May 27, 1958 R. E. PEARSON 2,836,380

AIRPLANE WING WITH SLOTTED FLAP, COVE LIP DOOR, AND SPOILER

Filed April 25, 1955 2 Sheets-Sheet 1

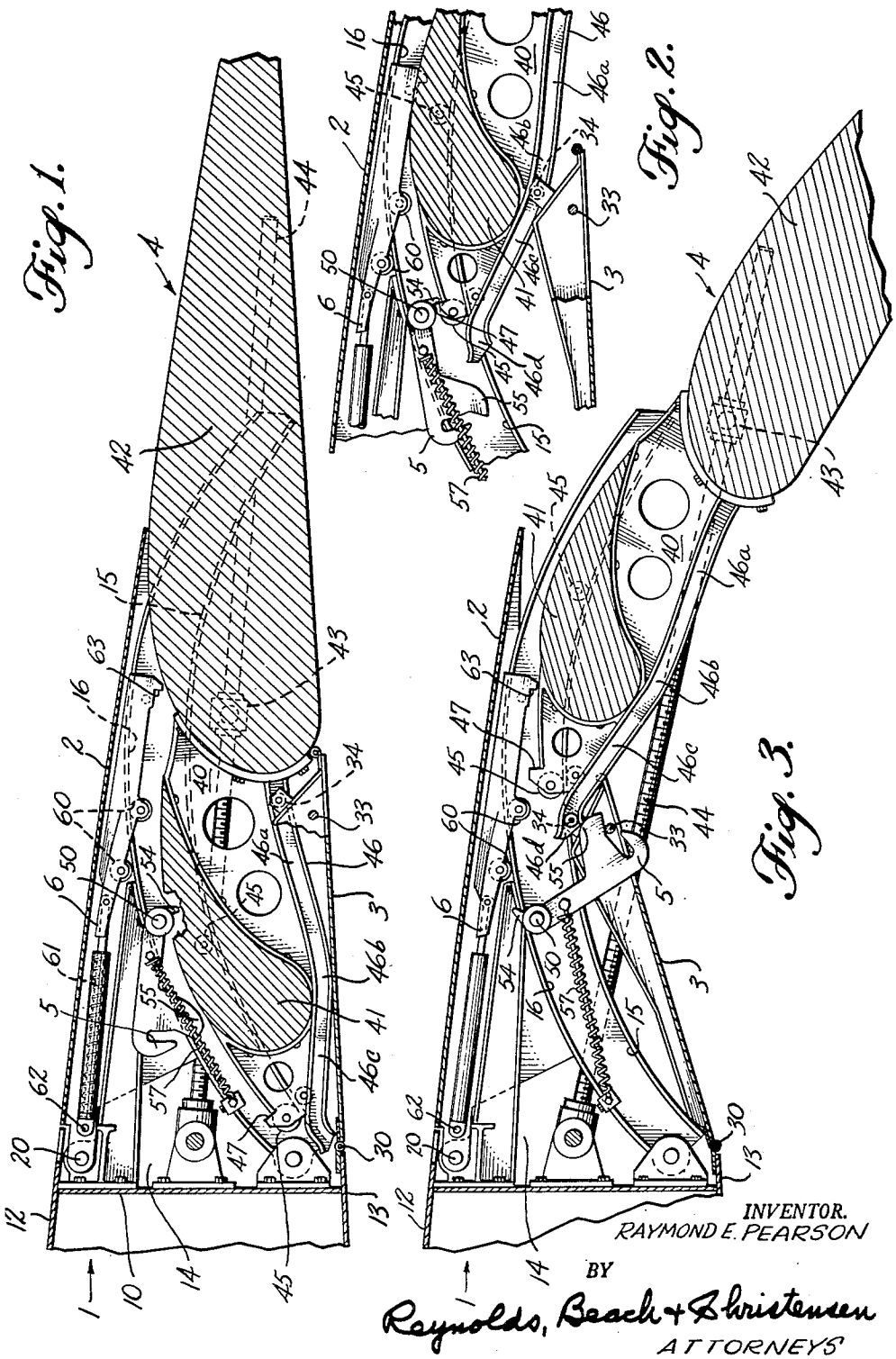


Fig. 1.

Fig. 2.

