March 22, 1955 E. B. DANE, JR 2,704,513

EYE BIAS DEVICE FOR HOMING BOMB

Filed May 5, 1947 3 Sheets-Sheet 1

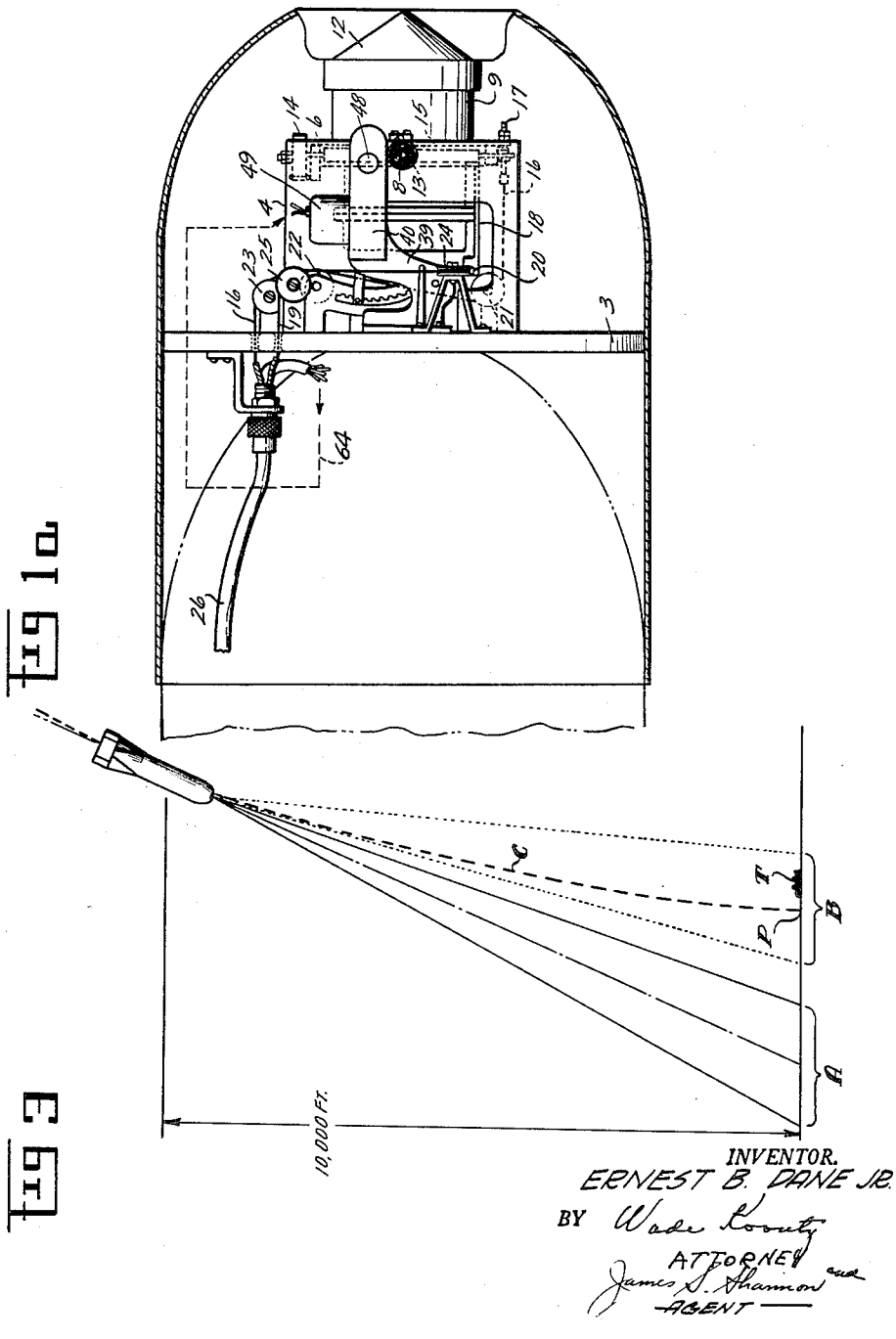


