United States Patent

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[54] FOLDING FINS FOR MISSILES

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **244/3.29**

[51] **Int. Cl.** **F42b 13/32**

[58] **Field of Search** 244/3.27, 3.28, 3.29

[56] **References Cited**

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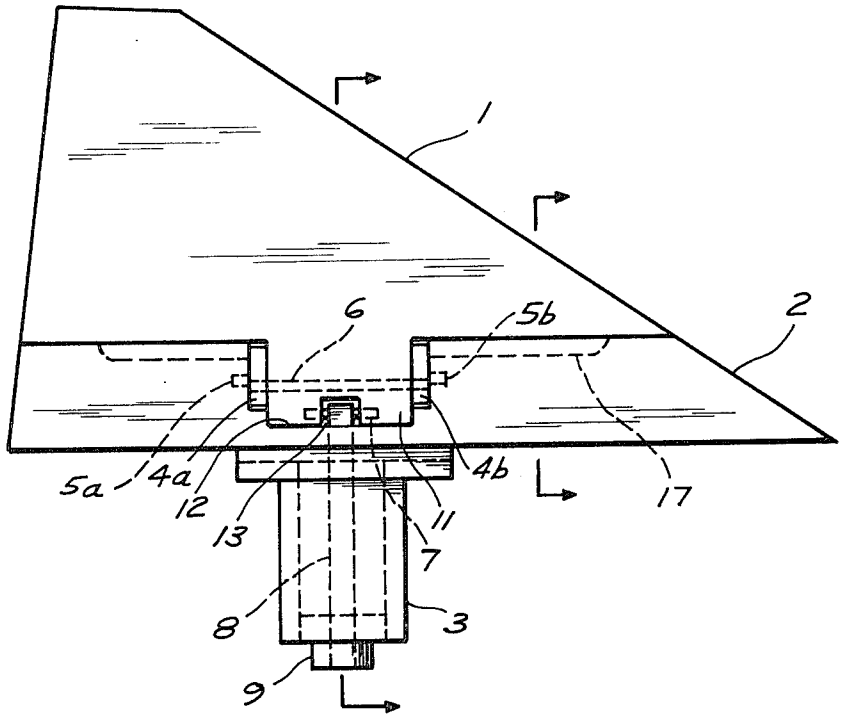
[57] **ABSTRACT**

A steering fin or rudder for a guided missile is divided into two parts, viz, a root part and a foldable part which is foldable in relation to the root part towards the body of the missile. The foldable part is connected to the root part by means of a link system, a first axis joining the link system and the root part, and a second axis joining the link system and the foldable part. An operating rod is connected to the foldable part by a third axis and is subjected to a spring force which strives to pull the rod towards the center of the missile, thereby striving to move the foldable part from folded position to its normal position in which it forms an extension of the root part. The three axes are parallel to each other and so positioned in relation to each other that the foldable part, when moved from folded position to its normal position, during the last part of its motion approaches the root part under an approximately translational motion.