Fig. 3.

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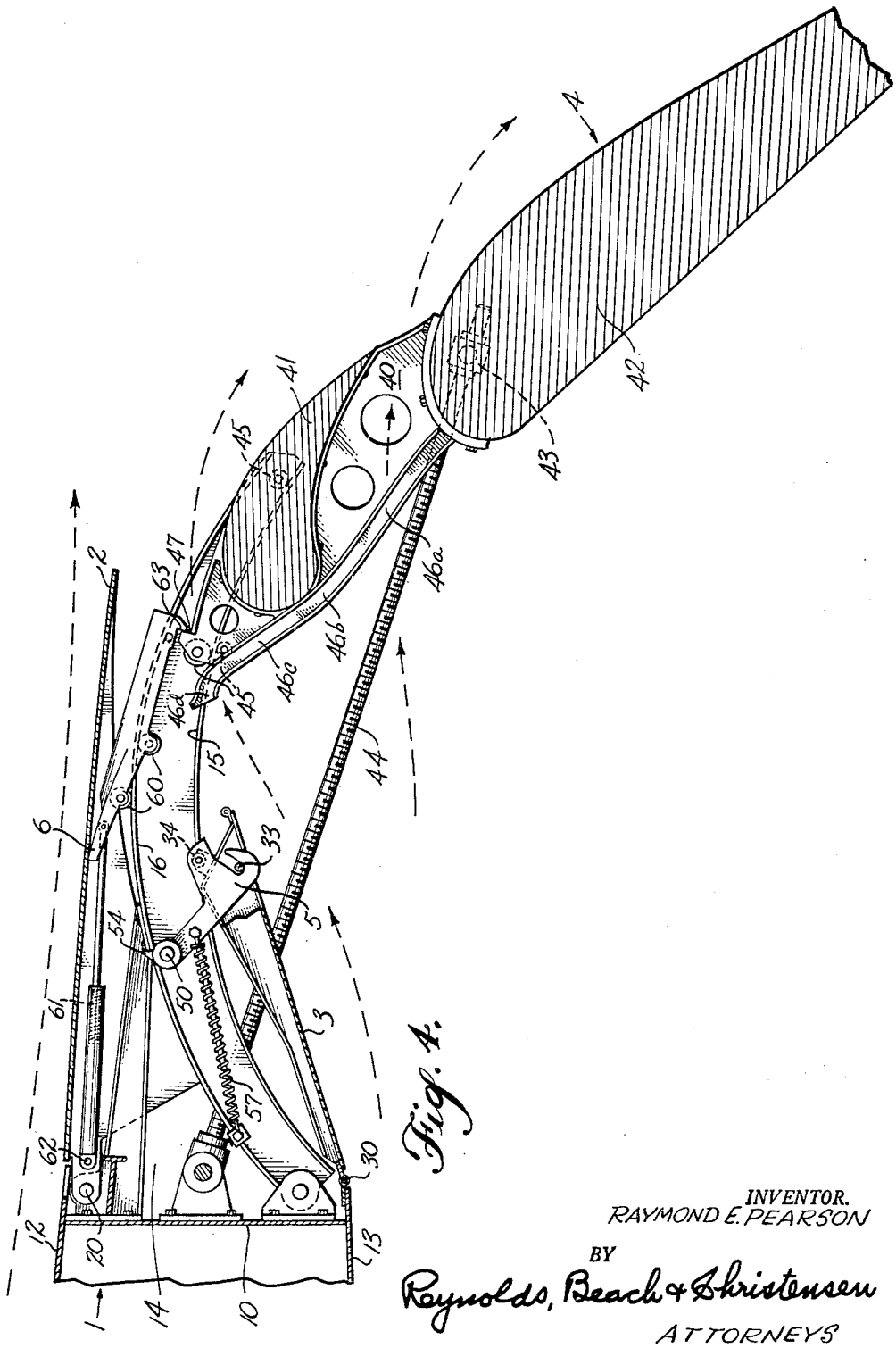



Fig. 4.

