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IMPROVED AIRCRAFT SAFETY FACTORS*

JOHN H. GEISSE†

Flying has its hazards and admission of this fact does not constitute a condemnation of flying as dangerous any more than does the admission of the hazards of any other activity condemn that activity. Adopting the tactics of the ostrich and refusing to face these hazards does not eliminate them nor does it remove them from the vision of others. Only by recognizing hazards and openly discussing them can we hope to make material progress toward their reduction. I make these observations because there are those in the aviation industry who consider it almost treason for anyone in that industry to even mention the facts which I shall present to you this afternoon.

Flying is now safe—relatively. In the first six months of 1930 the passenger miles flown per passenger fatality were 2,375,664. In the first six months of 1935 the corresponding figure was 40,714,664, an increase in safety on scheduled airlines of 1,700% in the short period of five years. That is a wonderful record and a tribute to all who had any part in its accomplishment. But, again, I assume that the fact that one should be able to fly twenty-four hours per day and 365 days per year for the rest of his or her life on our airlines and still die from natural causes is not what you are interested in. You desire to have pointed out the causes of fatalities in aviation that you may participate in efforts to reduce them.

It would seem most logical in an effort to reduce fatalities in any industry to first study the records of that industry to determine the greatest source of hazard and hence the most vulnerable spot for attack. I imagine that your thoughts, like those of most people, turn immediately to scheduled flying and stop right there when air transportation is mentioned. It will probably be somewhat of a surprise to you to learn that scheduled flying is not even the better half of flying—in terms of mileage flown or passengers carried.

Relative to air miles flown, from the latter half of 1928 to the first half of 1935 (the last period for which statistics are available),

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miscellaneous flying accounted for approximately 80% of the total mileage until it started its retrogression.¹ In the first six months of 1935 it still exceeded *scheduled* flying by about 40% and it is to be expected that this is its all-time low in relation to scheduled flying. Further, it is interesting to note that, in 1929, the non-scheduled flyer supported a larger manufacturing industry than did our military services and scheduled flying combined.

During the seven-year period, 1928-1935, the fatalities in scheduled flying accidents totaled only 222 whereas non-scheduled flying exacted a toll of 2,561, a ratio of almost 12-1. Such figures should be convincing to you in indicating that phase of flying toward which your activities could well be directed. Lest you assume that non-scheduled flying concerns only pilots, another chart has been prepared to show the relative number of passengers carried by scheduled and non-scheduled services. In 1929, non-scheduled operations carried eleven times as many passengers as were carried by the scheduled lines. During 1930, '31, and '32, the non-scheduled activities fell off considerably, but I believe I am safe in saying that the present ratio of approximately 3 to 2 is probably as low as this ratio will ever become.

The curves showing the semi-annual fatalities for scheduled and non-scheduled flying gave the impression that the record for the latter was improving more rapidly than that for the former. This was due to the reduction in non-scheduled flying and the increase in scheduled flying. The relative safety of the two branches of flying is better depicted by the chart showing the number of fatal accidents per 10,000,000 miles of flying. Here again you will find evidence pointing unmistakably to the most vulnerable front against which to direct your attack. Two things will be noted. First, the accident rate for non-scheduled flying exceeds that for scheduled flying in the order of ten to one. Second, the accident rate for non-scheduled flying has not shown as great an improvement over the past seven years as that shown by scheduled flying.

In fairness to the aviation manufacturing industry it should be pointed out here that this record does not necessarily indicate the advance which they have made in decreasing the hazards of flying. In contrast to the airlines which have a relatively rapid turnover of equipment, the airplanes used in non-scheduled flying today have an average age which is greater than would be normally expected

1. It has been necessary to omit several charts which accompanied this address. The substance of the material in the charts has, however, been included. [Ed.]

due to the large production in 1929 and the decreasing production since that time. If the rate of retirement of airplanes had a more normal relation to the rate of production this record would undoubtedly be better. The airplane of today's production is undoubtedly safer than the airplane of yesterday's production and if you were to purchase a new airplane today you could discount to a considerable degree the hazards as shown by this curve.

