AVIATION MEDICINE

IN

THE A. E. F.

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The following publication, entitled "Aviation Medicine in the A. E. F.," is published for the information of all concerned.

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BY ORDER OF THE SECRETARY OF WAR:

PEYTON C. MARCH,
General, Chief of Staff.

OFFICIAL:

P. C. HARRIS,
The Adjutant General.

FOREWORD.

This publication contains an account written by Col. William H. Wilmer, Medical Corps, who was in charge of the Air Service Medical Research Laboratories at Issoudon, France, from September, 1918, until the armistice. The account describes the various phases of the physiological and psychological problems of aviation, the organization of the work in the A. E. F., and the application of the newly discovered principles to the maintenance of the efficiency of the flier. It also suggests the future possibilities that lie in aviation medicine. In addition, it records the tasks accomplished by the various departments of the medical research laboratories, the character of the work with the British, conferences with various types of fliers, and it analyzes accidents and their causes.

At the beginning of the Great War, the medical principles involved in flying were realized even less than many of the other problems of aeronautics. But by a thorough study of the physiology and psychology of flying officers, resulting in care for their efficiency, much was done to decrease the accidents in the flying schools of France. The tests and standards thus established will be of inestimable value in all future work to determine the qualifications, not only of the military pilot and observer, but of the commercial flier as well. The great value of this account lies in the fact that it embodies matter that "will be of great importance in promoting the safety and more rapid development of aerial navigation."

M. W. IRELAND,
Surgeon General, U. S. Army.

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INTRODUCTION.

From legendary times, man has sought to emulate the birds—to conquer the air. Yet at the beginning of the war, Aviation was in its pioneer stage—scarcely more advanced than marine navigation at the time that Columbus discovered America. It was only in the decade previous to the war that Wright had established the possibility of aerial navigation by his successful flight in the air. Several years after that famous exploit it was still considered unsafe to fly in a 10-mile breeze; to bank in turning was to tempt fate; to descend with a dead motor attracted wondering crowds. Lieut. Nesteroff, the courageous Russian officer, had just performed the first loop in the air, and M. Pégoud, the famous French flier, had made the first descent by parachute from a single-seated machine. The former was destined, on September 8, 1914, to offer himself upon the altar of Patriotism by destroying an enemy plane by running it down in the air, while Pégoud, in making the supreme sacrifice for his beloved France, so impressed himself upon the enemy that during his military funeral their planes dropped flowers and words of condolence.

During that period of aviation history, the "ceiling" of the single-seater rarely exceeded 12,000 feet; a continuous flight of 250 miles was remarkable, and the motors were all low powered.

When the United States authorities, in 1914, gave out specifications for a biplane with a maximum speed of 70 miles an hour and a climb of 4,000 feet in 10 minutes, the manufacturers thought the requirements too strict.

In the armament of fighting planes, hand grenades, bags of bricks for throwing into the enemy's propeller, carbines, automatic pistols, cannon firing through the propeller hub, machine-gun firing from the upper wing of the aeroplane, gave place in turn to the synchronized machine-gun firing through the revolving propeller blades.

Maj. McCudden, in his "Five Years in the Royal Flying Corps," sums up the condition of the British Air Force at the onset of the war as consisting of about 50 machines fit for military purposes, with 40 trained pilots. The plight of the United States was even worse. Maj. McCudden very graphically described a fighting machine of 1914: "About one-half hour after the German had departed a Henri Farnam, of No. 5 Squadron, fitted with a machine gun, was still climbing steadily over the aerodrome at about 1,000 feet in a strenuous endeavor to catch the Boche. In these days every pilot and observer dabbled in many things—reconnaissance, artillery, observation, bomb raids, photography, and fighting. But the service has since expanded so much, both in size and importance, that each squadron is made to specialize in one or two branches, while other specialists look after the remainder." When the condition of the British Air Force in 1914 is compared with its wonderful efficiency and achievement by the close of the war, the results seem little short of miraculous.

The increase in speed and "ceiling," under the necessities of war, gave rise to many additional military, economic, and medical problems. For without an efficient pilot as guide, the ever-improving plane would become a useless thing for all military purposes. Capt. Sweetser says in "The American Air Service:" "When the British analyzed their casualties during the first year of the war, they found that 2 out of each 100 fliers in the casualty list were killed by the enemy, 8 of them owed their misfortune to defects in their planes, while the other 90 came to the hospital or the grave because of themselves, their carelessness or recklessness, their physical failings, and all other things which may be summed up in the human equation." Therefore the proper selection, classification, and maintenance of efficiency among pilots are of the utmost economic, military, and humane importance.

Aviation attracted Youth by its offer of the "great adventure." In "The Airman's Outing" is written: "Somewhere behind a ridge of clouds, in the nothingness of space, on the patchwork of the ground, the True Romance has hidden a new experience which can only be found by the venturer with alert vision, a quick brain, and a fine instinct for opportunity." Maj. Bishop writes: "I do not think I was ever happier in my life. It seemed that I had found the one thing that I loved above all others. For me, it was not a business, or a profession, just a wonderful game."

For the proper appreciation of that wonderful game, and of the qualifications that make for success in it, one must consider the types of air work, the physical and the psychological standards of requirements, and make a profound study of personality. Tested by purely physical standards, Guynemer, the marvelous French flier, would have been disqualified. By certain psychological tests, he would, perhaps, have been classified as "nervously unstable." But this tall, slender youth with "unforgettable eyes," was the embodiment of that subtle "something" which exists in all "masters of fate." It seems as hopeless to attempt to record this compelling force by correlative numerals as to measure the weight of the soul. Some of its component parts can be estimated—such as quickness of response, calmness, perseverance, and steadiness. Its existence can be recognized by intimate conferences ascertaining love for the work, self-reliance, initiative, imagination, aggressive spirit, unbreakable will, courage, infinite capacity for taking pains, and great desire to serve one's country. All the star fliers of the allied services—notably Bishop and Ball of the British, and Rickenbacker, Lufbery, and Luke of our own—possessed these qualities in a marked degree, while Guynemer was their rarest expression. They have all embodied the beautiful idea of Col. Roosevelt's as paraphrased to read: "Only those are fit to 'fly' who have not feared to die." In connection with the early history of Guynemer (which showed a great skill in shooting and fencing with a fine ambition to excel) it may be interesting to note that certain sports like cross-country riding, polo, and sailing have a tendency to give the flier "hands"—most helpful in maneuvering a sensitive single-seater fighting machine. Diving also gives one a great sense of equilibrium. The Cavalry has produced a number of the most successful fliers, among them Bishop, Heurteaux, and the German pilot, Von Richthofen.

So many contradictory requirements for "picking the birdman" have been stated by those interested in the problem, that Maj. Patten's analysis of the fighting pilot is both humorous and true. "He is a tall, short, stout, slim, blond, brunette, quiet, nervous, languid, alert, reckless, conservative individual." Even after the "birdman" is selected, he may prove a wonderful flier without bringing down a single enemy plane, or he may be a fighter of the first class without giving much thought to the flying itself. Bishop modestly writes of himself: "I belong to the steady flier's class, but some day soon I am really going to learn to fly—to do aerial acrobatics and everything." It is impossible to make a clear composite picture of a group of men who are the highest exponents of individualism. For each adopts the method of fighting that suits his peculiar requirements. In addition, in the classification for efficiency, one has to consider the various kinds of work which have constantly become more specialized. In order to avoid repetition in the chapters that will present the work of the departments of the medical research laboratories, it seems best to give, at this point, a brief analysis of the varied types of air work for which the fliers were selected, each according to his individuality.