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2,836,380

# AIRPLANE WING WITH SLOTTED FLAP, COVE LIP DOOR, AND SPOILER

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11 Claims. (Cl. 244—42)

The use of slotted flaps at the trailing edge of an airplane wing, for added lift and for air-braking, is common. This invention concerns such a flap, especially in a high-speed airplane, with certain accessory devices such as a cove lip door and a spoiler door, and the actuation of these doors as a result of and coordinated with movement of the flap by its actuator, between its up position, wherein it lies in substantial continuation of the interrupted wing trailing edge contour, and a down position, wherein it is displaced rearwardly and deflected downwardly from its up position.

According to the present invention the downward pitching moment about a local center of rotation, such as is produced by the downward deflection of the flap, is countered by the use of a spoiler door which is normally arranged to constitute a rearward continuation of the upper wing skin, but which is uptilted at its rear edge when the flap is in or as the flap approaches its full down position, such uptilting of the spoiler, even by a few degrees, producing a torque about the local center of rotation counter to the downward pitching moment produced by the downward deflection of the flap.

Also according to this invention a cove is defined between the upper wing skin (or the spoiler door as a rearward continuation thereof) and a rearward continuation of the wing's lower skin, such as may be constituted by a cove lip door hingedly mounted by its forward edge upon the wing; cove houses the slotted nose of the flap in the flap's up position, and the upper and lower continuations of the wing skin—the spoiler door and the cove lip door, respectively—close the exit and the entrance to the flap's slot when the flap is in its up position, but are of a length such that when the flap is displaced rearwardly and deflected downwardly, the flap's slot will be uncovered. In the full down position of the flap one or both of two doors will be tilted upwardly to define a slot ahead of the flap's nose.

Because of space limitations it is preferred that the movement of the doors between the positions indicated above, in coordination with the flap's movements, be accomplished not by separate actuators, but by the flap or by mechanism carried by or engageable by the flap during the latter's shifting between its up position and a down position, and in particular that a cam track carried by the flap engage a cam follower carried by the cove lip door to tilt the rear edge of the cove lip door upwardly, after a predetermined rearward movement of the flap from its up position; further, that latch means be shifted, by rearward movement of the flap, from an unlatched to a latching position, to interengage complemental latching means on the cove lip door to hold the latter uptilted after the cam track (the length whereof is limited by space limitations) disengages the cam follower as the flap continues its downward movement; still further, that a spoiler actuator be positioned for engagement by the flap (preferably by the same means that shifts the latch means, and after such shifting) and guided for movement in a definite path, so that it will tilt the spoiler door upwardly at its rear edge as the flap approaches or reaches its full down position; finally, that the several parts are reversely actuated, positively or by yieldable resilient means, or both, and in reverse order, by return movement of the flap to its up position.



It is not intended to imply that the spoiler is only actuatable by and during downward movement of the flap, for in the actual installation the spoiler may be tilted upwardly for air-braking independently of the flap, by an actuator independent of the flap's actuator, but this constitutes mechanism separate from this invention, and is not herein disclosed. The actuation of the spoiler in coordination with the flap, and by the flap's actuator, through the mechanism of this invention, is part of the subject matter of this invention, both per se, and in conjunction with the cove lip door and the latter's relationship with the flap, the latching mechanism, etc.

The general objects of this invention, and the mechanism whereby such objects may be attained, are outlined above, and will be better understood from the detailed description to follow.

The drawings illustrate the invention in a typical installation.

Figure 1 is in general a chordwise section through the trailing edge of an airplane wing, and through a flap associated therewith, illustrating the flap and associated parts in the up position.

Figure 2 is a similar view showing the parts following the completion of the first phase of movement toward the down position.

Figure 3 is a similar view showing parts in the position corresponding to the completion of the second phase of the movement towards the full down position, and Figure 4 is a similar view showing parts in the full down position.

Since an airplane wing, interrupted in its trailing edge contour for the reception of a flap, is known and commonly used, it is only necessary to show here the wing, indicated generally by the numeral **1**, in its trailing edge portion, the wing including a spanwise bulkhead **10**, an upper wing skin **12**, and a lower wing skin **13**. To the rear of the bulkhead **10** a flap indicated as a whole by the numeral **4** is of a general shape to complete the upper and lower wing skin contours, notwithstanding that it is formed with a slot **40** between its nose portion **41** and its main portion **42**.

