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PLANNING FOR SAFETY*

RICHARD C. GAZLEY†

All of you, I am sure, are familiar with the remarkable progress that has taken place in aviation within the past few years. It has been a development that has touched the daily lives of all of you in one way or another. It has made possible the speedy delivery of mail and express and has enabled us to travel distances in a matter of hours that only recently required days. In addition, many of you probably use your own aircraft in daily business for the transportation of materials and personnel, or in your recreation hours for pleasure and relaxation. Or, if you do not, you more than likely have friends or know of some one who does make use of the airplane in this manner.

Naturally the question of safety is of paramount importance. If an aircraft were not reasonably safe, then it would be of little use. For, despite its unquestioned advantages in the matter of speed and comfort, no one would care to gain these advantages at the risk of his life.

Fortunately, however, safety has kept pace with the growth of aviation, and there are relatively few accidents, considering the volume of travel. Of the accidents which do occur, only a small percentage can be attributed to structural or mechanical failure. The use of better materials, increased skill in the fabrication of aircraft, and improved engineering technique have seen to that. Fortunately also that fine group of individuals which comprises our pilots has been able generally to keep in step with the increasing complexity of the machines by displaying a high degree of skill and competency.

Despite the fact that we have attained a large degree of safety in present day aviation, our job is not done—as a matter of fact there is yet a huge unexplored field before us. We must not only prepare the way for further improvements in mechanical safety, but we must learn more about the human factor, and find out what

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† This and the following papers, which were presented at the National Safety Council Meeting, are printed here because they relate to the newer and more important airline operating problems and involve questions of fact which would necessarily become a part of mixed questions of law and fact in future litigation in connection with aviation.

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can be done to decrease its importance, and extend our field of inquiry into realms about which we now know little.

Even if all aircraft development were to stop now our job would not be finished because we are a long way from understanding all of the problems of present-day aviation. But progress will not stop. Next year's land transport will be larger, and probably faster, than any now built. Next year's ocean transport will be almost twice as large in carrying capacity, as the largest flying boat now operating. The rapidity of these developments is breath-taking in itself and is amazing when you consider that each step forward must be preceded by exhaustive research and study to insure both safety and efficiency in a totally unexplored field. It is like a man running in the dark over rough ground, which would be utterly impossible without a torch to light the way.

The Bureau of Air Commerce is concerned primarily with safety in all its phases. It imposes regulations and restrictions upon all types of civil flying for the purpose of making certain that aircraft are airworthy and airmen are competent. But, in addition to this, the Bureau has long realized the necessity for study, planning and experimentation, and has engaged in a certain amount of this type of work toward the end that its regulations and policies should be helpful rather than entirely restrictive. The industry has, of course, conducted extensive experimentation in order to perfect equipment and improve its services.

The Bureau of Air Commerce has been, in the past, particularly concerned with the improvement of aids to air navigation on the Federal Airways System, although also engaging in other experimentation. As there have been few precedents by which manufacturers of this type of equipment could be guided, the Bureau, as practically the sole customer for airways aids, has found it necessary to design a large share of the material needed for installation on the airways.

In its planning work, each regulatory official of the Bureau and each executive concerned with installation of airways aids, has tried to carry on his work with one eye on today and the other on tomorrow, to the end that regulations placed in force today, and airways installed today, should not be antiquated two or three years from now.

That policy worked very well when the industry was small and development proceeded slowly. We could foretell with some degree of accuracy, what changes could be expected, and as our regulations were made flexible from the start, it was comparatively easy to

make the changes required to take care of advances as they came. When the airway installation program was formulated, it was so planned that the airways would not reach their full capacity within any one period, and plans were made for an increase in the number of aids and the total mileage of the airways from year to year to accommodate additional flying.

In other words, it was possible to take care of problems as they arose and make adequate provision for them without any compromise with safety. However, in the last year or so, aviation has swiftly become a highly complex and highly technical factor in the transportation world. This growth has come so rapidly that we have had just about all that we could do to take care of problems as they arose, without an opportunity for thoughtful planning for the future.

Due to the necessity for full attention and full time to the needs of air transportation for the present, there has been little opportunity for the consideration of much needed safety work, revision in technique, or changes in general policies of the Bureau.

In taking stock of the situation, the Bureau concluded that the obvious remedy was the creation of a division for the sole purpose of taking charge of, and being responsible for, all work concerned with planning for the future of aviation. In this way, other divisions would be free to carry out their existing duties in connection with enforcement of regulations, and construction, maintenance and operation of airways facilities. In this manner was born the Safety and Planning Division.