6 Claims, 7 Drawing Figures



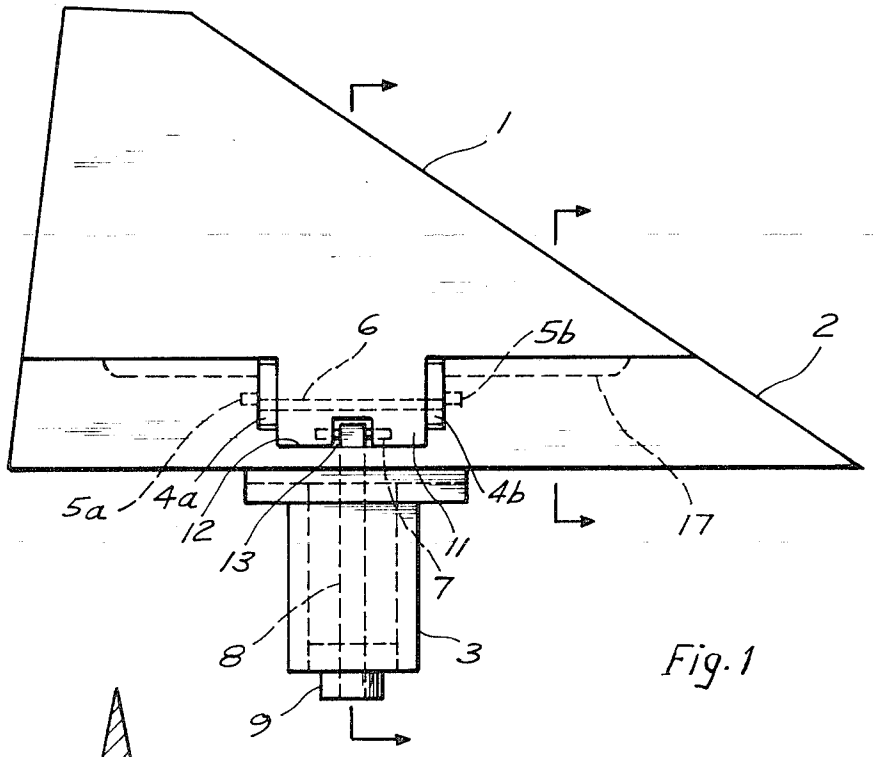


Fig. 1

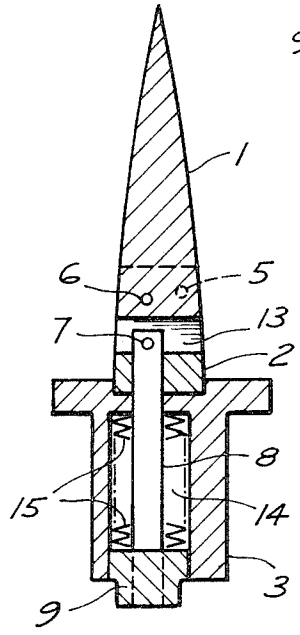


Fig. 2

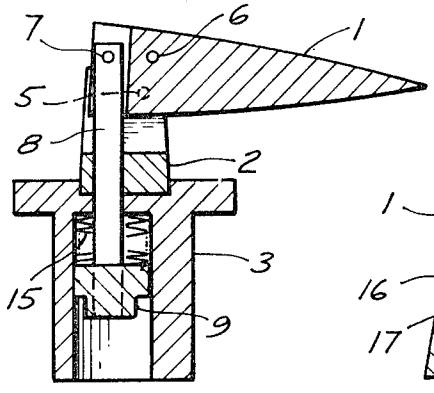


Fig. 3

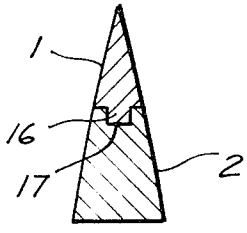


Fig. 4

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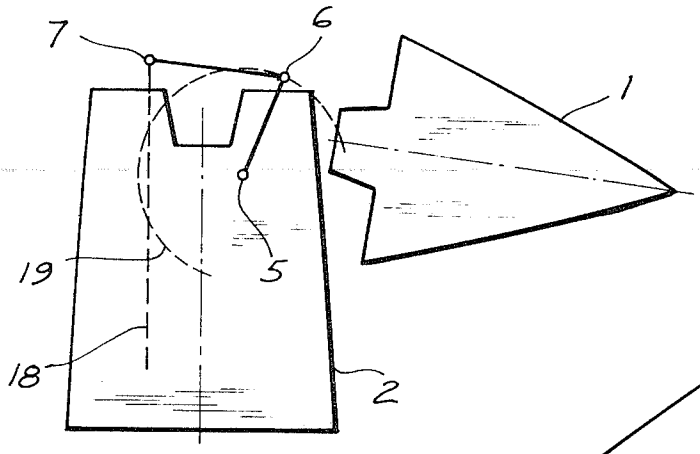