Rearwardly of the bulkhead **10** the two wing skins have rearward continuations which define between them, and rearwardly of the bulkhead, a cove **14**, within which is received the nose of the flap **4**. For the purposes of this invention it is preferred that these rearward continuations of the upper and lower wing skins be formed through the medium of two doors, an upper spoiler door **2** hingedly mounted at **20** along its forward edge in rearward continuation of the upper wing skin contour **12**, and a lower cove lip door **3** hingedly mounted at **30** upon the wing structure, to constitute a rearward continuation of the lower wing skin contour **13**. These two doors **2** and **3** are of such length that when the flap **4** is in its full up position the spoiler door **2** extends past and closes the exit of the slot **40** of the flap, and the cove lip door **3** extends rearwardly to the main portion **42** of the flap and closes the entrance to the slot **40**. This position of the parts is shown in Figure 1.

A lead screw **44**, rotatable by power means, not shown, with respect to a nut **43** carried by the flap, or any other suitable actuator, effects movement of the flap from and back to its up position. The flap is supported and guided for movement along a track **15** mounted upon the wing structure extending rearwardly from the bulkhead **10**,

and contained substantially wholly within the cove **14**, along which track roll the track rolls **45** carried by the flap in the vicinity of its nose. The track is given a predetermined curvature, so related to the flap as to cause the flap to move, under the influence of the lead screw **44** and nut **43**, rearwardly and at the same time to be deflected downwardly, as compare, for instance, Figures 1, 3 and 4. This is a more or less known construction and mounting of a flap and its actuator, and by itself is not claimed in this application.

The cove lip door **3**, being subjected to positive pressure tending to deflect it upwardly, must be positively held in all its positions. A cam track **46** is fixedly held to the flap **4**, extending forwardly from the slot entrance at the main element **42** of the flap as far as it is feasible for it to go. A cam follower **34** is carried by the swinging edge of the cove lip door. Because of space limitations and the shape of the cam track which would be necessary if the cam track were to remain at all times engaged with the cam follower **34**, it has been found necessary to stop the cam track short, and to effect disengagement between the cam track **46** and the cam follower **34**, at least in the full down position of the flap. Latching means **5**, to be later described, are at such time in engagement with the complemental latching pin **33** carried by the cove lip door, and these latching means hold the door uptilted as later described.

Reverting to the cam track **46** and the cam follower **34**, it is necessary to provide for little or no upward swinging of the cove lip door during the first phase of rearward shifting and downward deflection of the flap **4**. To that end the initial portion of the cam track **46**, designated **46***a*, is, in the up position of the flap, more or less of the same curvature as the flap guide track **15**. In consequence, as may be seen by comparison of Figures 1 and 2, until the cam follower **34** reaches the point **46***b* in the cam track **46**, there is no appreciable upward tilting of the cove lip door **3**. At that point the cam track rises rather steeply in the portion **46***c*, so that in the movement of the flap from the position of Figure 2 to that of Figure 3 the cove lip door is tilted upwardly fairly rapidly and substantially. Eventually, however, and before the flap has reached its full down position, the end of the cam track disengages the cam follower **34**, and the latter passes out of the open mouth **46***d* of the cam track. By this time the latching means, already referred to, have become engaged.

The latching means includes a cove lip hook or catch **5** pivotally mounted upon fixed structure at **50**, and acted upon by an overcenter compression spring **57**, tending to position the hook in the upswung or unlatched position of Figure 1, or when moved past center, to position the hook in the position of Figure 3, ready to engage the cove lip door. In order to move it between these two positions a lug **47** is carried by the flap at or ahead of its nose, in position to engage a corresponding lug **54** on the hook **5**. These two lugs are shown coming into engagement in Figure 2, and by a slight further movement of the flap to the right, towards its down position, the latch hook **5** is thrown to and held in its read-to-engage position, as shown in Figure 3, being stopped in that position by its blunt nose **55** engaging the end of the cam track **46**, as shown in Figure 3. In this position the cam follower **34** has not disengaged the cam track **46**, and just before it does, the latch hook's nose **55** disengages the cam track **46** and spring **57** throws the hook itself into latching engagement with pin **33** on the cove lip door. Such engagement occurs no later than the time when the cam follower **34** passes out of the open end **46***d* of the cam track **46**.