Having located that part of flying which affords the greatest opportunity for improvement, the next logical step is to locate the particular hazard which exacts the greatest toll. Another chart shows the fatal accidents per 10,000,000 miles which may be credited to pilot errors. For non-scheduled flying they account for over 50% of all of the accidents. It has been assumed here that the ratio of causes applying to all accidents also applies to fatal accidents. The tremendous difference between the record for non-scheduled and scheduled flying should be noted. It is startling proof of the statement credited to Mr. Ford that flying is 90% pilot and 10% airplane. Here then is a source of accidents in flying which accounts for most of the fatalities and has a record which is deserving of the most careful consideration. Again, the reduction in fatalities per month shown is due to a great extent to the reduction in the amount of flying and unless the mileage accident rate is reduced this curve is due to mount upward again as private flying regains its stride.

It is fully appreciated that some may argue that it is impossible to make a plane fool-proof just as it is impossible to make an automobile fool-proof. However, I cannot, and I believe you will not, agree with the philosophy of thought that if a pilot crashes it is generally his own fault and nothing should be done about it. Nor can I agree with those who believe that all airplanes are constructed for the purpose of teaching people to fly and that for this purpose an airplane which is unusually safe is unsatisfactory. It is my sincere belief that it is essential to a normal growth of private flying that some airplanes be made as safe and as easy to fly as is humanly possible. Let us not deny a canoe for the man who wants one but let us also not deny a rowboat to the man who prefers it. We may find him more numerous and also better able to buy.

I regret to say that all airplanes now being constructed are not as simple to fly and as safe as they could be. The reason are three-fold: (1) the influence of those mentioned previously who see no reason for seeking added safety or ease of control; (2) the belief on the part of many that the sacrifice in speed which would gener-

ally be required would not be justified; (3) the lack of funds to carry on the development work required to attain the desired results. Recognizing the importance of private flying and faced with the facts heretofore presented, the Bureau of Air Commerce requested and secured legislation permitting it to assist in the development of flying equipment in an effort to bring private flying up to the level which it should attain in the United States. Believing that the greatest impetus that could be given would be that attained by simplification of the art of flying and a decrease in its hazards, the Bureau has directed some of its efforts in this direction.

There has been considerable opposition to this activity on the part of the Bureau and perhaps partly due to this opposition the funds which have been available have been pitifully meager for the task undertaken. A significant indication of this opposition appeared in the press lately in connection with the investigations of safety in air transport being conducted by a Senate Committee. It was reported that an investigator for this Committee testified that the Bureau was guilty of using funds appropriated for airway aids for the development program. The appropriation act to which he referred specifically provided that it was to encompass the expenditures on development and the proportion to be used thereon was not specified. Actually the amount so used was \$50,000. less than 1% of the appropriation. In contrast to this figure, representatives of the airlines appearing before this Committee recommended that \$30,000,000 be appropriated for improving airway aids. Considering the fact that no fatalities have yet been proven to be due to inadequate airway aids and that even if they were charged with every accident in which they could possibly have played a part it would not amount to five per cent of the total, I do not believe that you who are interested in the reduction of hazards regardless of whom these hazards may affect will agree that the Bureau has been negligent as charged. In fact, I would expect that you would feel that the Bureau should be commended rather than condemned for recognizing and directing at the most prolific source of aviation fatalities some of its efforts to increase the safety of this means of transportation.

Accident records show conclusively that the most frequent cause of accidents charged to pilot errors is that of stalling. In general it may be stated that when the speed of an airplane is reduced below a certain value, either intentionally or unintentionally, uncontrollable and sudden loss in altitude results. If this occurs at a sufficient elevation and the pilot is competent it is not serious. If

it occurs at too low an altitude the results are apt to be fatal regardless of the skill of the pilot. Stalls are generally the result of attempting to climb too rapidly, attempting to extend the glide to reach the desired landing spot or to an error of judgment in a down-wind turn. Unfortunately there is generally nothing in the attitude or performance of a plane to forcibly call to the attention of the pilot that he is approaching a stall. Unfortunately also the stall is attained by a perfectly normal and natural movement of the controls.