The *chasse, scout, or fighting pilot* is the type of flier suggested to the public mind when the word "aviator" is used. He is the "birdman" of the press. His duties are various. He must fly to any height, changing altitude instantaneously, from "ground strafing" to the limit of the plane's ability to climb. He must escort and protect the other airmen in their special lines of work. He is, as Lieut. Rath aptly expresses it, "the mine sweeper of the air." In squadron, or stalking the enemy alone, he must be ready to fight without a moment's notice, always anticipating the maneuver that the enemy is most likely to make. His reaction time must be quick but associated with cool, calm judgment. The most successful pilots achieve their victories with the first few shots, after taking deliberate aim. Like other types of airmen, he must be absolutely familiar with the topography of all the country over which he must fly. While many older pilots have been most successful, as a rule the fighting pilot is at his best from 19 to 25 years of age.

The *night chasse pilot* has the duty of keeping the enemy planes from crossing the lines, and of protecting the targets (cities, etc.) from these raiders. The very nature of his work subjects him to the double danger of his own as well as the enemy barrage. Later in the war, the British night fliers met with great success at the front. In our own service, this branch of aviation work was just being inaugurated when the armistice was signed.

The work of the *observer* each day was growing in importance, and all combat pilots are ready to pay tribute to his personal qualities and to the value of his work. He was fast developing into a skilled specialist in artillery and infantry liaison, with highly technical knowledge of radio, the making and interpreting of maps, photography, visual reconnaissance, with reports and aerial gunnery. Col. Reille, of the French Artillery, says: "The flying machine should not be considered so much as one arm of the Artillery as one of its eyes—and that the better one. The bringing down of the enemy's plane blinds his Artillery." Rickenbacker says: "I believe their function of seeing for the Army is the most important one that belongs to the aviation arm in warfare." Early in the war through the aerial reconnaissance of Capt. (now Gen.) Charleton, the attempt of the Germans to flank the British Army was discovered in time to save the latter by the great strategic retreat from Mons. The history of the Air Service to the very end of the war is replete with instances of the importance of observation. Richthofen says: "Frequently a photographic plate is more valuable than shooting down a squadron." In spite of all that must be seen on the ground, only one-eighth of the time can be spared for this work when the observer is near the enemy's lines, the rest of the time must be spent in looking for hostile planes. His duty carries him to all altitudes—from dropping a message at 300 meters to a long reconnaissance at 5,000 meters. Because of the great need of mature judgment in such work, the observer may be somewhat older than the combat pilot—provided that he has a strong physique.

Day bombing has been aptly described by Lieut. Rath as "artillery on wings." The objectives are in the immediate rear of the enemy's lines, zone of activity, and strategical points far within the hostile country. These distant flights are frequently of four or five hours duration and often at an altitude of over 4,000 meters to avoid the enemy's antiaircraft guns. The bomber must not be less minutely familiar with the topography of the country embraced in his mission than the fighting pilot.

The *night bomber* seldom flies higher than 2,000 to 3,000 meters. But he must be thoroughly familiar with every foot of ground back of his own lines in order to make a landing without really seeing—should that necessity arise. He must be familiar with the topography of the hostile country in order to recognize guiding landmarks. He must be able to recognize all roads, rivers, woods, vineyards and towns—the latter largely by the geometrical formations. He must know the constellations and their positions on the compass. Moreover, he must constantly consult his maps and compass. The following contretemps—due to unfamiliarity with the section—is told by some French fliers: "An expedition actually bombed Nancy instead of Metz and finally capped the climax by landing in Luxembourg." Many night fliers have spoken of the very confusing effect of moonlight on the earth-mists which are so common in France during certain seasons. All allied fliers speak of the greater effectiveness of the enemy's searchlights which leave one blinded for a long time. One of our fliers working with the British told of an amusing experience of a very successful night bomber, who, on a very beautiful day, went up for a "joy ride" and got lost. He was not accustomed to the landmarks in daylight.

The *aerial gunner's* work has now been taken over by the observer, who has added the use of the machine gun to his other duties.

The *aerial navigator* is a late product of the war evolved by the necessity of flying in foggy or rainy weather, and at night. He directs the flight of his pilot by map and compass. So far there are very few thoroughly trained aerial navigators.

The *ferry pilot* flies the machine from a central station to some aerodome near the front. So he does not have to consider the questions of combat or of altitude. In the British service the ferry pilot usually flew the planes across the Channel.

In the *lighter-than-air ships*, the altitude is usually not over 500 to 1,000 meters, and the landing does not require the fine adjustment of sight and judgment of distance. The pilot may be older than the combat pilot, but the long patrols are very fatiguing and require a strong physique.

In the *captive balloon*, the work is of the most trying and nerve-racking type. Very few balloon observers have the nerve to resume their work after three or four forced descents with a parachute. The altitude is not usually over 1,000 meters. Good sight is of great value, but the observer is relieved of the responsibility in landing.

In the *free balloon*, also the finest ocular adjustments are not necessary in landing.

In regard to the *seaplane*, Maj. McCombs, who has had much experience in the matter, feels that owing to the heaviness of the ship and its slow response to the controls, a certain amount of physical strength is necessary for the pilot in "taking off" and in getting out of a "side slip." There should also be sufficient length of legs to easily reach the rudder bar. He also says: "The level of the water is difficult to judge, especially when the water is very calm and at night." The altitude is rarely over 500 meters.

In addition to these divisions of air work—which keep the flier to some extent in the public eye—there are two types of aviation experts at the training centers whose work is less spectacular, though it is far-reaching in the development and success of the Air Service—the monitor and the tester. The *monitor* or instructor has to be in the air many hours a day and has to be always on the alert. Without him the successful combat pilot could not have existed. The *tester's* work is still less understood, and it is certainly not generally realized that some of the most remarkable acrobatic fliers of the service belong to this group. It is the tester's duty to see that there are no defects in flight or in maneuverability in the planes to be used by the student fliers. He "hops" up 500 to 1,000 feet to test the ship's alignment—whether nose heavy or tail heavy, whether it leans too much in banking or whether there is anything else that interferes with its stability. He indicates to the mechanics the necessary correction, and he continues his flights until he is satisfied that all of the faults have been eliminated. To be successful the tester must be not only an exceptionally good pilot, but he must be conversant with the theory and practice of rigging and mechanical flight, and he must possess a knowledge of the principles of engineering. The safety of the student flier depends upon his conscientious, painstaking, fearless carrying out of his important work.

Toward the end of the war all types of fliers at the front joined in the sport of "strafing" the enemy. In this very effective phase of aerial warfare the aviator flies very low, at times within a few yards of the enemy whom he "sprays" with bullets from his machine gun. He is impartial, and he does not slight any group of the enemy from the front line trenches to the engineers of the troop trains in the rear.

The period following our entrance into the World War was comparatively too brief and the necessities of that conflict too great to further the research work upon many important aviation problems; but it is hoped that our experience both in the United States and in France may have some value for those who may, in the future, have the time and opportunity to pursue these investigations more completely.