Before I go into details as to the progress of this division, I should like to present for your inspection the word "Safety." As you know, that word is one of the most vital and yet one of the most poorly defined in our entire lexicon. The same is true of its antonym "Dangerous." In driving your automobile, for example, you have often seen warning signs reading "Dangerous Curve" or "Dangerous Intersection." As a matter of fact that curve or intersection probably is not in the least dangerous if your driving is governed to accommodate the particular situation encountered. A safe curve or intersection would seem to be one which could be negotiated with a minimum of care and attention. Similarly, in aviation, when we speak of work looking toward greater safety, we really mean the process of making aircraft easier to fly, capable of going through severe weather without danger, and capable of being handled with a minimum of care and attention.

Planning and development work in the Bureau for the purpose of bringing about greater safety has not been entirely neglected because it has been difficult. As a matter of fact, a surprising amount of work has been undertaken in many fields. For instance, development work on a practical instrument landing system has been going on for a number of years, many improvements have been made in the field of radio, a large number of devices have been perfected to assist in the navigation and safer operation of aircraft, and work has been going on in other avenues, such as lighting research and aircraft development. However, in the past, this work has been carried on more or less independently and without systematic coordination.

The formation of the Safety and Planning Division brought into being an agency which would bind all of this development and research work into a single unit with clearly defined objectives, the advantages being obvious. All sections heretofore engaged in safety and planning work have been brought into the new division and several other sections have been added to extend needed research into other fields.

As its name indicates, the Safety and Planning Division is the planning agency for the Bureau of Air Commerce, with safety as a central theme. The scope of this division is large, requiring as it does a knowledge of the entire field of aeronautical research. In general, the Safety and Planning Division will study trends in the industry and sponsor and coordinate, or initiate, certain types of research and investigation, and on the basis of these studies guide the industry and the Bureau in a long range program. This division will therefore serve as a clearing house and coordinating agency with respect to the research needs of the industry and the Bureau.

The specific nature of the work of the Safety and Planning Division can best be presented by illustrations of projects which are being undertaken.

One section of the Division is devoted to aircraft problems. As you will agree, the field is large, in spite of the fact that great progress has been made in aircraft design and construction.

The handling qualities of aircraft present one problem, especially in the smaller types which have been criticized from time to time as being too difficult to learn to fly. Several contracts, looking toward improvements in this direction, were let prior to the formation of this Division. Whether or not these will provide a clue to the course of further research cannot be determined at so early

a date. Much has been done in the way of inventions and development along this line for years, of course, but as yet there does not seem to be any formidable rival to the conventional airplane as a practical vehicle. Perhaps the answer lies in the further improvement of conventional types. I could find you well-informed persons to argue either side of the question. As for myself, I do not know the answer.

In any event, the question has certainly not been finally settled once and for all and if it is possible to construct a plane that can be operated safely with a minimum of piloting skill, it is without a doubt a subject worth further research.

In addition to problems connected solely with the mechanics of aircraft construction and operation, there is the problem of weather which has always been with us. A formidable foe of all forms of transportation, weather assumes even more importance in aviation, for in the air a pilot is almost entirely at the mercy of the elements, unless he is armed with efficient and proved safeguards to offset each danger as it is presented.

Ice has been one of the most stubborn and persistent trouble makers, but a great deal has been accomplished in the fight against it. Ingenious de-icing devices, which by a pulsating movement crack ice forming on the leading edges of wings and tail surfaces, have been developed and are in service use. The formation of ice on propellers has long been one of the outstanding hazards of aircraft operation. A major advance in the solution of this problem has been brought about by the Bureau of Air Commerce in cooperation with the aeronautics industry, with the development of a simple device known as a "slinger ring" which provides for the continuous feeding of an anti-ice solution to the propeller blades while the aircraft is in flight.

Ice formation in carburetors, equally as hazardous to safe flight as that on propellers, has been the subject of extensive research by Bureau engineers. Ice in the carburetor checks the flow of fuel mixture, and this may occur even when the outside temperature is as high as 50 or 60 degrees Fahrenheit, due to the fact that the vaporizing fuel causes a temperature drop. The development of a type of carburetor that would be inherently ice free was sponsored by the Bureau, and was completed.