Fig 1a

Fig 3

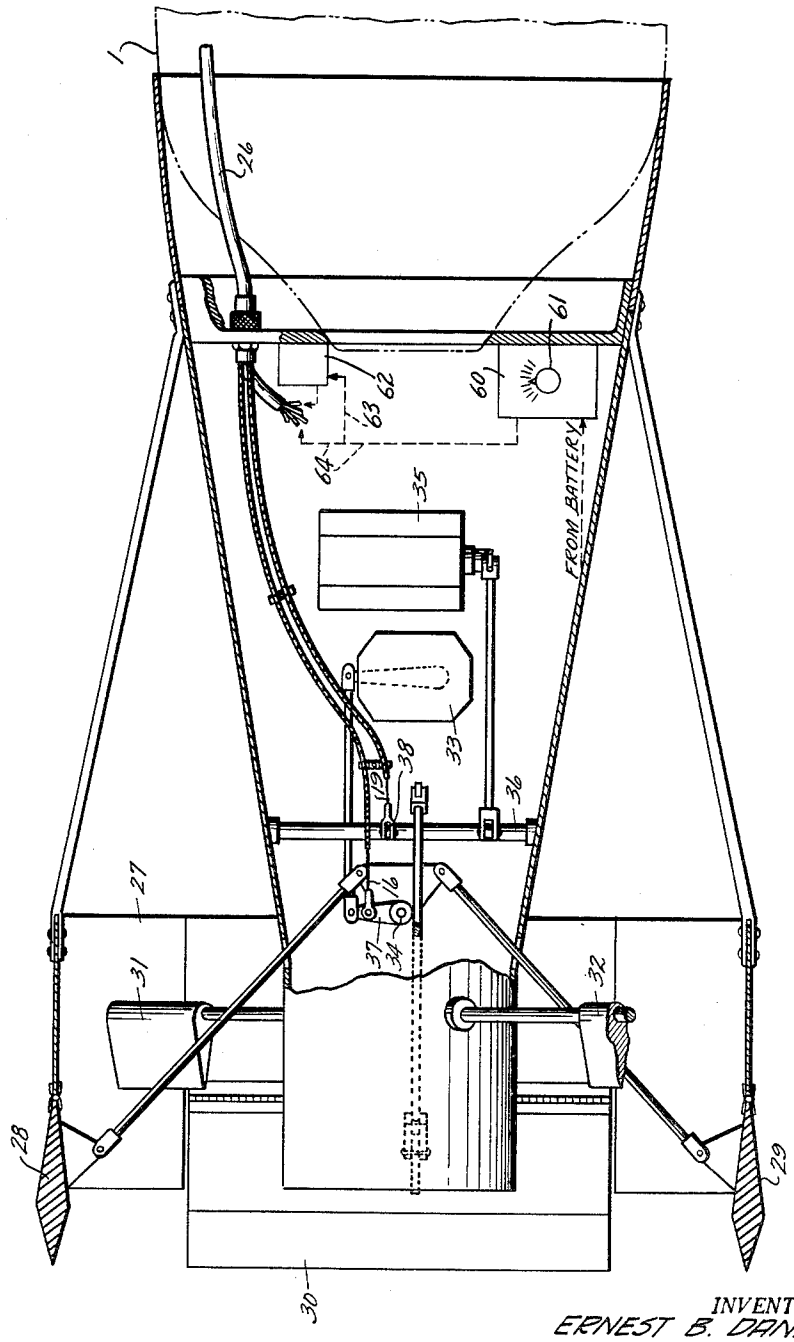
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Fig 4



