THE ALL-MOVABLE HORIZONTAL TAIL

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The all-movable horizontal tail first made its appearance on a glider, as have many other aeronautical innovations and improvements. However, these early tail surfaces were not entirely satisfactory as regards to stability and stick force requirements. These conditions were in part remedied by the addition of bungee springs and some degree of trim speed adjustment was attained by varying the spring tension. Undoubtedly, further development was due in part to lack of substantial test data.

Today, the situation has changed considerably. The NACA, in 1943, undertook to investigate the all-movable type of tail for use on modern high speed aircraft. This tail design was selected in an effort to overcome some of the difficulties encountered when conventional tail surfaces proved inadequate for proper balance throughout the speed range of the aircraft in question. The original tests were conducted on a Fairchild XR2K-1 airplane using an all-movable vertical tail (Reference I). The results of these initial tests substantiated preliminary predictions and justified proceeding with further investigations. The next series of tests were conducted using the same type of aircraft but with a vertical tail of reduced area (Reference II). These tests also showed positive results. Some comments from these test reports are as follows:

1. The pilot reported that the all-movable tail performed satisfactorily in all respects. Flying the airplane differed in no essential respects from flying an airplane with conventional fin and rudder.
2. The airplane all-movable tail developed considerably greater normal force per unit area than the original tail.
3. The damping of large rudder-free oscillations was satisfactory.
4. The pilots were able to make satisfactory normal turns with the all-movable tail using only the stick.

Further testing was continued later using a Curtiss XP-42 with an all-movable horizontal tail (Reference III). The flight test results were in agreement with previous tests and substantiated the original theories. Some comments from these tests are presented.

1. The stick-fixed and stick-free longitudinal stability characteristics of the airplane were not materially changed with the all-movable tail.
2. No unconventional elevator control characteristics were encountered in sideslips or when the airplane was stalled.
3. The pilots considered the all-movable tail indistinguishable from a good conventional elevator.

It was also found that, as with the vertical tail, the area of the horizontal tail could be materially reduced using a specified center of gravity range. Reference IV gives detailed design information for those designers who are interested in using this type of tail or for those who wish to pursue the subject in more detail.

The advantages of the all-movable tail are manifold for most light aircraft but especially for sailplanes where the ultimate in performance and weight saving is of large significance.

The reduced tail area obviously results in less drag and lighter weight. The design also lends itself to the attainment of a simpler structure without any sacrifice in strength requirements. This, too, contributes to lower cost and ease of construction.

The essential difference between the original all-movable tail and that developed by the NACA, is the use of an anti-servo plain flap or tab. The flap can be either full or partial span depending on the

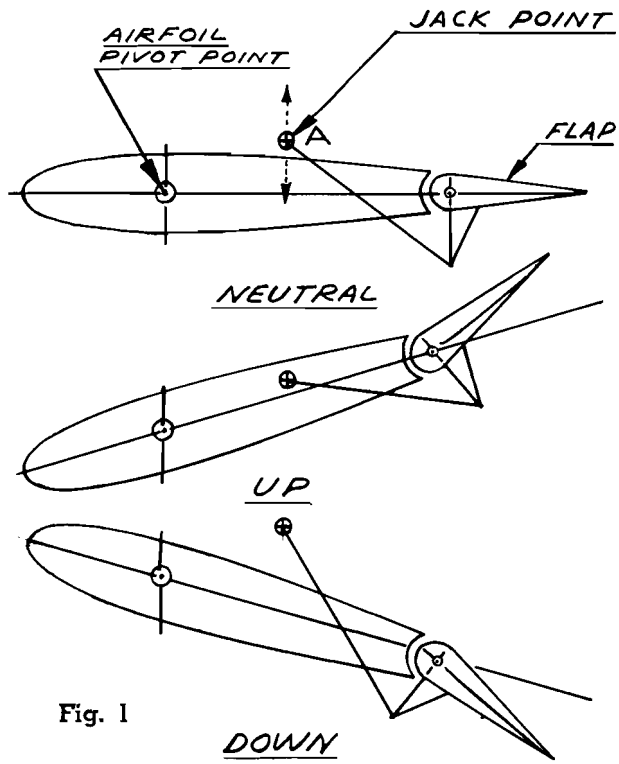

Fig. 1

design requirements. Figure I shows the basic functions of the flap. It will be seen that as the main airfoil is deflected either up or down, the flap, in effect is deflected in the same direction at the same time. The flap actuating linkage can be designed to obtain any desired ratio of flap deflection to the main airfoil deflection. This feature can be designed as either fixed or adjustable in flight. By changing this ratio any desired stick force can be obtained within the stability limits. Figure I shows a fixed arrangement. By moving jack point A up or down, the desired trim speed can be obtained. This adjustment merely changes the flap neutral point which in turn moves the whole surface to a new position.

The all-movable tail is at present used on the Thorp airplane, "Sky Skooter," and on the powered sailplane, the Nelson "Hummingbird." On the latter the horizontal tail area was reduced by twenty-five percent from the original conventional tail. The weight of the new assembly was reduced by forty percent, due in part to the reduction in area and to the simplification of the structure. A more favorable center of gravity range also resulted.

The flight characteristics of the new all-movable