The spoiler **2** is arranged for operation by the last stage of movement of the flap towards its full down position. It is hingedly mounted along its forward edge at **20**, and being subjected at all times to downward



pressure, needs no latching means to hold it down, but can be pushed upwardly from within the cove at the proper time. A spoiler actuator **6** is guided upon a cam track **16**, which generally parallels the guide track **15**, the actuator **6** being mounted by means of rollers **60**, and being urged to the left, as viewed in the several figures, by a cased compression spring **61** secured to the spoiler actuator **6**, and at **62** to fixed structure of the wing. The spoiler actuator is formed also with a lug **63**, positioned to be engaged by a corresponding lug movable with the flap, and preferably by the same lug **47** as actuates the lug **54** of the latch hook **5**, after this lug **47** has moved the hook to ready-to-latch position and has passed therebeyond. The lug **47**, upon engaging the lug **63**, pulls the spoiler actuator **6** rearwardly, or to the right as seen in the several views, compressing the spring **61**, and the parts are so shaped and arranged in conjunction with the curvature of the cam track **16** that this rearward movement of the spoiler actuator **6** pushes upwardly on the trailing rear edge of the spoiler and deflects it upwardly to the desired extent, in the manner shown in Figure 4.

It will be observed that in the up position of the parts shown in Figure 1 the cove lip door **3** and the spoiler door **2** constitute smooth rearward continuations of the respective lower and upper wing skin contours, and close the entrance and the exit, respectively, of the slot **40** through the flap **4**. In the full down position of Figure 4, however, the cove lip door **3** is uptilted to an appreciable extent and cooperates with the spoiler door and with the nose portion **41** of the flap to define a further slot about the nose of the flap, which is of further assistance in controlling the air flow over and about the flap.

To recapitulate, the first stage of the rearward movement of the flap **4** causes little or no change in the positions of the cove lip door **3** and the spoiler door **4**. The completion of this first phase is shown in Figure 2. The slot **40** has been opened, and the flap is slightly downwardly deflected, so that the lift of the wing is increased. During the next phase, the completion of which is shown in Figure 3, the slot **40** is fully opened, and the cove lip door has been deflected upwardly to assist in leading the air flow over the lower wing skin into that slot, and the latch hook **5** has been rotated from its unlatched position, as in Figures 1 and 2, to its ready-to-latch position, as in Figure 3. Immediately thereafter the cove lip door is supported solely through its pin **33** in this upswung position, so that when the cam track **46** disengages the cam follower **34**, the cove lip door will not drop down. No appreciable movement of the spoiler has occurred up to this time, however.

During the third stage of the rearward shifting of the flap the spoiler actuator **6** is engaged by the lug **47** carried upon the flap, and is pulled rearwardly, causing the spoiler **2** to tilt upwardly at its trailing rear edge. This uptilted spoiler produces a torque countering the torque about a local center of rotation, such as is caused by the downward deflection of the flap. All this movement has been caused by the flap actuator, namely, the lead screw **44** and the nut **43**, and no separate actuator for the spoiler nor for the cove lip door is required.

Upon return of the flap to its up position the corresponding operations occur in reverse order. It is believed that it will be obvious how and when they occur, and that detailed description thereof is not necessary. In the first phase of the return movement, the spoiler actuator is returned to its normal position, and the spoiler door is permitted to drop down. The cam follower **34** reenters the open mouth **46***d* of the cam track **46**, and that cam track pushes aside the hook **5**, back towards its unlatched position, the final movement thereof being effected by the snapping of the spring **51** past its center position, as

the free end of the cam track 46 reaches a position about as in Figure 2. The cove lip door is controlled again by the cam track 46, and when the parts reach again the position of Figure 1, all parts have been restored, again by operation of the flap actuator alone, to their normal positions, that is, to the positions they would occupy during normal flight.