The published work of our colleagues in the allied services has been of great assistance from the beginning of our task. It is most logical that the nation which produced Paul Bert should have contributed so much towards elucidating the effects of reduced oxygen tension. Bert's pneumatic cabinet still holds its place in the Sorbonne—an eloquent reminder of Science's debt of gratitude to the great physiologist. The French have also gathered together very valuable statistics upon various reaction times, which have been most helpful in our work. The Italians have contributed much data of importance concerning practical psycho-physiological examinations. The British have developed a number of practical tests for the selection of the flier, for the recognition of his fitness and for the detection of staleness.

Aviation has been developed during the past decade, and medical aviation is still younger—only in the very infancy of its experimental stage. "Damnant quod non intelligunt." Every new thing is liable to be met with indifference if not with actual hostility. It is therefore a pleasure to note that moral support as well as material help were invariably extended to the medical research laboratories in the A. E. F. America's genius for organization showed itself in the transportation and in the adequate housing of the laboratory equipment in the center of France at a time when every branch of the service was so severely taxed.

In general, officers of all branches of the service have been interested and helpful. In particular, tribute is due to the chief of the Air Service, the chief surgeon, and the commanding officers at all the fields in the A. E. F. where laboratories were installed for their vision, their encouragement, and their unfailing assistance. It is not possible to express adequate appreciation of the loyal and efficient work of the research board, of the units, and of the flight surgeons. To them the care of the flower of American Youth has been not only an absorbing scientific interest, but a sacred trust from the Nation.

CHAPTER I.

ORGANIZATION AND GENERAL ASPECT OF THE WORK OF THE AIR MEDICAL SERVICE, A. E. F.

When the chief surgeon, A. E. F.—a man of fine scientific attainments and of broad culture—asked for the official report of the work of the medical research laboratories in France, he said: "Make it a human document rather than a collection of purely scientific data." Therefore, it seems best to give some account of the happenings associated with the development of the work, even at the risk of some tedious detail.

Immediately upon the declaration of war the vital part that our Air Service should play in the conflict was recognized. The Surgeon General of the Army was logically in charge of that part of the preparation that pertained to physical standards, and he made the timely recommendation that this work be placed under the supervision of one medical officer who, under the direction of the Chief Signal Officer of the Army, would assume control of the physical examination of aspirants for flying duty. Acting under verbal instructions, Col. Lyster had, early in the summer of 1917, established and standardized the work of physical examining units in 35 of the large cities, so that at the time of issuance of the formal order, thousands of men had already been accepted for the Aviation Service and some of them had been sent overseas. As the organized units of the Air Service passed through the ports of embarkation, they were assigned medical officers and received their standard medical equipment for active service. But it was recognized that these medical officers—picked more or less at random—had not been trained with reference to the peculiar problems of aviation. They had had neither laboratory experience nor special opportunity of working with the fliers.

The establishment of the central office and the work of organizing and standardizing the various examining units were closely followed by the formation of the Medical Research Board to "investigate all conditions affecting the efficiency of pilots; to institute and carry out, at flying schools and elsewhere, such experiments and tests as will determine the ability of pilots to fly in high altitudes; to carry out experiments and tests to provide suitable apparatus for the supply of oxygen to pilots in high altitudes; to act as a standing medical board for the consideration of all matters relating to the physical fitness of pilots. * * *." This board was officially established by paragraph 113, Special Orders 243, Adjutant General's Office, October 18, 1917, and met in the chief surgeon's office or at the American University until the middle of the following January (1918), when the original research laboratory at Mineola was completed. The work now proceeded with constantly increasing volume, so that two months later it was found necessary to treble the size of the building in order to properly house the different departments and to set in motion the machinery involved in training the personnel required for branch laboratory units at the flying fields and at the ground schools, and also for the newly created "care of the flier" department, made up of flight surgeons and physical directors. By this time the strength of the laboratory force was considerably over 100, commissioned and enlisted.

In June, 1918, branch laboratories had been established in many of the fields, and flight surgeons were on duty. Additional personnel were under instruction at the main laboratory and hundreds of fliers were undergoing the low-oxygen tension tests, either in the low-pressure tank at the Mineola laboratory or by means of the Henderson-Pierce rebreathing machines at the branch laboratories. The results immediately showed such value to the individual and to aviation that it was early determined to establish laboratory units at the ground schools so that the candidates could be classified prior to or immediately following their entry into the service.

The reports of the work of the Medical Research Laboratory at Mineola prior to August 6, 1918, have already been published in the "Manual of Medical Research Laboratory."

On August 6, 1918, in response to a cablegram from Gen. Pershing, a group of 33 officers and 15 enlisted men, who had been especially trained in laboratory methods, embarked for service in the A. E. F. The officers composed the following groups: Medical Research Board No. 1, Branch Units No. 1 and No. 2, Medical Aviation Unit No. 1 (temporarily assigned to work with the Royal Air Force), and the Ophthalmo-Otological Unit. The personnel of the various groups were as follows:

Medical Research Board No. 1: Col. William H. Wilmer, Medical Corps; Lieut. Col. Leonard G. Rowntree, Medical Corps; Maj. Edward C. Schneider, Sanitary Corps; and Maj. (later Lieut. Col.) Henry W. Horn, Medical Corps.

Branch Unit No. 1: Maj. James L. Whitney, Medical Corps; Capt. (later Maj.) Conrad Berens, jr., Medical Corps; Capt. Claude T. Uren, Medical Corps; Capt. Floyd C. Dockeray, Sanitary Corps; First Lieut. George F. Hanson, Sanitary Corps; First Lieut. W. Harvey Kernan, Sanitary Corps; First Lieut. Prentice Reeves, Sanitary Corps.

Branch Unit No. 2: Maj. Robert R. Hampton, Medical Corps; Capt. Frank M. Hallock, Medical Corps; Capt. George D. Carter, Medical Corps; Capt. Henry R. Skeel, Medical Corps; First Lieut. Schachne Isaacs, Sanitary Corps; and Second Lieut. Harold W. Gregg, Sanitary Corps.

Medical Aviation Unit No. 1: Maj. Albert F. Beverly, Medical Corps; Maj. Robert S. McCombs, Medical Corps; Maj. John P. Gallagher, Medical Corps; Maj. Edwin S. Ingersoll, Medical Corps; Maj. Kosciusko W. Constantine, Medical Corps; Maj. Charles W. Hyde, Medical Corps; Capt. Eugene Cary, Medical Corps; Capt. Robert A. Trumbull, Medical Corps; Capt. John B. Powers, Medical Corps; First Lieut. Paul A. Garber, Medical Corps.

Ophthalmo-Otological Unit: Maj. William C. Meanor, Medical Corps; Maj. Wilson M. Bassett, Medical Corps; Maj. Theo. S. Blakesley, Medical Corps; Maj. Andrew W. McAlester, Medical Corps; Maj. Richard W. Perry, Medical Corps, and Maj. William F. Patten, Medical Corps.