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Fig 2

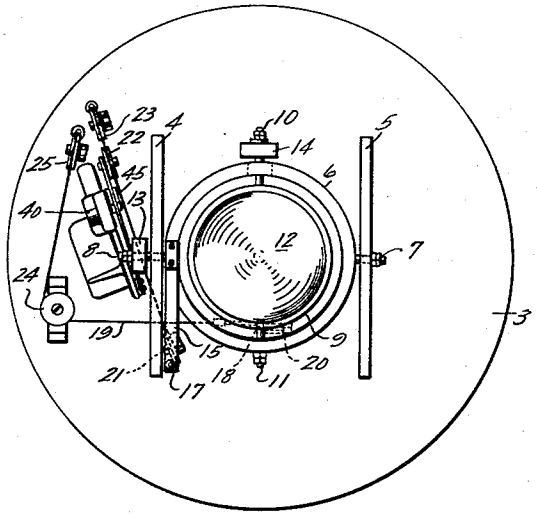
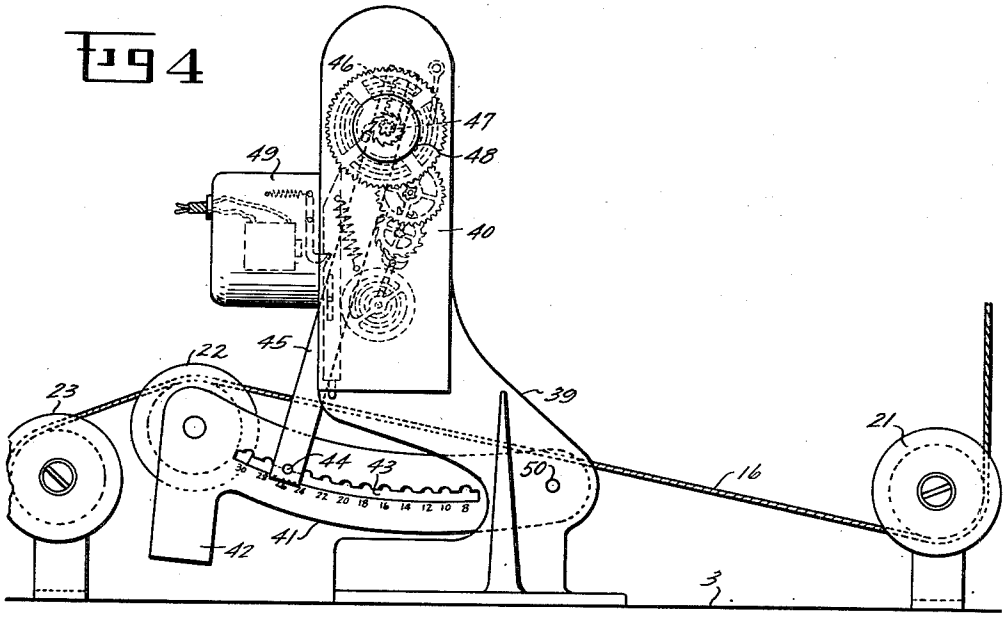


Fig 4



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EYE BIAS DEVICE FOR HOMING BOMB

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Application May 5, 1947, Serial No. 746,025

7 Claims. (Cl. 102—3)

This invention relates to the control system of a maneuverable bomb of the type designed to home on a source of infrared radiation, and particularly to an eye-biasing device for use in the control system of such a bomb. Bombs of this type have limited maneuverability and are dropped in the conventional manner with the aid of a bombsight. The control system is operative during the last thirteen seconds or so of the bomb's fall and serves to steer the bomb to the target as represented by the strongest source of infrared radiation in the field of view of the bomb's eye. The real function of the control system therefore is to correct for initial errors in the aiming of the bomb by the bombsight.

The flight of the bomb is controlled by rudder, elevator and aileron surfaces located in the tail. The ailerons are gyroscopically controlled and serve to stabilize the bomb as to roll. The rudder and elevator surfaces are controlled by servomotors operating in response to signals received from the infrared sensitive eye and an associated electronic circuit, and serve to control the direction of travel of the bomb by means of a yawing or "skidding" action.

A main timing device is provided in connection with the control circuit and is set in accordance with the altitude of release to turn on the control system when the bomb has reached an altitude of about 10,000 feet, or about thirteen seconds before the time of impact. Prior to the time at which the control system becomes operative, the bomb falls with its eye and controls in the neutral position. It is desirable that the target be in the center of the field of view of the eye at the time that the control system becomes operative, however, when the eye is in the neutral position, its field of view is centered about the axis of the bomb, and the attitude of the bomb at this point is such that the field of view falls beyond the target area. This difficulty is corrected in accordance with the invention by providing an initial downward bias to the eye which is gradually decreased to zero as the bomb nears the target.