Fig. 5

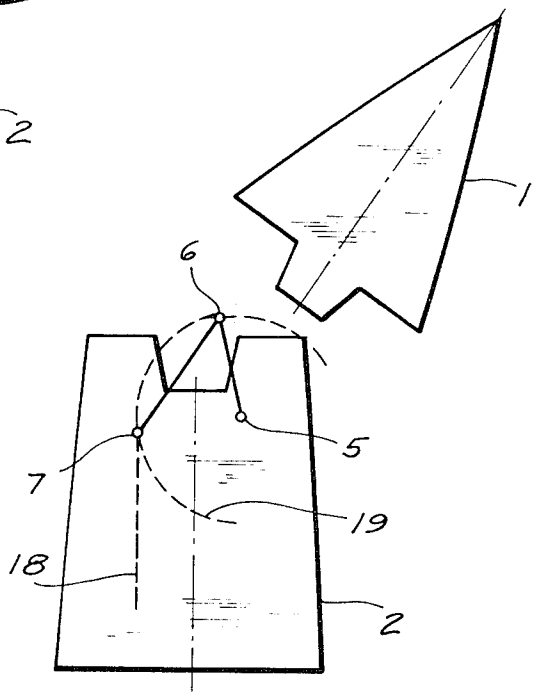

Fig. 6

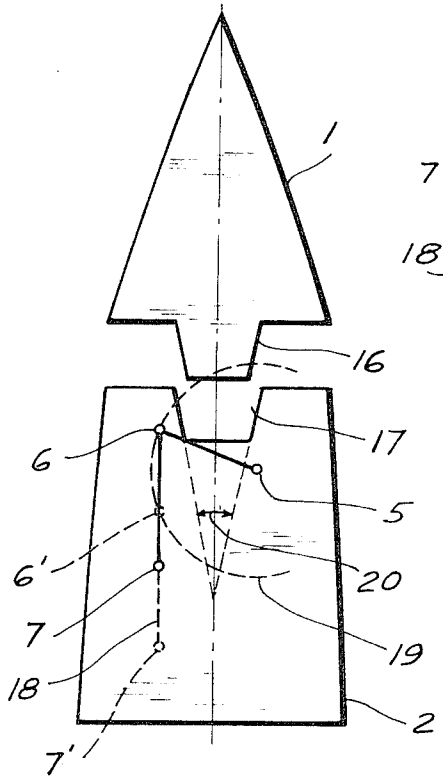

Fig. 7

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FOLDING FINS FOR MISSILES

BACKGROUND OF THE INVENTION

The invention relates to steering fins or rudders for a guided missile. Such a missile is usually provided with four fins arranged with equal angular spacing around the periphery of the missile. If the missile is to be launched by means of a launching tube these fins should be foldable so that during the travel of the missile through the launching tube they are folded towards the missile body and when the missile leaves the launching tube they are automatically unfolded to normal position. Another reason for making the fins foldable is to reduce the required space and to facilitate the handling of the missile in storage and transport. For these reasons the fin is usually made in two parts, namely a root part situated adjacent to the external surface of the missile and a foldable part which in its normal position forms an outwards extension of the root part and which can be folded from the normal position towards the body of the missile.

In prior art fins of this kind the foldable part has been connected with the root part by a pivot device so that the foldable part could be rotated in relation to the root part in the same manner as one part of a hinge can be rotated in relation to the other part. The pivot device has been combined with a spring device, e.g., a torsion spring, which strives to move the foldable part to the normal position. In its normal position the foldable part must be somehow locked in relation to the root part so that the foldable part is prevented from fluttering in relation to the root part under the action of the lateral forces exerted on the fin during the flight of the missile. In a steering fin of this known kind a relatively complicated locking device is required to lock effectively the foldable part in relation to the root part.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the present invention to provide a steering fin comprising a root part and a part foldable in relation to the root part in which the foldable part is effectively locked in its normal position in relation to the root part in a simple manner.

According to the invention the foldable part is connected with the root part by means of a link device which is rotatable in relation to the root part about a first axis and rotatable in relation to the foldable part about a second axis, and a control member is connected to the foldable part by a third axis which can be displaced by means of the control member along a substantially rectilinear path, said three axes being parallel to each other and so positioned in relation to each other that the foldable part when moving from folded position to the normal position during the last part of its motion approaches the root part under an approximately translational motion.