Capt. Harold F. Pierce, Sanitary Corps (later major), with the enlisted personnel, took overseas for the board a steel low-pressure chamber, the Dreyer nitrogen dilution apparatus, four sets of the Henderson-Pierce rebreathing apparatus, and equipment for 10 flight surgeons, in addition to extensive apparatus and equipment for carrying out in every department of the laboratory, investigation and clinical work relating to the fliers. Altogether, there were 84 separate boxes in addition to the steel chamber, and the weight was approximately 14 tons.

All of the officers had been trained in the special problems of medical aviation, and many of them had been in aviation work from the time that the United States entered the war. They had all had experience in flying; some had even done solo work, while one member of the group won his "wings" later on in France.

On leaving Liverpool the group assigned to the British was detached from the main body and proceeded to assist our colleagues in their work of examining and caring for the fliers. They remained in England doing a variety of very useful work until after the armistice. The ophthalmo-otological group proceeded from Havre to Vichy, while the board and the two laboratory units, after going through St. Aignan and Thésée, finally reported at the Third Aviation Instruction Center, Issoudun, September 2, 1918.

As a result of a general survey of the Third Aviation Instruction Center, we found that the 575 students, out of the approximate number of 3,000 American fliers in France, were as fine a lot of youngsters as one would wish to see; but that, on the whole, their physical condition was bad. Their morale was low, and they had acquired a

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fatalistic attitude of mind. At that time, there had been about 500 flying hours per day with increasing fatalities, which in August reached the number of 17. There was very little venereal disease, but staleness was common. The men were overeating and under-exercising, constipation being very common. There was no physical training beyond some setting-up exercises before daylight—a recent innovation. According to an early post order, there was no medical examination—beyond a rotation test—before a man began flying; while a later post order—before Col. Bingham's incumbency—had allowed a student to consult a doctor only with the permission of the commanding officer. Even after consultation the surgeon had power to recommend leave of only two days.

In addition to an adequate camp hospital of some 500 beds, there was a Red Cross convalescent hospital for fliers established in a very pretty château—Ville-Chauvan. It was presided over by a very efficient French lady, and it could accommodate about 20 men. As it was only about 4 miles from the main field it was not very satisfactory. Its very proximity to the noisy fields made it impossible for the men to get the necessary mental rest from flying activities. The whirr of the motors was constant, and in consequence the men talked "shop." The need of an adequate and quiet rest station, where tired and sick aviators could recuperate was most pressing and immediate. For this purpose Madame Siegfried had most generously and patriotically offered her beautiful home to the men—the ancient royal Château Langeais on the Loire, about 24 kilometers west of Tours. It was much regretted that the Red Cross decided that Langeais was too inaccessible to be practicable.

Col. Thomas R. Boggs, Medical Corps, had made a comprehensive study of the Air Services of our Allies, and he had already sent in a valuable report to the Chief Surgeon and to the Chief of Air Service, A. E. F. Col. Boggs was made "Medical Consultant, Air Service, A. E. F.," with headquarters at Neufchateau. Col. W. H. Wilmer, Medical Corps, was designated "Surgeon in Charge of Medical Research Laboratories, Air Service, A. E. F."

The board and the units, under command of Col. Wilmer, were given a cordial welcome at the Third Aviation Instruction Center, and throughout their stay they enjoyed the most helpful cooperation of headquarters and of Camp Hospital 14. Lieut. Col. Bingham, commanding officer, was not only helpful, but inspiring. The cordial reception of the work by this aviation center is well illustrated by the following editorial in the "Plane News:"

Investigations of the Medical Research Board of the Air Service have shattered the long-time belief of aviators that Fate is responsible for the large number of aviation casualties. Pilots formerly believed that when their time came to be "bumped off" they would be "bumped off," regardless of how they attempted to guard against fatalities. Absolute scientific researches of the medical board have proved that this is not true. The board is no longer an experiment. It has saved hundreds of aviators thus far, and with the cooperation of the pilots themselves will save hundreds more. What is necessary, is for the pilots to thoroughly understand that the board is not here to grab them off the flying list. The board was created to advise and cooperate and to assist the aviators in saving themselves.

Human lives are not expendable; planes are expensive and hard to get. The pilots are needed on the front, and the aircraft is needed both for training purposes and for flights over the enemy lines. It therefore behooves every aviator to cooperate with the board in order that his life may be saved, not only for himself, but in order that he can be of service to the Government; furthermore, the pilot should remember that when he wrecks a plane and kills himself, due to causes which could have been avoided, he is criminally negligent. A pilot's life and the planes are too valuable at this stage of the game for a man to permit himself to be guilty of such a crime.

Plans were immediately submitted for a main laboratory at the Third Aviation Instruction Center, and for branch laboratories at

FIG. I.—Medical Research Laboratory, Third A. I. C., A. E. F.

the Second Aviation Instruction Center and at Columbey-les-belles. Capt. (now Maj.) Harold F. Pierce, Sanitary Corps, not only took charge of the transportation of the laboratory equipment, but he also rendered most valuable assistance in making the plans and carrying on the construction of the laboratory at Issoudun and at Tours. But the board did not wait for even the commencement of this construction. After a careful study of the hospital histories and a survey of the medical needs of this center, work at the Third Aviation Instruction Center was begun, being carried on in the officers' rooms (8 by 15 feet), in the reading room of the hospital, and in the ends of wards which were screened off by sheets. As the epidemic of influenza kept the hospital very full, the laboratory work was handicapped by the lack of space. Maj. Boswell, in charge of the hospital, and his successor, Maj. Noé, gave us all the assistance in their power.

The various departments of the laboratory carried on their work in the rooms of the new building as soon as they were partially completed. But the board was not able to hold its initial meeting in the new laboratory until November 19, 1918.

On the afternoon of September 2, 1918, a tour of the outlying fields was made for the purpose of studying the machines in use, types of instruction, accidents, general conditions, and specific medical problems embraced in the altitude and time of flying, recreation, leaves, etc. At this time, there were nine fields, with the formation of three more under consideration. At field 8 combat work was taught, and accuracy in shooting was registered by the machine-gun camera. Maj. Davis, commanding officer of the field, and Lieut. Austin, instructor, were most interested in our work, and they were keen to improve the efficiency at their field. Lieut. Austin was not only the most finished exponent of combat flying himself, but remarkably successful in instruction. In all contests with visiting combat and acrobatic pilots he had been victorious. In a conference with him on September 3 he expressed appreciation of the need of exercise, change of diet, shorter hours for work. In his experience the man who vomited and who did not feel all right immediately afterwards was a poor type, as a rule. An interesting fact about field 8 was noted. Men were often sick at this field who had never been sick before, although they had gone through similar acrobatics in their previous training. Relativity presented by the opposing machine, played an essential part.

Lieut. (later Capt.) Ferguson, in command of field 5, was a most broad-minded and efficient officer. In a very satisfactory conference with him on September 4, he deplored the overeating, the constipation, the low morale, and the lack of physical training; for here, as at the other fields, the only exercise was a setting-up drill before daylight. The students worked four hours a day in landing and in spirals of all kinds, in cross-country flying, in acrobatics, and in altitude up to 12,000 feet. The 15-meter Nieuport with 80 to 120 horsepower motor was used here. The many accidents that occurred at this field in August, 1918, seemed to have been caused by the bad physical condition of the fliers.