I claim as my invention:

1. In combination with an airplane wing the trailing edge contour whereof is indented to define a rearwardly open cove intermediate its upper and lower skin contours, a slotted flap the nose whereof is receivable within such cove, means guiding and supporting said flap for movement between its up position, wherein its nose is received within said cove, and it constitutes a general continuation of the wing's contour, and a down position displaced rearwardly and deflected downwardly from its up position, an actuator to shift the flap between the up and down positions, a spoiler door hingedly mounted by its forward edge upon the wing, in rearward continuation of the wing's upper skin, and defining the upper boundary of said cove a cove lip door hingedly mounted by its forward edge upon the wing, in rearward continuation of the wing's lower skin, and defining the lower boundary of said cove, said doors being of a length to overlap and close the exit and the entrance, respectively, of the flap's slot when the flap is in its up position, but to uncover the same by rearward shifting of the flap, means operatively connecting said flap to said doors, to tilt each door upwardly as the flap shifts rearwardly and downwardly, to define in the flap's full down position a slot directed generally upwardly and rearwardly over the nose of the flap, and intermediate such nose and the doors, the uptilted spoiler door constituting a spoiler for airflow over the wing's upper skin.

2. In combination with an airplane wing the trailing edge whereof is indented to define a rearwardly opening cove located intermediate its upper and lower skin contours, a flap consisting of nose and trailing portions rigidly interconnected but spaced apart to define a leading-edge slot, means guiding and supporting said flap for movement between an up position, wherein its nose portion is projected within the cove and its slot is closed by the wing skin contours, and a down position, wherein it is displaced rearwardly and deflected downwardly, with its slot located externally of the cove, a cove lip door hingedly mounted by its forward edge upon the wing's lower skin, and constituting the lower boundary of the cove and the trailing portion of the wing's lower skin contour, and being of a length such, in relation to the amount of rearward displacement of the flap into its down position, as to uncover the flap's slot and nose portion when the flap is in such down position, and means operatively interconnecting the flap and said cove lip door to tilt the latter upwardly as the flap approaches its down position, to define in the flap's full down position a further slot between the wing's upper cove-defining skin contour and the nose portion of the flap.

3. The combination of claim 2, including complementally engageable latching elements one on the cove lip door and another support from the wing and fixedly located thereabove, and means carried by the flap and engageable with said latching elements to move them into engagement to hold the door uptilted as the flap moves further towards down position, and vice versa.

4. The combination of claim 2, including a spoiler door hingedly mounted by its forward edge upon the wing's upper skin, and in the region of the cove constituting the wing's upper skin contour, and being of a length such, in relation to the amount of rearward displacement of the flap into its down position, as to uncover the flap's slot when the flap is in such down position, and means operatively engageable between the flap and the spoiler door to tilt the latter upwardly as the flap approaches its down position, to define the upper



surface of the further flap between tiself and the nose portion of the flap.

5. The combination of claim 1, including a movable latch supported from the wing and located above the swinging edge of the cove lip door, a complemental latching element carried by the cove lip door in position for engagement by said movable latch when the door is uptilted, a latching dog operatively connected to the spoiler door, and a trip element carried by the flap, and engageable with said latch as the flap moves towards down position, to move the latch into engaging position, said trip element being located to engage said latching dog when the flap reaches full down position, to retain the spoiler door in uptilted position.

6. The combination of claim 2, including a movable latch supported upon the wing structure within the cove, and located in an unlatched position above the swinging edge of the cove lip door when said door is in its down position, a complemental latching element carried by the cove lip door in position for engagement by said latch when the door is uptilted, a trip element carried by the flap, and engageable with said latch to move the latter into latching engagement with said complemental latching element as the flap moves towards down position, to move the latch into engaging position, and means carried by the flap and engageable with said latch as the flap moves towards its up position, to shift the latch towards its unlatched position.

7. The combination of claim 6, including a cam track upon and projecting forwardly from the flap, within the cove, a cam follower on the cove lip door guided upon said cam track, constituting the door-tilting means, the cam track being of a length to disengage the cam follower prior to the flap reaching its full down position, the flap-carried latch-shifting means being positioned to engage and shift the latch into latching position prior to disengagement of the cam track from the cam follower, for subsequent latching engagement with the complemental means upon the door following further shifting of the flap towards its down position, and so to hold the door uptilted, and the door-carried cam follower in position for reengagement by the cam track during shifting of the flap towards its up position, and the flap-carried latch-shifting means being also positioned to reengage the latch after such reengagement of the cam and cam track, and to return the same towards unlatched position following further shifting of the flap towards its up position.