It is therefore the object of this invention to increase the accuracy of control of bombs of the described type by providing means to enable the eye to see the target during the entire period of operation of the control system.

The means for accomplishing this purpose are described in detail in connection with the accompanying drawings in which:

Fig. 1*a* shows a cut away view of the nose section of a homing bomb;

Fig. 1*b* shows a cut away view of the tail section of a homing bomb;

Fig. 2 is an end view of Fig. 1*a* with the shroud removed;

Fig. 3 is a diagram showing the relationship between the bomb, its field of view, the target and the free fall impact point; and

Fig. 4 shows the details of the eye biasing device.

As shown in Figs. 1*a* and 1*b*, the control system of the bomb comprises a nose section and a tail section which may be attached to a standard 1,000 pound bomb **1**. Referring to Figs. 1*a* and 2, the plate **3** is fastened to the nose of the bomb and carries two supports **4** and **5** between which are mounted a gimbal ring **6** pivoted by pins **7** and **8** to rotate about a horizontal axis. The housing **9** contains the infrared sensitive eye of the bomb and is mounted in the ring **6** by pins **10** and **11** which permit the eye to rotate about an axis in the vertical plane. The principal elements of the eye contained in housing **9** are

a parabolic mirror rotated at constant speed, a bolometer located at the focus of the mirror and a commutating device. The mirror is mounted so that its optical axis makes an angle of about 5° with its axis of rotation and so that the principal focus falls at the intersection of the two axes. The bolometer is placed at this intersection and is of such size as to subtend an angle at the center of the mirror equal to twice the angle between the two axes, or about 10°. With this arrangement, the eye scans a circular area 10° in diameter centered on the axis of the eye. The bolometer is a resistance element having a high temperature coefficient and coated with a black substance so as to convert the infrared radiations incident thereon into heat. The resistance of the bolometer is therefore a function of the infrared radiation striking it. The signal from the bolometer is applied to an electronic circuit which controls the servomotors actuating the rudder and elevator surfaces in the tail. The commutator is mounted on the same shaft as the mirror and rotates therewith and cooperates with the electronic circuit to distinguish between signals received from the four quadrants of the scanned area. Infrared radiations are admitted to the mirror through the conical window **12** which is made of material having a high transparency to this radiation such as fused silver chloride.

The eye housing **9** is biased upward by the coil spring **13** and to the right by coil spring **14**. The housing is restrained from rotating upward by arm **15**, attached to gimbal ring **6**, and cable **16** which is fastened to arm **15** by adjusting screw **17**. Housing **9** is also restrained from rotating to the right by arm **18**, which is fastened to the housing near its bottom pivot point, and cable **19** which is fastened to arm **18** by adjusting screw **20**. Cable **16** passes over pulleys **21**, **22** and **23** and cable **19** passes over pulleys **24** and **25** and thence through holes in plate **3** and through cable **26** to the tail structure of the bomb. The cables **16** and **19** are provided with armored sheaths for passage through cable **26**. Cable **26** also carries all electrical connections between the nose and tail structures. The electronic unit is contained in the nose structure and batteries for supplying power to the control system are located partly in the nose structure and partly in the tail structure, however, these elements have been eliminated from the drawings for the sake of simplicity. Increasing the tension in cable **16** causes the eye to turn downward, and increasing the tension in cable **19** causes the eye to turn to the left. Decreasing the tension in cable **16** allows the eye to be rotated upward by spring **13** and decreasing the tension in cable **19** allows the eye to be rotated to the right by spring **14**.