On September 13 Assistant Secretary of War Ryan and Gen. Patrick, Chief of Air Service, A. E. F., paid the Third Aviation Instruction Center an official visit of inspection. They were both very cordial in their reception of the work we had brought to the A. E. F. After the departure of the Secretary for Paris, Gen. Patrick remained, and there was a most satisfactory conference with him at the office of the commanding officer. The organization of the Medical Research Laboratory and the results of its labor in the States, together with the scope of the work proposed in the A. E. F., were fully described. Gen. Patrick was interested and helpful down to the smallest detail. He said: "I am delighted that you have brought this work over here where it is badly needed. You are in the nick of time. I am only sorry that you could not have come over earlier." He was most interested in the work of the flight surgeon. The following day a request for a flight surgeon at the main field was received from Maj. Lamphier. Maj. Hampton was suggested and appointed, thus becoming the first official flight surgeon, A. E. F. Shortly afterwards several assistants to him were appointed. The surgeon in charge of the laboratories and Lieut. Col. Rowntree (as substitute) were requested to sit upon the accident board.

A suggestion was made to post headquarters that a bulletin be sent to all the fields forbidding the use of drugs, such as aspirin, etc., without medical advice, and instructing all fliers to report to the flight surgeon whenever they were not feeling fit. Every morning at 11 o'clock (except Sunday) the commanding officer held a meeting, which was attended by the commanding officers of all fields and by the officers in charge of the various departments. Everything concerning the good of the service was discussed. The daily meeting of these officers, whose duties were widely different, was of great value. Every one was kept en rapport with all the activities of the fields, and fine team work was thereby engendered. On September 18, 1918, the surgeon in charge of the laboratories was requested by the commanding officer to attend this daily meeting of officers. On the same day there was an interview with Maj. Marsh, who felt that the men at the front should have clubs, with Victrolas, magazines, papers, etc., for diversion, and that they should have a holiday every three months. Nearly everyone had lost a friend and had, in consequence, a fatalistic idea that he might be the next victim. Maj. Marsh's experience agreed with our own, that the men in training who did not progress as rapidly as the others, should be kept longer on the more stable Avro, thus enabling them to gain more confidence before taking up work on the more sensitive Nieuport.

Judiciously granted holidays and leaves are just as important at the training centers as at the front. This need was well illustrated by an accident that had occurred that day at one of the fields. The commanding officer of the field was inclined to be a little hard upon the monitor who was instructing at the time. In point of fact, the monitor had been working and flying for 18 months without a rest. The work of the monitor is quite as exacting and trying as that of the student flier.

On September 19, at the officers' meeting, the commanding officer announced that Maj. Lamphier had been made executive officer and that Capt. Ferguson had been placed in charge of flying—both of them most efficient officers and most helpful in every way to the

Medical Research Board. At this meeting the need of an ambulance equipped with fire extinguishers and a pole to hook a pilot from a burning plane was brought out. The surgeon in charge of the laboratories was asked to prepare a schedule of exercises and of physical training for the various fields. It was also suggested that all fliers should have a half holiday in the middle of the week without any regard to the weather; that all sports, particularly those with an element of competition, should be instituted, such as baseball (using soft indoor ball), handball, volley ball, medicine ball, tennis, squash, etc. The question of training with the Ruggles orientator to accustom fliers to vrilles was brought up.

One of the very pleasant and useful things about life at this great instruction center was the association with the pilots returning from the front. We had a long conference with Lieut. Winslow (brother of Alan), who was typical of the splendid American youth at the front. He had just brought down his third official enemy plane. He spent the evening showing many photographs of interest and in relating many of his experiences. He said that whenever he was flying at a high altitude he was forced to breathe through his mouth, and with the mouth wide open; and that the mere exertion of moving the "joystick" winded him. He laid great stress upon the need of exercise and diversion both during training and at the front. He spoke of the great discomfort of the present tunic in flying—the binding of the neck by the tight collar prevented the easy turning of the head in looking for enemy planes, etc. He had come over with 200 other Americans to be trained by the British. Of that number, 75 were lost in training and 15 in actual combat.

On September 20 the laboratory group was much pleased by having an initial visit from Col. Boggs, who later gave them a very interesting talk. He stated that our "units had made medical aviation possible for the first time in the war."

About this time Maj. William C. Meanor, Medical Corps, who was in charge of the Ophthalmo-Otological Unit, came to the Third Aviation Instruction Center. He rendered most valuable assistance to the flight surgeon as well as to the laboratory. Later, Maj. Wilson M. Bassett, Medical Corps, came to the laboratory, where he was connected with the Department of Internal Medicine. The experience in aviation problems that these officers had gained in the United States proved most useful in the work in the A. E. F.

At the officers' meeting on September 24 a policy for dealing with the following types of student fliers was considered: Car-sick type; men who could be salvaged by operation and leave (sinus trouble, tonsils, etc.); men who were stale but in fairly good physical condition and who would respond quickly to rest and change. Another matter considered was the question of a clearance by the Medical Research

Board of every man before he returned to work, if he had been in the hospital for any accident or illness that would have a tendency to vitiate his fitness for flying. Later there was a conference with Maj. Lamphier, executive officer, who said that all old post orders in regard to medical examination would be abrogated and that the findings of the board would be definite and final. The questions of all kinds of leaves for students, instructors, and pilots from the front were discussed. It was felt that the car-sick man who could not overcome this trouble should be classified "unfit for flying," leaving his disposition to headquarters. It was suggested that stale pilots from the front should be given a leave before they began their work as instructors. A cable was sent to the Surgeon General, United States Army, requesting that the films "Fit to fight" and "Fit to fly" be sent to the Third Aviation Instruction Center for purpose of instruction.

On September 25 a communication was sent to Col. Boggs requesting him to cable for the following personnel, together with equipment for two branch laboratories: Two physiologists, 2 psychiatrists, 2 clinicians, 2 ophthalmo-otologists, 1 psychologist, 10 enlisted men (4 of them having been trained in the laboratory at Mineola). It was suggested also that the inventor of the Ruggles Orientator and two of the apparatus be sent for. In a conference about the "joy riding" by the monitors, it was felt that it gave them relaxation (so far without any serious accident) and that it had a tendency to keep the men in good training for the front.

On September 27 there was a visit from Lieut. Gaylord who had been connected with a day bombing squadron for six months at the front. He had noticed that the observer was often troubled by gases from the engine. Lieut. Gaylord had suffered from eye strain and bad goggles. He had been so badly knocked out that he had had to take bromide and aspirin for headache. A few days previously he had been so dazed in landing that instead of throttling the engine, he had given her full gas, and had nearly run down a mechanic. He told about one flier who was stale and "fed up." He applied for leave but instead he was given a compound cathartic pill and told to go back to his work.

Special care for sick or injured aviators was a supreme necessity in order that their complete recovery could be effected before their return to flying duty. The hospital at Vitelle and Contrexeville were visited with Col. Boggs. For it was considered most important to keep the fliers under observation there until their recovery was sufficiently advanced to permit their transfer to Rest Chateaux.

On September 30 Col. Boggs and the surgeon in charge of the laboratories visited some of the aerodromes at the front. Among them was the station of the First Pursuit Group, in charge of Maj.