In a preferred embodiment of the invention those surfaces along which the foldable part and the root part meet when the foldable part is in its normal position, are provided with cooperating projections and recesses which extend parallel to the center plane of the fin and have a tapering cross section. When the foldable part, moving from folded position to the normal position, approaches the root part under an approximately translational motion, these projections which may be situated on the foldable part will engage the corresponding recesses which for instance are situated in the root part. If the lateral sides of these projections and the corresponding recesses form a sufficiently small angle to the center plane of the fin, these projections and recesses will cause a self-locking of the foldable part to the root part in the normal position, so that the foldable part cannot be turned in relation to the root part when subjected to lateral forces.

The said control member may consist of a rod subjected to the force from a spring device which strives to pull the rod inwards towards the center of the missile, thereby causing the rod to act upon the foldable part by means of said third axis. As soon as the force retaining the foldable part in folded position in relation to the root part ceases, the foldable part will thus be automatically moved to its normal position under the action of said spring force. When the missile is launched through a launching tube the foldable part is retained in folded position by the inside of the launching tube, but as soon as the missile leaves the launching tube the foldable part is moved to its normal position and is locked in this position.

DRAWINGS AND DETAILED DESCRIPTION

The invention will be described more in particular with reference to the accompanying drawings.

FIG. **1** shows a side view of a fin according to the invention with the foldable part in its normal position in relation to the root part.

FIG. **2** is a section taken along line A—A in FIG. **1**.

FIG. **3** shows the same section as FIG. **2** but with the foldable part in folded position.

FIG. **4** is a section along line B—B in FIG. **1**.

FIGS. **5–7** illustrate schematically the motion of the foldable part in relation to the root part when moving from the folded position to the normal position.

In the drawings the foldable part of the fin is designated **1** and its root part **2**. The root part is attached to a cylindrical fin holder **3** which is fitted into a corresponding boring in the body of the missile. The fin holder **3** is rotatable about its central axis and connected to a drive mechanism of known kind to impart the steering motion to the fin. The drive mechanism of the fin is however outside the scope of the invention and will not be described in detail.

When the foldable part is in its normal position as shown in FIGS. **1** and **2** its base surface is in contact with the top surface of the fin root **2**, so that the foldable part **1** forms a continuous outwards extension of the root **2**. The cross section of the fin is tapering outwards and has an aerodynamically suitable shape as shown in FIGS. **2** and **4**.

The base surface of the foldable part **1** is provided with a central projecting portion **11**, which, seen from the side, has a rectangular form and fits into a corresponding recess **12** in the root part **2** when the foldable part **1** is in its normal position. To a certain depth the recess **12** has a length which is somewhat larger than that of the portion **11** so that a spacing is formed between the end faces of the recess **12** and the portion **11**. In these spacings are mounted links **4***a* and **4***b* which are pivoted in the root part **2** by means of pins **5***a* and **5***b* respectively. The links **4***a* and **4***b* are also pivotally connected with the portion **11** of the foldable part **1** by means of a shaft **6**. The pivot pins **5***a* and **5***b* register with each other and in FIGS. **2** and **3** their position is indicated by the dotted circle **5**. The links **4***a* and **4***b* are in the form of plates which fill up the interstices between the portion **11** and the root part **2** as far as possible without obstructing the motion of the foldable part **1** in relation to the root part **2**. Thus, these plates have such a shape that when the foldable part is in its normal position the outer edges of the plates closely follow the cross sectional outline of the fin.

At its bottom the portion **11** of the foldable part **1** is provided with a recess **13**. A rod **8** extends by one end into the recess **13** and is here pivotally connected to the portion **11** by means of a shaft **7**. The rod **8** extends through an opening in the root part **2** and a cylindrical boring **14** in the fin holder **3**. The other end of the rod is screwed into a nut **9** which is formed as a piston and slidable within the boring **14**. A stack of disk springs **15** surrounds the rod **8** within the boring **14**, and exerts a spring force on the nut **9** striving to move the nut **9** away from the fin root. Hereby the rod **8** attached to the nut **9** is subjected to a pulling force which strives to pull the rod **8** inwards towards the center of the missile.