There remain, however, some very important problems in connection with ice formation. Ice still has the annoying and dangerous habit of freezing on windshields, thereby obstructing the pilot's vision, and on pitot heads, causing inaccurate instrument readings.

Ice formation on certain types of ailerons can also present a hazard. A number of organizations, working independently, have been busily engaged on these problems and it is obvious that the Bureau should give whatever impetus and help is needed to the end that everyone interested may have the results available at the earliest possible moment. We are preparing to act accordingly.

Present types of position lights, which protrude from the surface of the airplane, provide a start for the formation of ice on wing tips and present another problem. We believe that a satisfactory flush-type light would provide added safety and work is now being undertaken toward that end. An added advantage of such a light would be its contribution to increased aerodynamic efficiency.

Sometime ago an airline pilot brought to the Bureau an idea that was thought of so highly that we are sponsoring its development. Not yet complete, the plan is to provide in the airplane cockpit a properly orientated chart of an airport. When descending through thick weather, the pilot would see by this means an accurate reproduction of the airport below him just as he would see the airport itself in clear weather. He is then in a much better position to align his plane with the proper runway and avoid obstructions. Such an idea, if seriously advanced years ago, probably would have been considered somewhat visionary, but it very definitely has practical possibilities today.

Airports, it goes without saying, are an essential part of aviation, and we would be helpless without proper and sufficient airport facilities. For a number of years the Bureau has maintained a section devoted entirely to airport work. The engineers of this section have been available for consultation with city, town, and community officials interested in constructing or improving their airports. Under the emergency works program, the Airport Section has worked closely with the Works Progress Administration and its predecessors in a nationwide airport construction and improvement program.

The Airport Section, which is now a part of the Safety and Planning Division, will continue this work, and it has been assigned additional duties in connection with future planning.

One of these projects is closely concerned with a problem which we have with us today and which will be even more pronounced in the future—the relation of the size and location of airports to the types of operations conducted from them. In an effort to obtain exact information as to take-off and landing distances required by different types of airplanes in varying atmospheric conditions and

at different altitudes, motion picture cameras are being used to photograph various aircraft as they land and take off. The pictures are then placed in a specially designed and calibrated projector which throws the images on a ground glass screen. In front of the screen and directly against it is a glass grid which enables the observer to read directly the rate of climb and angle from the take-off point. This information, together with the recommendations and advice of the Post Office Department, Navy Bureau of Aeronautics, Army Air Corps, private flyers, scheduled air lines and commercial operators, and data from other sources will be the basis for future airport planning.

Another project assigned to the Airport Section calls for the compilation of a photographic record of all airports in the United States. These will be assembled from the Army, National Guard and other agencies, and will be brought up to date by field personnel of the Bureau of Air Commerce and scaled. The photographs will show facilities of all kinds, whether zoned or not, area available for expansion, drainage system, length and direction of runways, types of hangars and other buildings, lighting system, communication system, type of field, and storage and transportation facilities. Much of this information will be collected from a nationwide survey and sketched on the photographs. The complete data will be used to determine the classification of various airports in the formulation of plans for development over a long period. By comparison of facilities shown on the photographs and information collected by the survey with the opinions of airport officials, the types of aircraft that can be ultimately handled by each airport can be determined. A financial survey will also be conducted, and this in conjunction with the survey and photographic project will enable the Bureau to determine the estimated cost of the development of a field and facilities to its ultimate capacity.

Somewhat related to airport problems and also of major importance in air transportation are the long range planning aspects of so controlling airway traffic as to prevent collisions and at the same time to keep airports and airways available as public facilities.

About a year ago the Bureau inaugurated an airway traffic control system to relieve congestion along the airways and at major airports. This system is under the jurisdiction of the Airways Operation Division, which must necessarily concern itself with problems of the present and immediate future. The Safety and Planning Division, through its Air Transport Section, will be concerned with the future aspects of this problem, for just as it has become

of importance today it will certainly assume a far greater importance year after year as the amount of traffic increases. Therefore, in our planning program we must attempt to ascertain just what proportions this increase will assume, in which direction it will be, and shape our plans accordingly so that we will not be caught off guard with an outmoded system five or six years from now.

Another major field of inquiry concerns the human element. This is a problem to which no existing rules can be applied. We can set up exacting limitations and requirements as to physical fitness and piloting skill, but there we must stop. From then on we are confronted with questions about which little is known. We have designated this problem as "pilot fatigue."