8. The combination of claim 6, including a cam track upon and projecting forwardly from the flap, within the cove, a cam follower on the cove lip door guided upon said cam track, constituting the door-tilting means, the latch being in the form a hook pivotally mounted within the cove to swing between latching and unlatched positions, a lug formed on said hook, a trip member carried by the flap in position to engage said lug as the flap moves toward down position, said cam track being shaped to defer uptilting of the door during the initial rearward shifting of the flap, and to swing the door upwardly for engagement of its complemental means with said latch, following the latter's movement into latching position.

9. In combination with an airplane wing the trailing edge contour whereof is interrupted, a slotted flap shaped as a whole generally to complete the trailing edge contour, means guiding and supporting said flap from the wing for movement between its up position, in general continuation of the wing's contour, and a down position displaced rearwardly and deflected downwardly from its up position, an actuator to shift the flap between the up and down positions, a spoiler door hingedly mounted by its forward edge upon the wing, in rearward continuation of the wing's upper skin, and of a length to close the exit of the flap's slot, when the flap is in its up position, but to uncover the same by rearward shifting of the flap from

such up position, and means interengageable between the flap and the spoiler door to tilt the spoiler door upwardly about its hinge axis as the flap shifts rearwardly towards its full down position, to define a slot between the spoiler door's trailing edge and the nose of the rearwardly shifted flap.

10. In combination with an airplane wing the trailing edge whereof is indented to define a rearwardly open cove located intermediate its upper and lower skin contours, a slotted flap, means supporting said flap from the wing for movement between an up position, wherein its nose is received within said cove and its slot is shrouded by the boundaries thereof, and the flap constitutes a general continuation of the wing's contour, and a down position displaced rearwardly and deflected downwardly from its up position, with its slot uncovered, an actuator to shift the flap between the up and the down positions, a spoiler door hingedly mounted by its forward edge in rearward continuation of the wing's upper skin, and constituting the upper boundary of the cove, a spoiler actuator for engagement with the spoiler door, a cam track upon the wing whereon said spoiler actuator is guided for forward and rearward movement, and for upward movement as it moves rearwardly, yieldable means to retain said spoiler actuator in its forward position, wherein it exerts no upward force upon the spoiler door, and means carried by the flap, positioned to engage and move said spoiler actuator rearwardly as the flap shifts rearwardly, for engagement with and uptilting of the spoiler door, thereby to define a slot between the uptilted spoiler door and the nose of the rearwardly shifted flap, and vice versa.

11. In combination with an airplane wing the trailing edge contour whereof is interrupted, a slotted flap shaped as a whole generally to complete the trailing edge contour, means guiding and supporting said flap for movement between its up position, in general continuation of the wing's contour, and a down position displaced rearwardly and deflected downwardly from its up position, an actuator to shift the flap between the up and down positions, a spoiler door hingedly mounted by its forward edge upon the wing, in rearward continuation of the wing's upper skin, a cove lip door hingedly mounted by its forward edge upon the wing, in rearward continuation of the wing's lower skin, said doors being of a length to cover the exit and the entrance, respectively, of the flap's slot, and to define a cove receiving the nose of the flap, when the flap is in its up position, but to uncover such exit and entrance by rearward shifting of the flap, cam mechanism carried by the cove lip door and by the flap, respectively, to tilt the cove lip door upwardly by shifting of the flap towards its full down position, latch means interengageable between the wing and the cove lip door to retain the door in its uptilted position, said latch means including a hook swingably mounted upon the wing to rotate between a latching and an unlatched position, a lug upon the flap, positioned to engage said hook to rotate it into latching position during rearward movement of the flap, a spoiler actuator, cam means upon the wing guiding said spoiler actuator for forward and rearward movement and for uptilting in its rearward position, resilient means holding said spoiler actuator normally in a forward position, wherein it will be engaged and moved rearwardly by said lug following rotation of the hook by said lug into latching position, the spoiler actuator being organized and arranged to tilt the spoiler door upwardly when the spoiler actuator is thus moved rearwardly and tilted upwardly.

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# CERTIFICATE OF CORRECTION

Patent No. 2,836,380 May 27, 1958

Raymond E. Pearson

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 61, for "support" read -- supported --; column 6, line 1, for "tiself" read -- itself --; line 53, after "form" insert -- of --.

Signed and sealed this 9th day of September 1958.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents