THE "STALL BARRIER" AS A NEW PREVENTIVE IN GENERAL AVIATION ACCIDENTS

C. W. Von Rosenberg
F. R. Keen
Stanley R. Mohler, M.D.

Approved by

J. R. Dille, M.D.
Chief, Civil Aeromedical Institute

Released by

P. V. Siegel, M.D.
Federal Air Surgeon

September 1966

FEDERAL AVIATION AGENCY
Office of Aviation Medicine

FOREWORD

Mr. Von Rosenberg was Chief, Flight Standards Technical Division, Aeronautical Center, Federal Aviation Agency, Oklahoma City, Oklahoma. He is presently Vice President, Lear Jet, Wichita. Mr. Keen is a research pilot in the Flight Standards Technical Division. Dr. Mohler is Chief, Aeromedical Applications Division, Office of Aviation Medicine, Federal Aviation Agency, Washington, D.C. Presented at the April 17–21, 1966, Meeting of the Aerospace Medical Association in Las Vegas, Nevada.

Qualified requestors may obtain Aviation Medical Reports from Defense Documentation Center. The general public may purchase from Clearinghouse for Federal Scientific and Technical Information, U.S. Dept. of Commerce, Springfield, Va. 22151

THE "STALL BARRIER" AS A NEW PREVENTIVE IN GENERAL AVIATION ACCIDENTS

I. The Problem.

In 1964 the following accident experience occurred in general aviation. There was a total of 5,185 general aviation accidents and, of this number, 508 were fatal accidents resulting in 972 fatalities.[1] There were 653 accidents that resulted from stalls and these accounted for:

12% of all accidents (653 of 5,185)
26% of all fatal accidents (131 of 508)
25% of all fatalities (242 of 972)

This shows how much of a killer this type of accident is. Actually, stall-spin accidents have plagued aviation since its inception, and, as shown above, continue to do so.

In the light of this, the Federal Aviation Agency's Flight Standards Technical Division at the Aeronautical Center, Oklahoma City, was asked to study the stall requirements of Part 23 (Airworthiness Standards) of the Federal Aviation Regulations. This study was for the purpose of determining if any revision of the regulation may be indicated.

Early in the project, it became apparent that the regulations were such that any substantial increases in stringency would impose impractical airworthiness requirements. In other words, it was felt there was nothing that could reasonably be done at present to the regulations.

It was concluded that in order to stop people from killing themselves in stall-spin type accidents, we would have to stop them from stalling the airplane. With this thought in mind, we began thinking of what has been done in this direction and what else can be done. We reviewed the efforts of designers who used slotted wings, restricted controls, stall warnings of various types, etc. All of the methods had deficiencies or limitations. Stall warning has been looked upon through the years as a means of helping the pilot avert a stall.

Natural stall warnings have consisted of characteristics such as change of sound as airflow velocity changed, buffet, vibration, control pressure changes, and others. Numerous methods have been used to produce artificial warnings in light aircraft such as horns, lights, and whistles. In collaboration with the Civil Aeromedical Research Institute, it was learned that visual and aural sensory input channels are often overloaded in flight, while the tactile sensory channel is not.[2]

It seemed, therefore, that a warning device such as a "stick shaker" would possibly provide a solution. However, as the name implies this unit requires the pilot to sense the warning, interpret it, and take action. This system still has the deficiency that a pilot who is not alert or is preoccupied with any one of a great many flight situations is susceptible to being victimized by a human failure: the failure to sense the stall warning and the impending stall.

As military aircraft were pushing into the higher performance regions in the early 1950's, stall difficulties were encountered which necessitated the installation of powerful stick pushers to prevent a stall from ever occurring. Refinements of this device are in use today in some of the higher performance military and civil aircraft.

As we reviewed this work, it became apparent that a similar device could be the means of saving many of the lives in general aviation that are lost each year through inadvertent stalling.

II. Method of Procedure.

In order to validate this approach to the problem, a small electric servo unit was installed in the cockpit of the Beechcraft T–34B aircraft operated by the Civil Aeromedical Research Institute. A cable from the drum of the servo unit was connected to the stick. The magnetic clutch of the servo was wired into the airplane's conventional stall warning system (present in almost all light aircraft) so that as the stall warning is triggered by a high angle of attack, the magnetic clutch is energized. The stick is then pulled forward until the angle of attack of the wing is restored to a normal flight range, at which point the stick is released. A rheostat was installed enabling the stick-pull force to be varied between 5 and 90 pounds.

Thirty pilots of all degrees of flight proficiency, ranging from low-time general aviation pilots to highly experienced professional pilots having thousands of flight hours, flew the T-34 with the "Stall Barrier."

Each flight followed a definite protocol. A check pilot monitored the entire sequence. The sequences consisted of the following:

1. Normal take-off.
2. Normal climb.
3. Cruise (4000–5000 feet).
4. Stalls (normal, climbing, descending, turning, accelerated, high speed, secondary).
   a. power-off (differing gear and flap combinations).
   b. power-on (differing gear and flap combinations).
5. Short Field take-offs, landings.
6. Normal landings.

The average flight lasted between one and two hours.

III. Results.

Under all normal flight conditions, the subject pilot was unaware that the device was present. The need for stall landings has passed with the advent of tricycle landing gear. It is unnecessary to stall such present day aircraft under any but the most remote circumstances (possible example: ditching at sea).

All subjects found that just prior to the onset of a stall, the stick was pulled firmly forward, preventing the stall. The timing in all cases was precisely coordinated with the actuation of the stall warning vane on the left wing.

It was determined that a stick pull force of twenty pounds was near optimum. Under unusual circumstances, the pilot can elect to override this force and keep the airplane in a stall. Twenty pounds is firm enough, though, that it cannot be disregarded readily by the pilot. In all unopposed circumstances, twenty pounds force will prevent a stall or, in a stalled attitude, provide stall recovery.

It was also determined that it is desirable to incorporate a two second time delay in the release so that the angle of attack is moved away from the edge of the retrigger position. This prevents the development of any "porpoising" motion about the pitch axis of the aircraft, such as might occur if a panicked individual inadvertently rocked the aircraft on the verge of a stall.

The effects of gusts were found negligible with respect to the device. No tendency was found near the ground for dangerous "nose down" attitudes to occur. Apparently, the "ground cushion" of air precludes this circumstance.

IV. Conclusions.

All subjects reported optimism over the ability of the device to prevent accidents even though many were initially skeptical.

The "Stall Barrier" as we call it is actually a stall warning indicator that initiates corrective action without the pilot having to sense the warning, interpret it, and take action. Since almost all present day light aircraft have conventional stall warning systems already installed, an inexpensive servo unit is the only additional component required for the "Stall Barrier."

The findings of these studies with the "Stall Barrier" provide promise that it can prevent at least 85% of all stall accidents in those aircraft having the device installed. If all general aviation aircraft had such a device, this forecasts the prevention of over 200 fatal accidents each year.

REFERENCES

1. Civil Aeronautics Board Summary Reports.
2. HAWKES, GLENN R.: "Tactile Communication," *Civil Aeromedical Research Institute Report* 62–11, Federal Aviation Agency, May 1962.

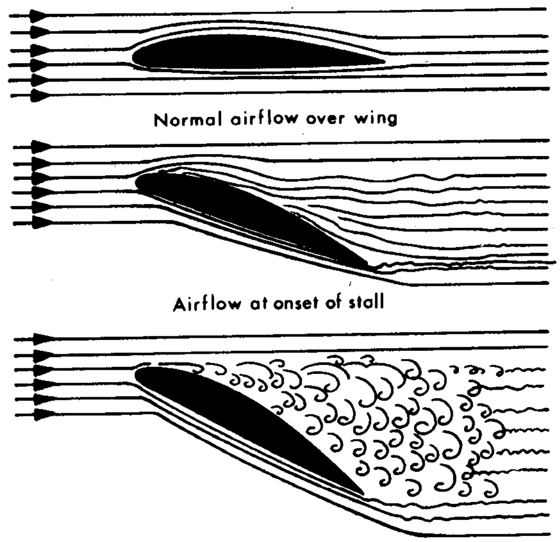

FIGURE 1. The breakdown of airflow as a wing is stalled is shown. The stall warning system provides a small vane at a point on the leading edge of the wing. Just prior to a shift in airflow over the wing which heralds an impending stall, the small vane is pushed upward completing an electrical circuit.

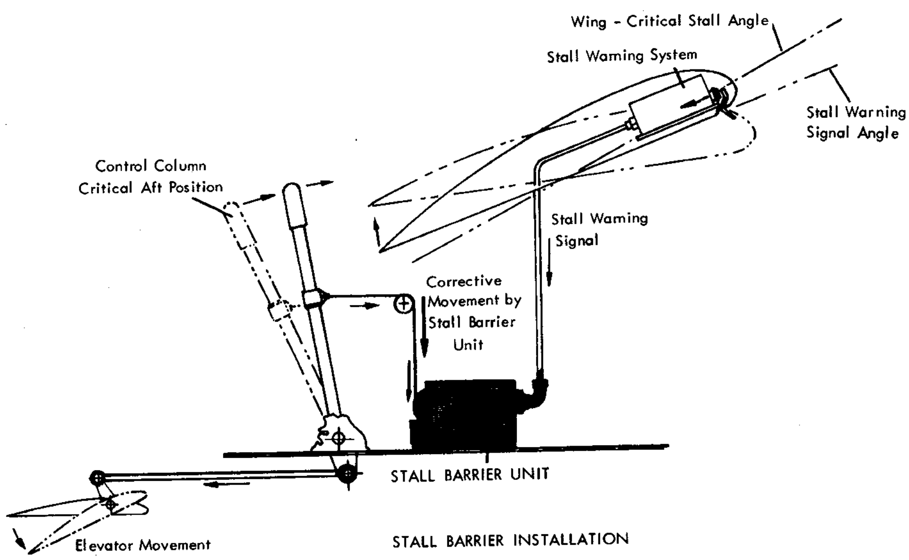

FIGURE 2. The "Stall Barrier" is shown diagramatically. When the control column is far enough aft to place the aircraft in danger of stalling, the stall warning system is activated and the servo motor in the Stall Barrier pulls the column forward. The stall is thus averted.