As will be seen from FIG. **2** the shaft **7** is situated at a small distance from the center plane of the fin and the rod **8** extends parallel to but a certain distance from the center axis of the fin holder **3**. Therefore, the boring **14** is eccentric in relation to the fin holder **3**.

The base surface of the foldable part **1** is provided with longitudinal ridges or projections **16** of such cross-sectional form

that their lateral surfaces converge outwards from the base surface. The top surface of the root part 2 is provided with grooves 17 having the same cross-sectional form as the ridges 16 so that when the foldable part is in its normal position the ridges 16 fit into the grooves 17. The projecting portion 11 of the foldable part 1 is preferably also provided with such ridges which can be fitted into corresponding grooves in the bottom of the recess 12 in the fin root 2. As will be seen in FIG. 1 in which the grooves are indicated by a dotted line, the grooves 17 and the corresponding ridges 16 need not extend to the rear and front edges of the fin but are preferably terminated at a certain distance from these edges.

When the foldable part 1 is in folded position as shown in FIG. 3, the rod 8 to a large extent is outside the fin holder 3, and the disk springs 15 are compressed and exert a strong pressure upon the nut 9 which is attached to the inner end of the rod 8. If the force retaining the foldable part 1 in this position ceases, the rod 8 will be pulled by the force from the disk springs 15 inwards towards the center of the missile, whereby the foldable part 1 which is pivotally connected with the rod 8 by means of the shaft 7 is moved to the normal position shown in FIGS. 1 and 2. This motion of the foldable part 1 will now be described more in particular with reference to FIGS. 5–7.

FIGS. 5–7 show on an enlarged scale a cross section along line B–B in FIG. 1, the projections of the axes 5, 6 and 7 also being indicated in these figures. In FIG. 5 the foldable part 1 is shown in folded position, while FIG. 6 shows the foldable part in an intermediate position and FIG. 7 shows the foldable part in the position it assumes near the end of its motion to the normal position.

The axis 7 which joins the rod 8 and the foldable part 1 is moved under the action of the rod 8 along a straight part indicated by the dotted line 18 in FIGS. 5–7. When the axis 7 moves, the axis 6 which connects the foldable part 1 with the link device formed by links 4*a* and 4*b* will move along a circular arc 19 the center of which is the axis 5 (pins 5*a* and 5*b* in FIG. 1) which connects the link device with the fin root 2. In FIGS. 5–7 the axis 6 and 7 are connected by a straight line which may be considered as representing that portion of the foldable part 1 which is not visible in these figures. The axes 5 and 6 are also connected by a straight line which represents the link device. The center plane of the foldable part 1 and that of the root part 2 have been indicated in these figures by dash-dot lines.

The foldable part 1 is retained in the position shown in FIG. 5 in relation to the fin root 2 under the action of some external force, e.g., by the foldable part by its outer portion bearing against the inside of the container of the missile or the inside of a launching tube. When this external force ceases to act, as for instance when the missile leaves the launching tube, the rod 8 (FIG. 3) is pulled inwards under the action of springs 15, and the axis 7 is thereby moved along the straight line 18, whereby the foldable part 1 is turned up to the normal position. FIG. 6 shows the foldable part 1 in an intermediate position during this motion.

FIG. 7 shows the foldable part 1 in the position it assumes immediately before it reaches the normal position (the end position). The axis 6 is here straight above the axis 7, the center plane of the foldable part 1 coincides with that of the fin root 2, and the base surface of the foldable part 1 is straight above and parallel with the top surface of the fin root 2. When the axis 7 continues to move towards its end position which is indicated in FIG. 7 by the circle 7', the axis 6 will move to the position indicated by the circle 6'. The base surface of the foldable part 1 then comes into contact with the top surface of the root part 2, and the ridge 16 is wholly moved into the groove 17. The distance between the axes 5 and 6, i.e., the radius of the circular arc 19, is somewhat larger than the perpendicular distance between the axis 5 and the path of movement 18 of the axis 7. When the foldable part 1 is moved from the position shown in FIG. 7 to the end position (the normal position), it will therefore perform a slight tilting movement (towards the left in FIG. 7). This tilting reaches its maximum when the connecting line between the axis 5 and 6 is at right angles to the path of movement 18 of the axis 7. During the continued movement towards the end portion the foldable part 1 is again moved towards the position in which its center plane coincides with the center plane of the fin root 2. When the axis 6 reaches the position indicated by the circle 6' in FIG. 7, the motion of the foldable part 1 is stopped by its base surface coming into contact with the top surface of the fin root 2. The ridge 16 is now wholly carried into the groove 17, and the center plane of the foldable part 1 again coincides with the center plane of the fin root 2. Thus, the motion of the foldable part 1 from the position shown in FIG. 7 to the end position substantially becomes a translational motion, since the axis 6 when moving to the position 6' moves along a circular arc which only slightly deviates from the straight line 18.