The tail structure of the bomb comprises an octagonal member **27**, in the upper and lower surfaces of which are mounted elevator surfaces **28** and **29**, and in the left and right surfaces of which are mounted left rudder surface **30** and a corresponding right rudder surface not shown. Also mounted within the octagonal member **27** are two ailerons **31** and **32** which are gyroscopically controlled and operate from the time the bomb is released to stabilize it in roll. Elevator servomotor **33** is arranged to actuate elevator surfaces **28** and **29** through shaft **34** and suitable linkages as shown, and, similarly, rudder servomotor **35** is arranged to actuate the rudder surfaces through shaft **36** and suitable linkages as shown. The cable **16** is attached to crank arm **37** on shaft **34** and cable **19** is attached to crank arm **38** on shaft **36**. Thus when the elevator surfaces **28** and **29** are actuated upward by servomotor **33**, the tension in cable **16** is increased and the eye is rotated downward against the action of spring **13**. When the elevator surfaces are rotated downward, the tension in cable **16** is decreased and the eye rotates upward due to the torque exerted by spring **14**. Likewise the left rotation of the rudders causes a right rotation of the eye and vice versa due to the action of cable **19** and spring **14**. Thus the eye is caused to rotate through an angle opposite in direction to the angle through which the bomb's axis is caused to rotate by the aerodynamic action of the control surfaces. In order to provide a slight anticipation in the control and thus avoid overshooting, the coupling between the tail surfaces and the eye is made such that the angle through which the eye rotates is equal to a constant less than unity times the angle through which the bomb's axis

is rotated. Thus the line of sighting of the eye is always on the target side of the velocity vector, or the direction in which the bomb is travelling, resulting in the eye removing the correction slightly before the velocity vector is pointed in the direction of the target. The above described coupling between the eye and the tail surfaces is necessary in order to keep the eye always looking along the velocity vector. Without this coupling changes in the attitude of the bomb brought about by the control system for the purpose of correcting the bomb's course would throw the eye off the target or else cause the eye to initiate a false correction.

The bomb is provided with a main timing device **60** shown in Fig. 1*b*. This may be any suitable device, usually a mechanical timer, for measuring a definite time interval, the length of which may be set by adjustment **61**, and for closing a set of contacts at the end of the time interval. The timer begins to operate at the time the bomb is released and measures the interval of time required for the bomb to reach an elevation of about 10,000 feet. The initial setting of the timing device is therefore determined by the altitude of release. At the end of the measured interval, the timing device renders the control system of the bomb operative, by applying a voltage through indicated connection **63** to control system energizing switch **62** for closing this switch and energizing the various components of the control system, so that the last 10,000 feet of the bomb's fall is controlled. The bomb is released from the airplane in a horizontal position and its longitudinal axis gradually tends toward a vertical position as the bomb falls. That part of the bomb's fall above 10,000 feet is made with the control system inoperative and with the elevator and rudder surfaces and the eye in their neutral positions. However, the ailerons are operative during this interval to stabilize the bomb in roll. The eye, in its neutral position, looks along the longitudinal axis of the bomb, and if in this position when the control system becomes operative, would scan a circular area of diameter A as shown in Fig. 3. It is seen that this area would not include the target, which is in the vicinity of the termination P of the free fall trajectory C. Therefore, in order to have the scanned area center around the free fall impact point when the control system becomes operative, it is necessary to provide the eye with an initial downward bias so that the area scanned is as shown at B in Fig. 3. The amount of the initial bias is determined by the altitude of release and is inversely related thereto, since the greater the altitude of release, the more nearly vertical is the axis of the bomb at 10,000 feet and the less bias angle required. As the bomb approaches the target, the bias angle should be reduced since the axis of the bomb continues to approach the vertical and the required bias angle becomes less. The eye bias device in accordance with the invention provides means for setting the initial bias angle in accordance with the altitude of release and means for gradually reducing the angle to zero as the bomb approaches the target.