(now Lieut. Col.) Hartney, who was an ideal commanding officer; suave, forceful, with a great vision. At this aerodrome there were 6 squadrons, 125 officers, 91 fliers, 918 enlisted men. There were 3 medical officers and 1 dentist. The aerodrome was situated on the hills and it was about half a mile distant from the town of Erize-la-petite. The infirmary was located on the immediate outskirts of the town. It had one ambulance in case of accident to take the injured man to Souilly. The weather on that day was wet, cold, penetrating, and the mud of such indescribable consistency that made its adherent qualities seem far superior to the cement obtainable at that time. But it was warming to the cockles of one's heart to see the trim Spads with the "Hat-in-the-ring" on their sides, lined up in front of the hangars. Unfortunately, Rickenbacker and his incomparable companions were out that day "strafing" the enemy. At the same time Lieut. Luke, who had won 18 victories in less than six weeks of active flying at the front, had been reported missing for 24 hours. This brilliant, erratic flier was beloved by all at the aerodrome, and while there was some anxiety, there was a general feeling that he would turn up all right. At all the aerodromes that we visited at the front, it was noted that the medical men, who were usually exceptionally efficient, did not live in close, constant contact with the fliers as would be the case with flight surgeons.

On October 1, a call was made upon Col. (later Brig. Gen.) William Mitchell at his headquarters near Souilly. As Chief of the First Army Air Service, Gen. Mitchell had done wonderful work in building up the service at the front. He was himself a fine flier, his brilliant accomplishments in tennis, in riding, and other outdoor sports having contributed much, no doubt, to his success in flying. While conferring with him, the presence was reported of two enemy observation planes over Clermont.

There was great interest in having a sufficient number of flight surgeons for the spring campaign. So in order that there might be no delay in this plan, a wire was sent the Chief Surgeon, A. E. F., on October 7, giving approximate weight and cubic space required for the emergency field equipment for 50 flight surgeons and 4 additional laboratories that had been previously recommended.

On October 8 Col. Royce arrived from the front. He told of the increasing amount of contour flying there. He was present at the officers' meeting. At this meeting, the commanding officer, in asking that all possible assistance be given the Medical Research Board, stated that despite the rains and the shortening days, the weekly record of the school had been broken by 300 hours, the number of flying hours in one day having amounted to 749 hours; that the post's record had been broken by 40 hours; that in spite of the increase in flying hours and of the fact that more leaves had been granted than ever before (no recommendation of the board for leave having been turned down), the death rate had been lowered. These facts proved to his mind that efficiency at the fields consisted in keeping men in good physical condition and not in having numbers of inefficient men trying to fly. After the officers' meeting, the Medical Research Board met at post headquarters with the heads of the Avro, acrobatics and combat work to consider the "car-sick" type of flier.

It was always a privilege to have a visit from Col. Kilner who was admired by the heads of all of the departments at the field. At the officers' meeting on October 9, he said that Issoudun was the greatest instruction center in the world and the backbone of the front.

On October 10 the surgeon in charge of the laboratories was requested to look into the question of the windshields of the Nieuports, as the heavy metal rim was very dangerous to the face during a rough landing. On the next day he made his report suggesting the removal of the windshields on the 23-meter Nieuport for the following reasons: (1) To prevent injury to the pilot's head by the rigid metal rim when the machine nosed over in landing. (2) In order that the monitor might instruct the student flier with greater ease. (3) In order that the vision of a short man might not be interfered with. While the short man might use a cushion to overcome the difficulty with the windshield, the extra height would make it harder for him to reach the rudder with his feet. (4) To render the flier independent of the windshield. If he were accustomed to a windshield, it would be hard for him to fly without one; but if he were trained to fly without the shield, he would enjoy it later on as an extra protection and not as a necessity.

By request arrangements were made about this time for the members of the Medical Research Board and the heads of the laboratory departments to write weekly articles for the "Plane News." These articles, while popular in character, were to deal with the medical and hygienic problems that had such influence upon the physical and mental fitness of the flier.

On October 13 Clermont-Ferrand was visited. In conversation with Lieut. Col. Horn, Lieut. Col. Rader, the former commanding officer of the post, said in regard to flight surgeons: "At first I was very much opposed to them in the States. I feared that they would be butting in on something they knew nothing about. But before I left they had demonstrated their value to such an extent that I have a note in my pocket to take up the question of having one sent to this field." In looking over the record of the accidents at Clermont-Ferrand we found that in one case the pilot was always sick in the air. On the day of the accident, just before going up, he had taken a large dose of "Mothersill's Seasick Remedy." At 300 meters he had gotten into a vrille and could not get out of it. There had been only eight deaths at this school since its formation.

Upon the return to Issoudun from Clermont-Ferrand there were several letters from our British colleagues expressing their appreciation of the Medical Research Laboratory Manual (of the work in the States) which had been sent to them. Capt. (now Maj.) Rippon, Royal Air Force, wrote: "I desire to congratulate the American research committee on having developed what will be the most accurate method of examining pilots to date."

On October 15 the officer in charge of flying sent in a very interesting memorandum. Among its compilations were the following: Excess of flying hours over previous records, day, 22.11; week, 769.03; month, 1,869.47. There had been to date, from October 3, 4,436.46 flying hours without a death, while the best previous record (June 29 to July 10) had been 3,528.11 hours without a death. Col. Bingham was very enthusiastic over this great improvement at the field. On October 17 he announced that for the first time in the history of the field there were 600 planes in commission. He said that this breaking of the record was due to the efficiency of the Engineer Department and of the Medical Research Board. The latter, by keeping the men in fit condition, had saved machines as well as lives.

Shortly after the arrival of the Medical Research Board at the Third Aviation Instruction Center, 12 articles of subsistence had been withdrawn by orders from G. H. Q. from sale at the commissaries, except to hospitals. So a request was made to the food and nutrition section for a survey of the messes of the flying officers, with suggestions in regard to their improvement. The following is a portion of the report on the subject sent in by Lieut. Hipps, Medical Corps, a nutrition expert:

> * * * there can be no question, I think, that they are in need of the very best of food, and that it should always be well prepared. Their problem is peculiar. They are in need of this, not that they should be pampered, but because they must be in perfect physical condition for their flying and especially for their stunt work. They are told by their instructors and flight surgeons that they must not "go up" if they feel the least bit "off color." Improper food, constipation, etc., with resultant dizziness or even a tendency towards the same, might well produce a fatality in the case of a flier with very little experience when he attempts a vrille or some other form of aerial gymnastics that is a part of their daily routine. Their need of a well-managed mess is greater perhaps than in any other form of the service.

On this day there was a visit from Capt. Eddy, who made the following suggestions in regard to the various messes: (1) To have a centralization of buying through Lieut. Watson, who had had much experience in this line; (2) to have Lieut. Hipps remain here and, by means of constant consultation, cooperate with the Medical Research Board upon the nutrition problems.

At the officers' meeting, October 18, it was reported that there were 637 planes in commission, with only 306 out of commission—the post's best record. Notice was received from G. H. Q., giving authority to the commanding officer of this center to grant immediate leave of two weeks upon recommendation of the board.