The angle of convergence (20 in FIG. 7) of the lateral surfaces in the grooves 17 and the ridges 16 is so small that the ridges 16 and the grooves 17 cause a self-locking of the foldable part 1 in relation to the root part 2, so that the foldable part 1 cannot be turned in relation to the root part 2 by the lateral forces which act upon the foldable part 1. In order to move the foldable part 1 from the position shown in FIG. 2 to the position shown in FIG. 3 it must first be pulled straight outwards from the root part 2 to the position shown in FIG. 7 and only then it can be turned to the position shown in FIG. 3 or 5.

In the shown embodiment the ridges 16 are positioned on the foldable part 1 and the groove 17 in the fin root 2, but it will be understood that the same effect is achieved if the ridges 16 are positioned on the fin root 2 and the grooves 17 in the foldable part 1. However, in view of strength is is preferable to make the grooves 17 in the fin root 2, since the thickness of the material surrounding the groove will then be larger than if the groove were positioned in the foldable part 1.

In the shown embodiment the rod 8 and the path of movement of the axis 7 are positioned at one side of the center plane of the fin root 2, while the axis 5 is situated at the other side of this center plane. This is a preferred embodiment, but it will be understood that the desired path of movement for the foldable part 1 can also be achieved if the rod 8 with the axis 7 and the axis 5 are arranged in other ways in relation to the center plane of the fin root 2.

Other modifications are possible within the scope of the invention.

What is claimed is:

1. Steering fin for a missile comprising a root part and a foldable part which is foldable in relation to the root part and in a normal position forms an outwards extension of the root part and can be folded from the normal position towards the missile, in which the foldable part (1) is connected with the root part (2) by means of a link device (4*a*, 4*b*) which is rotatable relative to the root part (2) about a first axis (5) and rotatable relative to the foldable part (1) about a second axis (6), and a control member (8) is connected with the foldable part (1) by means of a third axis (7) which can be moved by means of the control member (8) a motion along a substantially rectilinear path, said three axes (5, 6, 7) being parallel to each other and so positioned in relation to each other that the foldable part (1), when moved from folded position (FIGS. 3, 5, 6) to the normal position (FIGS. 1, 2), during the last part of its motion approaches the root part under an approximately translational motion.

2. A fin as claimed in claim 1, in which those surfaces along which the foldable part (1) and the root part (2) bear against each other when the foldable part (1) is in its normal position, are provided with coacting projections (16) and recesses (17) which extend parallel to the center plane of the fin and have a cross section of a tapering form.

3. A fin as claimed in claim 2, in which said projections (16) are positioned on the foldable part (1), and that said recesses (17) are positioned in the root part (2).

4. A fin as claimed in claim 1, in which the perpendicular distance between said first (5) and said second (6) axes are somewhat larger than the perpendicular distance between said

second axis (6) and the rectilinear path of movement (18) of said third axis (7), and said second axis (6) is in the path of movement (18) of the third axis (17) when the foldable part (1) is in its normal position in relation to the root part (2).

5. A fin as claimed in claim 1, in which said first axis (5) is positioned at one side of the center plane of the root part (2), and the path of movement (18) of said third axis (7) is situated at the other side of the center plane of the root part (2).

6. A fin as claimed in claim 1, in which said control member consists of a rod (8) which is longitudinally displaceable parallel to the center plane of the root part (2) and which is subjected to a force from a spring device (15) which strives to pull the rod inwards into the missile.

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