The apparatus for performing the above function is shown in Figs. 1*a* and 2, and in detail in Fig. 4. It consists of a support **39** upon which is mounted a timing device **40**. An arm **41** is pivoted at **50** in the support and has pulley **22** mounted on its other end. This end of the arm is also provided with an extension **42** which serves as a stop to limit the downward movement of the arm. The arm **41** has a slot **43** provided with a number of notches designed to be engaged by pin **44** and bar **45**. The opposite end of bar **45** is provided with a rack **46** which engages pinion **47** of the timing device. The timer **40** may be wound by a clockwise rotation of knob **48** which is mounted on the same shaft as pinion **47**. When fully wound, the bar **45** is in its uppermost position, as shown in Fig. 4. The timer is held in its fully wound condition by caging device **49** which is merely a magnetically operated release device to which an actuating voltage is applied by main timer **60** concurrently with energization of the control system of the bomb. The height to which pulley **22** is raised when the bar **45** is in its uppermost position is determined by which of the notches in bar **41** is engaged by pin **44**. In the embodiment shown in Fig. 4, notches are provided for bomb release altitudes ranging from 8,000 to 30,000 feet in steps of 2,000 feet. The apparatus in Fig. 4 is set for a bomb release altitude of 26,000 feet. Maximum bias angle is provided when pin **34** is placed in the 8,000 foot notch and the minimum downward bias is produced when the 30,000 foot notch is used. Since cable **16** passes over pulley **22**, raising this pulley increases the tension in the cable **16** and causes the eye to be rotated downward against the action of spring **13**, thus providing the initial downward bias for the eye. When the main timing device **60** renders the control system of the bomb operative at or near 10,000 feet, it also sends an electrical pulse to caging device **49** over indicated connection **64** (Figs. 1*a* and 1*b*) causing it to uncage eye timer **40** which, through rotation of pinion **47**, gradually lowers bar **45** and pulley **22**, thus gradually reducing the bias angle to zero as the bomb nears the target.

I claim:

1. A homing bomb having a control system containing an eye sensitive to radiant energy and capable of scanning an area about its extended axis, said bomb being of the type designed to be released from an aircraft with the aid of a bombsight in the manner of a freely falling bomb and with its controls inoperative and in a neutral position, timing means in said bomb set in accordance with the altitude of release to render said control system operative at a predetermined altitude above the target, means preset in accordance with the altitude of release for rotating the axis of the eye downward through an initial angle inversely related to the altitude of release and of such value that the free fall impact point falls within the scanned area of said eye at said predetermined altitude, and means rendered operative at the same time as said control system for gradually reducing said angle to zero over the period of time required for the bomb to fall from said predetermined altitude to said target.

2. A homing bomb having a control system containing means for stabilizing the bomb in roll and means for controlling the direction of travel of said bomb, said latter means comprising an eye sensitive to radiant energy and capable of scanning an area about the extended axis of the eye, a tail structure containing elevator and rudder surfaces, means for controlling said surfaces in accordance with signals received from said eye, coupling means between said elevator and rudder surfaces and said eye tending to keep the axis of the eye pointed in the general direction of travel of the bomb, and additional means acting on said coupling means for causing the axis of the eye to assume a downward bias angle with respect to said direction of travel the instantaneous value of which is a direct function of the instantaneous altitude of the bomb and an inverse function of the altitude of release of the bomb.

3. Apparatus as claimed in claim 2 in which said coupling means comprises a cable connected between said elevator surface and said eye and is so arranged that an increase in the tension of said cable rotates the eye downward, and in which said additional means comprises a movable pulley engaging said cable and arranged to vary the tension in said cable.

4. Apparatus as claimed in claim 3 and in addition actuating means for said pulley, said actuating means being capable of moving said pulley from a position producing a maximum increase in tension in said cable to a position producing zero increase in tension in said cable at a uniform rate.

5. Apparatus as claimed in claim 4 in which said actuating means contains adjustable means for fixing the maximum increase in cable tension in accordance with the altitude of bomb release.

6. Apparatus as claimed in claim 5 in which said control system is provided with a timing device adjustable in accordance with the altitude of release to function at a predetermined altitude to simultaneously render said control system operative and to initiate operation of said pulley actuating means.

7. Apparatus as claimed in claim 6 in which said pulley actuating means comprises a timing device for moving said pulley from the position producing maximum increase in cable tension to the position producing zero increase in cable tension during the time required for the bomb to fall from said predetermined altitude to zero altitude.

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