connection includes means to release the swivel from the first towing connection and operatively place it in tow line connection upon transfer to the second towing connection.

4. A target as defined in claim 1 in which the means to transfer from the first to the second towing connection comprises a tow line connector having explosive-severable parts, one part of which is secured to the tow line and the other part of which is secured to the body at the first named towing connection, and explosive means to sever said parts while the target is in flight.

5. In a towed target, an elongated tube-like body, a pair of vertical and horizontal stabilizing surfaces adjacent the rear of the body, the vertical surfaces being thick enough to house at least one infra-red flare, at least one flare in each of said vertical surfaces directed rearwardly and vertically to the longitudinal center line of the body of the target, radio signal receiver means and suitable associated mechanisms in the body of the target responsive to a radio transmitted signal to ignite at least one of said flares at a time, an antenna for said radio signal receiver in the form of a hollow tube located in the nose of the body of the target and extending fore and aft of the body substantially on the longitudinal center line thereof, a nose cone of radio wave permeable material surrounding the antenna, and a length of radio wave permeable material inside the antenna and secured to the target to which a cable may be attached for towing the target.

6. A target as defined in claim 5 in which the stabilizing surfaces carrying said flares are provided with vent means permitting the passage of air into said surfaces during flight of the target, thereby to cool the surrounding parts of said stabilizing surfaces upon igniting said flare or flares.

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