On October 21 the accident board considered the case of a flying officer who was killed in his attempt to return to his own field with a stalled engine, when a landing in an adjoining field would have been a simple matter. When the motor stopped, he was seen making the attempt first to turn and then to redress. But he got into a vrille from which it was impossible to recover. This type of accident is very frequent, and it is interesting from a psychological standpoint. From the very first, fliers are instructed never to make this turn when the engine stalls. They talk about it constantly and they know the danger. They are conscious of their mistake after the fatal turn is started and they endeavor to redress. Making the first turn seems to be an automatic action, and when the higher cerebral centers endeavor to correct the move it is too late. Many experienced fliers have lost their lives in this manner, among them McCudden, one of England's greatest combat pilots, who had brought down officially 58 enemy planes.

Among the questions taken up in an officers' meeting about this time was the demoralizing effect of holding the funerals about half past 5 in the afternoon—just when the men were at dinner. The officer in charge of funerals did not see why an objection was made to the dirge, as it was beautiful and classical, being Chopin's Funeral March. The surgeon in charge of the laboratory suggested that the best plan would be to take care of the flier and not have the funerals.

The accident board convened on October 23 to consider the cause of death of two pilots from a collision in the air. The evidence brought out the fact that the student responsible for the accident had been disqualified in the States on account of imperfect sight. In training, he had passed through several fields until he reached the one where acrobatics were taught. The other pilot, an excellent flier, was just finishing his turn and was coming out of a vrille preparatory to landing. By virtue of the rules of the field and his "dead stick," he had the right of way. But the student with poor sight ran into him without seeing him, and both were killed.

On October 24 the Medical Research Board received from Capt. Ferguson the "Rules and Regulations Governing Flying." The board felt that it was most important to study these rules minutely to see if there were any further suggestions that would improve the safety and efficiency of this work. At the officers' meeting that day it was announced that in spite of the rain and the mud the daily flying hours had increased on the previous day to 850 hours. The next day brought the welcome announcement that one of the headquarters hangars had been turned over for use as a gymnasium and that a fund had been started to procure a first-class equipment. There were bright prospects for the men to have the opportunity of getting regular health-giving exercise in spite of the inclement weather. Only those who have spent a winter in this part of France can realize how inclement weather can be. As Lieut. Col. Emmerson said: "The sun goes entirely out of the shining and drying business."

On October 26 there was again the unpleasant duty of sitting upon the accident board. The flier who was killed had been ill and he was not in condition to fly. At the meeting of the board the fact was brought out that he had vomited in his plane before going up, but he had concealed his condition for fear of losing time.

Col. Kilner asked the Medical Research Board to formulate standards of physical requirements for observers, balloon observers, bombers, and aerial gunners. He said that "the morale and the spirit of the fields had improved very rapidly and that every man was on tiptoe to do his bit. This condition had been brought about largely by the Medical Research Board because it made the fliers realize that though small in number they were of great value. They felt that they were being cared for and that infinite pains were being taken to look after their welfare and efficiency. I am delighted to say this, because I was scared of research boards. You know what a nuisance such a board could be if it were not the right kind."

On October 27 there was a long conference with three American fliers who had been trained with the British and had worked with them—Hall, Moffet, and Grimm. Lieut. Nordhoff, a delightful youngster, spent the evening with us. Speaking of some of his fights with the Richthofen circus under the younger Richthofen, he said: "After the war I would love to meet Richthofen and talk matters over with him." This remark was quite characteristic of the fine chivalrous spirit shown by the allied fliers toward a foeman whom they considered worthy of their steel. McCudden says, in his work: "Rhys-David proposed a toast to Von Richthofen 'our most worthy enemy,' which toast we all drank except one nonflier." In the Air Service even some of the enemy were infected with the spirit of chivalry. Richthofen the elder, in writing of his first victory, says: "I honored the fallen enemy by placing a stone on his beautiful grave." Later, in speaking of the British, he says: "They absolutely challenged us to battle and never refused fighting."

In order to study the problems of physical standards for various types of fliers in combat, the board held a conference on October 28 with the flight surgeons, and with Capt. (now Maj.) Berens, Capt.

Ferguson (in charge of flying), Capt. Davis, Capt. Titus, First Lieut. Williams, First Lieut. Garside, First Lieut. McMillen, Second Lieut. Longley, and Second Lieut. Eales (the last seven from the front). There was the general feeling that good physical condition with good hearing, good sight, and normal color vision were absolutely necessary for entrance into the Air Service. After the conference a schedule of physical requirements for all types of fliers was prepared. It was announced that the record of 912 flying hours had been reached that day. On October 29 a general order was received grounding all fliers who were suffering from venereal diseases.

On October 31 the goal of the field's ambition of 1,000 flying hours for one day had been more than reached in the record of 1,088 hours for that day, while the record for the month was 17,113 hours.

On November 4 the branch laboratory at the Second Aviation Instruction Center at Tours was opened under the supervision of Lieut. Col. L. G. Rowntree. Maj. R. N. Perry was flight surgeon. The laboratory personnel consisted of Capt. George D. Carter, in charge; Capt. R. H. Skeel, Lieut. George F. Hanson, and Lieut. Schachne Isaacs. The work had the heartiest support of Lieut. Col. Fitzgerald, the post commanding officer, and of his staff. Later, Capt. Cary was added to the group. His special work was to study all details concerning the duties of the observers, and to take charge of conferences with observers from the front who were undergoing examination and classification at the laboratory. Maj. John P. Gallagher and Capt. John P. Powers were also added to the unit, and Maj. W. B. McAlester was detailed to this station to make a special study of the visual functions involved in the work of the observers. His excellent report closed with the following words: "In view of the above I recommend that for observers a complete color field be taken and made a part of the record of the examination; that this be made in addition to the Jennings color test. Further, that stereoscopic vision is not a subject to be waived in the qualifications of an observer."

The laboratory at Columbey-les-belles had not materialized by the date of the armistice, consequently the plans for the work at that center were reluctantly abandoned.

Maj. McDonald, commanding officer of the Seventh Aviation Instruction Center at Clermont-Ferrand, where Maj. Blakesley had been detailed as flight surgeon, had desired the establishment of a branch laboratory at this center. This need could have been supplied if the war had continued.

On November 16 the commanding officer requested the Medical Research Board to be very strict from that time on in passing the men who should come up for examination. Previous to the armistice it had been the aim of everyone to salvage for the Government all men and material that presented possibilities. But the time for that had passed, and only the very fit were to be saved in the new process of elimination. No candidate for flying would be allowed even to begin his training unless he had been accepted by the board. Arrangements were made with the executive officer, Maj. Lamphier, for a DH–4 in order to experiment with the artificial use of oxygen at great altitudes. After a conference with Col. Bingham, on November 18, an arrangement was made for the Medical Research Board to assist in the demobilization of the fliers by acting as a board of elimination. Upon examination the men were to be divided into the following three classes: (*a*) Men perfectly fit; (*b*) men who in all probability would not be able to do any flying for six months; (*c*) men who should not fly at all. As the board had done everything in its power to aid in building up the service, it was now hoped that it might help in the orderly and systematic closing of this great school. Mr. McCurdy, a well-known authority upon physical training, who had charge of this department of the Y. M. C. A. in the A. E. F., had spent several days at the field, and he had exhibited the great desire to help that was so characteristic of nearly all American officers. The following quotation is taken from a letter received from him on November 19: "I believe the work you are doing is not only fundamental for the physical fitness of fliers, but *may* be made fundamental to the problem of racial fitness." The board was informed that no more candidates for entrance into the service were to be examined. A notice was also received from G. H. Q. that it was desired to ship home all sick, wounded, and convalescents as soon as possible.