The project which is set up under this somewhat vague heading seeks to determine in specific terms those factors which impair the efficiency of a pilot to the end that such factors may be eliminated, minimized or controlled. This is a vital problem, magnified as it is by the increasing size, speed and complexity of modern and projected airplanes. It is obvious that the amazing adaptive qualities heretofore displayed by American pilots cannot be stretched to a mastery of unlimited complexity and it may be true that, even under present conditions, the strain of competently handling their jobs is shortening the useful life of the pilots.

A considerable amount of research has been conducted on the problem, but there is still an untold amount of work to be done in order to reach satisfactory answers and the Bureau has accorded this project a prominent place in its program.

Returning to mechanical problems, we encounter the subject of power plant vibration and its relation to propeller failures. Under some conditions a combination of vibration in the power plant and engine mount is set up which if allowed to continue may produce a dangerous amount of fatigue in the propeller.

In present types of aircraft it is possible to determine the points at which the vibration will become dangerous, and the necessary precautions are taken to avoid the danger zone. Our problem then is not concerned so much with the elimination of vibration in present types, but with finding means to predict and avoid dangerous combinations in new designs now in the jig and on the drawing board. The Bureau is giving recognition to this problem and plans to conduct studies in cooperation with the industry to develop means for the prevention of propeller failures due to this cause.

The projects assigned to the Power Plant Section relate to its general responsibility of determining the hazardous factors in power

plant operation with respect to both forced landings and fire, and finding means to eliminate those hazards.

The Bureau has maintained a radio development section for a number of years which has been concerned chiefly with the development and perfection of radio aids to air navigation and this is now a part of the Safety and Planning Division.

You all are familiar with the role played by radio in the navigation of aircraft. As aircraft operations have been extended, radio has become increasingly important. On the Federal Airways System more and more emphasis is being placed upon radio. In former years, contact flying was more or less the rule in aircraft operation, as the aids necessary for flying for long periods out of sight of the ground had not been perfected for extensive use.

However, the use of radio has diminished the weather hazard from year to year as new devices and new means of replacing visual contact with radio information have been perfected. Now aircraft fly more or less as a matter of course above the clouds and away from sight of the ground, but still receive all the information needed to conduct the flight safely and without dependence upon ground landmarks. However, it must be pointed out that certain restrictions still limit this type of flying. Regulations forbid the starting of any flight in the face of known dangerous weather conditions, but if a pilot should encounter such conditions unexpectedly while in flight, it is possible for him to complete the flight although his vision may be shut off for protracted periods.

Most of you are probably familiar with the Federal System, but to refresh your knowledge I shall outline briefly the manner in which it functions:

Beacon lights and intermediate landing fields are spaced at regular intervals from airport to airport. The beacon lights outline the course by dots of flashing lights, and the landing fields are available if the pilot should need to land before reaching his destination.

Then there are the radio stations of two general types, those which furnish voice information to the aircraft pilot and those which furnish radio directional guidance by means of aural signals. These in turn are divided as to broadcast strength.

Also there are the teletypewriter circuits which form a huge communications network, the principal function of which is to collect weather information from points along the airway. This information is placed on the machines at various points in sequence

and is carried directly to the weather broadcast stations. There it is coordinated and broadcast to pilots.

As the type of aircraft operations on the airways has changed from year to year it has been necessary for the Bureau not only to keep abreast of these changes so that the aids to air navigation could be revised to accommodate the new developments, but it has been necessary that plans be made for future needs.

The bulk of the airways system is so huge that revisions cannot be made over-night, and, in the past, improvements have been made more or less gradually as equipment required replacement, or as new routes were constructed. This has served to keep the airways abreast of developments to a great extent, but changes have come so rapidly within the past few years that it has been necessary for the Bureau to plan for complete revision and modernization of the system. The Bureau is now starting on a large scale improvement project which will bring its facilities up to date in every respect.

Many of these improvements have been made possible by research and development work on the part of the Radio Development Section. It has been concerned largely with the indexing of future requirements and the carrying out of experimental work necessary to perfect new ideas. Because it has been concerned with requirements of the future, it is now possible for the Bureau to go ahead with its modernization program which will place in service use equipment which was in the laboratory several years ago.

Further improvements are still in the laboratory or just emerging from it. For instance, a large amount of work has been devoted to the perfection of a means by which teletypewriter machines could be operated by radio and reliability equal to land line operation has been obtained. The Bureau's radio development engineers are now seeking means by which teletypewriters may be placed in aircraft and the information transmitted directly to the pilot. The pilot will receive written messages in flight, thereby preventing misunderstanding, and also leaving the crew free to examine the messages later.