It is my impression that the Bureau of Air Commerce through its Development Section was first to call attention to the fact that in addition to the need of coordinating two controls for guiding the airplane in the horizontal plane it is necessary to coordinate two controls for guiding the airplane in the vertical plane and that the improper coordination of the latter two controls causes more accidents than the improper coordination of the former two controls. In guiding the airplane in the horizontal plane it is necessary to coordinate the rudder and the ailerons. Improper coordination will cause the plane to move sidewise, either toward the center of the turn which is called slipping or out from the center which is called skidding. In guiding the airplane in the vertical plane it is necessary to coordinate the elevators and the throttle. In most planes the individual movement of either of these controls will change the direction of the plane's path relative to the horizontal and also its speed along the path. Unfortunately the natural tendency of anyone is to consider the throttle as the speed control and the elevator as the direction control. There probably would be fewer accidents if this tendency could be reversed.

Although it was previously stated that an airplane became stalled when the speed dropped below a certain value, it could also have been stated that it stalled at a certain angle of attack of the wings, one being a direct function of the other. The elevators are primarily the control of the angle of attack and hence the speed. When they are used as a control of the flight path, then their effect upon the angle of attack and speed may be temporarily overlooked with the possibility of a stall as a consequence. This is actually what occurs when the pilot stalls in an attempt to climb too fast or to glide too far. In contrast to this, if the pilot considered the elevators solely as the control of speed, which they truly are, then he would have no occasion to reduce the speed to the stalling point unless with intent to do so.

In two of the airplanes with which the Bureau is experimenting the propeller has been so located that the throttle has little effect on

speed and is therefore solely a control of the flight path. In a third this characteristic was almost but not quite attained and probably will be present in any future models. Experiments will be continued on these airplanes in an effort to make the lever controlling the throttle effective in controlling the flight path beyond the range which can be attained with the throttle only. This will be attained probably by use of an air brake which will be applied by this lever after the throttle is fully closed.

Another method of guarding against the stall is that of so limiting the elevators that even though they are improperly used they have not sufficient power to cause a stall. The most serious objection to this procedure is its effect upon the landing characteristics of the airplane and the higher landing speed resulting. With the type of landing gear used on most airplanes today this is an important consideration. On the three airplanes previously mentioned, the landing gears are so designed that they may be landed at any speed or attitude and on these the limitation of the elevators does not complicate the landing procedure. The higher landing speed required is also offset by the ability to apply full brakes at any time. As an example one of these planes with controls limited so that the stall could not be reached and a landing speed of just under 50 miles per hour was landed over a 35 foot obstacle and brought to rest within 400 ft. of the base of the obstacle—which is probably a record for airplanes of its general class. It is believed that the work so far done on these planes has amply demonstrated the possibility of obviating the need of coordinating two controls for guiding the airplane in the vertical plane and of guarding against the inadvertent stall or completely eliminating it.

The need for coordination of two controls for directing the airplane in the horizontal plane and the possibility of eliminating this requirement has been much discussed. Much to my surprise the desirability of so doing was also a subject of discussion at a recent aeronautical engineering meeting. One of the engineers in the discussion stated that it had never even occurred to him that the desirability of eliminating one control should be questioned; to him it appeared axiomatic. This engineer expressed my thoughts exactly. The arguments on the other side illustrated quite well the tendency of airplane engineers to design for the pilot and not for the would-be-pilot. One engineer taking this side of the question stated that he had addressed an inquiry to a large number of pilots and that he found them generally opposed to the elimination of any control. I would have assumed this reaction. However, tests con-

ducted in England proved beyond doubt that the most difficult part of learning to fly was that of having to coordinate controls. In a series of experiments the time required to learn the operation of all of the controls separately was found to be only a fraction of the time required to learn the proper coordination of any two.

As in the case of limited elevator control there are obstacles in the way of the elimination of either the rudder or the ailerons. In addition to the difficulty of getting one control to be as effective as two controls, which I believe can be satisfactorily overcome, there is the present need of permitting an intentional side slip which does require the independent use of the ailerons and rudder. The side slip is used as a means of control of the glide path and in the absence of a satisfactory substitute it does assist greatly in landing at a desired spot. As mentioned previously, however, other means can be provided which will not only be much easier to handle but will not be a source of danger.