With the growth of radio, the question of frequency allocations in the bands now assigned for aviation purposes has become a pressing one. In order to get around this problem, and also in an effort to obtain certain distinct advantages, the utilization of ultra-high frequencies is now under serious investigation. Two new types of radio marker stations developed for airway traffic control purposes operate on ultra-high frequencies and consideration is

now being given to the utilization of these frequencies for radio range use.

The radio range stations, upon which a pilot is dependent for directional guidance along the airways have a tendency in some localities to present bent and multiple courses which give the pilot false indications of his position with respect to the airway. Static, which sometimes blankets out the signals, is also a disadvantage.

It is now felt that the use of frequencies in the ultra-high zone would eliminate many of these disadvantages or at least minimize them to the point where a greatly increased efficiency and reliability would be obtained. Projects concerned with the development and test of ultra-high frequency radio range transmitters and receivers have been assigned to the Radio Development Section for immediate consideration.

Also in the field of radio is the problem of landing aircraft when low visibility makes it impossible for the pilot to make a normal landing by visual contact with the ground. While in the air, the pilot can navigate by means of his instruments and radio if visibility is lowered by fog or other conditions. It is possible for him to locate the airport by instrument and radio, but he must be able to see in order to land his airplane.

We are confronted, then, with the problem of finding some means to replace the necessity for visual contact with other means of furnishing the information necessary to complete the landing.

At present, if a pilot learns by radio that the airport at which he is to land is closed in, he must land at another airport, and on all airline flights certain airports are designated in advance as alternates so that he can complete his flight safely even though it does not end at the scheduled stop.

This, of course, seriously interferes with schedules, although it is imperative that safety be considered first of all. But, it causes inconvenience to passengers who must wait until the weather clears at the terminal airport or proceed by some other means of transportation.

The Bureau of Air Commerce and the aviation industry have been concerned with this problem for a number of years, and active work has been under way in an effort to perfect a practical instrument landing system. During the past ten years several types of landing systems have undergone development and tests and a considerable fund of information concerning the advantages and disadvantages of each has been obtained. A survey of all types has been made and it is now possible to fulfill the requirements of a

satisfactory system by combining the best features of those proposed in the past. The major airlines, the Federal Communications Commission and the Bureau of Air Commerce are now in agreement as to the features necessary in a practical instrument landing system.

While radio is becoming more and more important to air navigation, effective airway and airport lighting is still of prime concern and the Bureau is conducting research looking toward the improvement of facilities of this type. It has assigned to the National Bureau of Standards, research projects looking toward improved airway beacons, aircraft landing lights, runway illuminators and other problems in lighting.

All of the subjects discussed in the foregoing in addition to others of a similar nature are on the immediate program of the Safety and Planning Division. We know that these are not by any means all of the questions that must be answered, but they are all important and of immediate concern.

Laboratory work in connection with carrying out projects adopted by the Division will be performed by agencies outside of the Bureau of Air Commerce, preferably commercial laboratories, under the general supervision of the Bureau and supported in part or wholly by our funds. Where it is necessary to determine specifications to guide outside agencies, the Bureau will do some development work, but it seeks to avoid even such activities if the result can be satisfactorily obtained otherwise.

The most important project of all has not yet been touched upon. It consists of a determination, study and classification of the present and future needs of the industry, the results of which should form the basis for our future program. In other words, it is largely futile for us to attempt long range planning for the industry or the Bureau until we have first conducted some intelligent planning for ourselves. This work is now under way and should provide intensely interesting results. It will never end, of course, but perhaps that is the secret of the fascination of this profession.

These problems are not the Bureau's concern alone. They are of importance to the entire aviation industry and to every one who makes use of aviation in any form. The Bureau is acting chiefly in a coordinating capacity and is furnishing facilities for the prosecution of this work so that it will be carried out along definite lines. It cannot carry the entire burden alone, and, therefore, we are extremely anxious to have suggestions and information from any

informed source so that we may truly be in a position to aid the related causes of aviation and safety.

We should like to have your individual cooperation. If you have any definite ideas as to projects which should be undertaken, the Bureau is anxious to have them and you may be sure they will be given the fullest consideration.

Coöperative planning and effort of this type are without doubt the most certain means of making available to the nation the tremendous potentialities of this greatest form of transportation yet devised.