The intentional side slip is also used in making cross wind landings which are becoming more common with the construction of landing strips. Here again the unusual type of landing gear previously mentioned appears to offer a solution. This type of landing gear has so far shown an ability to automatically correct for cross wind landings with no tendency toward groundloop. In one of these ships tests have been made with single control for directing the airplane in the horizontal plane. The results were exceedingly promising and landings and take-offs 90° across the wind were readily made with only one control.

For most of the airplanes purchased by the Development Section there has been one requirement which to the uninitiated would appear to be quite superfluous. They would expect it to be met without special mention. This requirement is that the pilot be able to see where he is going. It is generally not met more often than it is met. Although it is true that the pilot in all planes can see along his flight path when he is flying at cruising or top speed, in most he can not see along this path during landing, taxiing and take-off, just when it is most essential that he be able to do so. Just how bad this visibility can be, was well illustrated not so long ago when a pilot taxied into a Ford automobile and did not know what he had hit until he left his seat. And that airplane was supposed to have good visibility.

The subject of visibility is closely related to another characteristic of airplanes which certainly does not simplify their control and which can be eliminated whenever this seems to be justified. I

speak of the fact that airplanes point in the direction of their flight path in the vertical plane only at one speed. At higher speeds they point below the flight path and at lower speeds they point above the flight path. The speed at which they point along the flight path is generally the cruising speed and under this condition visibility along the path is usually attainable. The loss of such visibility during landing, taxiing and climbing is due to the plane pointing above the flight path during these maneuvers.

It is my belief that many of the fatal accidents of the past would not have occurred if the airplane did not have this characteristic. As mentioned previously, common causes of inadvertent stalls and spins are those of attempting to climb too rapidly or glide too flat. It was pointed out that there was nothing in the attitude or performance of the plane to indicate to the pilot that he had passed through that point of control movement which gave him his best performance and that the control had reversed the relation between direction of movement and effect. If the plane always pointed in the direction of the flight path, then its attitude would tell the pilot immediately just what effect the control was exerting. For example, in going into a climb the pilot would continue to pull the control back just so long as the nose of the plane continued to come up and would quite instinctively stop the movement of the control when further movement caused the nose to go down instead of up. The same would be true in any attempt to secure the flattest glide possible.

Such a characteristic should also have some effect upon reducing the number of accidents occasioned by failing to clear an obstacle by providing the pilot with an indicator of his flight path. In the absence of one it is only natural that a pilot may be deceived by the attitude of his plane and believe that his flight path clears the approaching obstacle. There probably have been many amateur pilots who have paid the penalty because they believed that if they could point their airplane over an obstacle they would not hit it.

This characteristic can be obtained with variable incidence wings which permit the angle of the fuselage with the flight path to remain fixed while that of the wings is varied. Several airplanes of this type have been successfully flown, the most noteworthy experiments probably being those of Professor Merrill. Just why they have not made more progress I do not know but I do recall that the Guggenheim Safety Council either overlooked this characteristic of such airplanes or considered it of no importance as in their report they stated there were no advantages to be gained by

this type of construction. Although the Bureau has done nothing with this type of plane to date its investigation will be taken up when funds permit.

Another aviation problem which has received our consideration and the solution of which appears to be at hand is that of engine and propeller icing. This is a not infrequent source of accidents. With the assistance of the Bureau a carburetor has been developed which appears to be entirely free of any icing tendency. The Bureau is also responsible for the development of a means for preventing ice formation on propellers.

Flying is now safe—relatively. A competent pilot flying a modern airplane is probably much safer traveling in the air at 120 miles per hour than he would be traveling on the highway at one-half this speed. Flying does have its hazards, however, and the Bureau of Air Commerce hopes to continue to exert its energies toward reducing them. It is my belief, which is shared by many others, that within the short life of the Development Section of the Bureau and with an expenditure which has been insignificant as compared to that spent on airway aids, the Bureau has been responsible for developments which in the next two years will probably account for a greater reduction in fatal accidents per mile flown than would be accomplished by the complete elimination of all accidents on our scheduled airlines. Let us hope that the Bureau will be permitted to continue unmolested and with adequate funds.