On November 19, the board held its first meeting in the new laboratory—a red-letter day.

By November 21 the work of the monitors and testers had been sufficiently lessened to enable more of them to undergo a thorough examination at the laboratory, the testing of this group having started in October.

That afternoon was spent at field 14, where aerial gunnery was taught. The target was a silhouette of a German Rumpler. The plane used in training was the Nieuport 15 meter, with the Vickers machine gun. The jamming of the guns was the bête-noir of the student flier as well as of the combat pilot. The work of this field was excellent.

The first contingent of the 10 men who had been working with the British arrived at Issoudun on November 23. On November 25 there were visits from Col. Lister and Lieut. Col. Parsons, of the B. E. F., and from Lieut. Col. Greenwood and Lieut. Col. Derby, of the A. E. F. They all evinced much interest in the work of the laboratory. A portion of this day was spent in making tests with oxygen in an aeroplane.

On November 26, the board had the privilege of a visit from Lieut. Col. Dreyer, of the British service. No one has done more toward the solution of the many medical problems of aviation than Col. Dreyer. He had a conference with the laboratory staff, and at this meeting he said, in substance, that the blood volume should be considered in relation to the surface of the body; that blood pressure

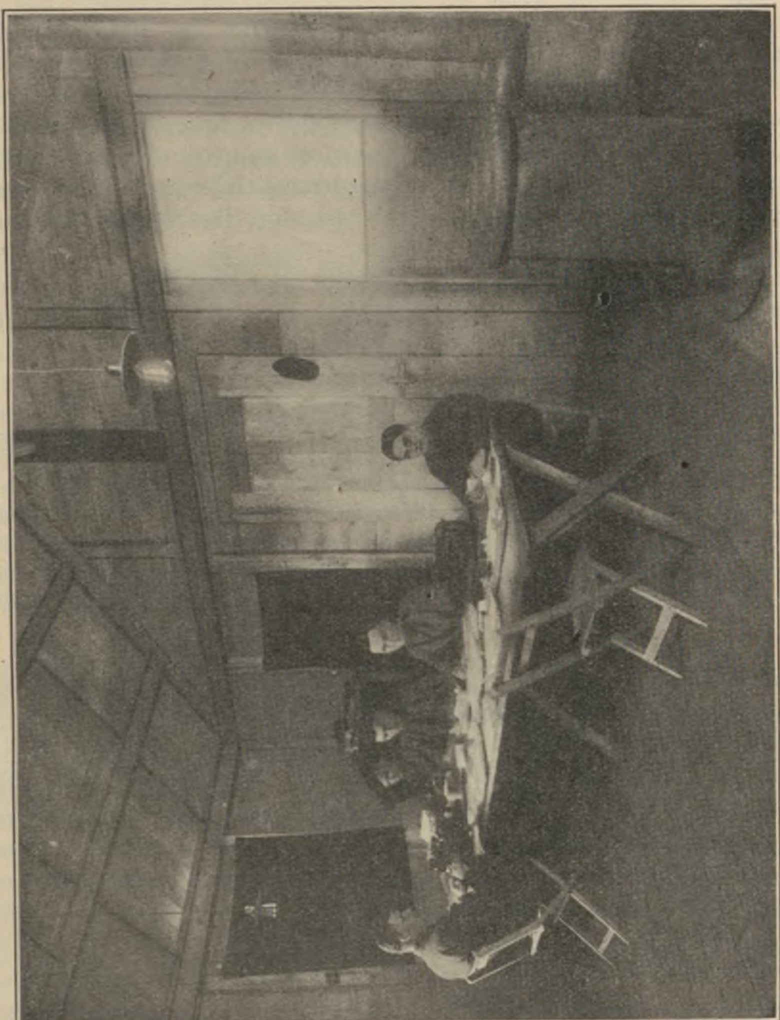

FIG. II.—Room for records and for meetings of research board, Third A. I. C., A. E. F.

was relative to muscular development; that a most important point was the relation of systole to diastole. Examination of the vital capacity, he felt, was more of a test of endurance than anything else, and that the British tests were only tests of endurance. Reaction times, as taken by the French, were tests of mentality, and Nepper had been correct in 90 per cent of his selection of fliers by these tests.

American pilots should be classified A–1—the best of all pilots owing to greater sensitivity and intelligence. But on long fatiguing, bombing trips they would not, perhaps, hold up as well as duller men.

By this time all of our fields had compulsory physical exercise as a part of their regular instruction program, with a daily report upon the subject.

On November 29, a conference was held with the chief surgeon, A. E. F., concerning the medical problems of aviation and the importance of the continuance of this work in the future. In spite of the armistice, the work at the two laboratories progressed steadily. On the afternoon of November 30, the chief surgeon, A. E. F., with a number of other officers, visited the branch laboratory at Tours. He was particularly interested in the tests for classification and for visual memory.

On December 3, the following communication was received by the commanding officer:

From: Assistant Chief, Air Service.
To: Commanding Officer, Third Aviation Instruction Center.

(1) The Chief, Air Service, has already arranged for a series of laboratory tests to be made at Issoudun on pilots returned from the front. The details of this matter are understood to be under the supervision of Col. Wilmer.

(2) The French and English Governments have been invited to send a number of pilots to take these tests in conjunction with our own men and the French Government notified our service to-day that they would send between 20 and 30 pilots.

(3) It is requested that information be furnished as to when these tests will begin so that the French Government may be notified when to send their men to Issoudun.

HALSEY DUNWOODY,
Assistant Chief, Air Service.

This letter was in reply to a request that a limited number of French and British aces be sent to the laboratory for examination and classification. It was felt that the results of these examinations would be of great scientific and practical value in standardizing still further the knowledge already gained in testing large numbers of American fliers. Later 12 French fliers arrived at Issoudun for examination. It was a great regret that on account of transportation and other difficulties, no British fliers were examined. During a visit to the Third Aviation Instruction Center on December 6, Col. Boggs said that he had written out a memorandum for an organization of the Medical Department of the Air Service, and that he had suggested to the Chief of Air Service that it should be a special service and separate from the Surgeon General's Office.

On December 10, Col. Birley of the British Air Service arrived at the laboratory for a visit. It would not be possible to find in any of the Air Services a man whose experience in the practical medical problems of aviation had been wider than his. He stated that artificial oxygen had been of great value to the British squadrons whose duty was flying far back of the enemy lines at an altitude of 20,000 feet. With the oxygen and an extra supply of petrol, these squadrons were able to stay up four and five hours. Although their duty kept them at this high altitude for hours at a time, these men were able to go sometimes three months longer without getting stale than the men in the bombing squadrons who did not have the oxygen. On the same day, DH-4 No. 1584 was turned over to the laboratory for experimental altitude work with oxygen—a cause for great satisfaction. A report of this work will be found elsewhere in this history.

Dinner was taken on Christmas Day with the officers, Capt. Oliver, Lieut. Peters, and Lieut. Malthan, of field 9. They were delightful and efficient men, and the general excellence of their work in flying was reflected in the character of their mess and of their pleasant quarters. The psychological effect of such surroundings is valuable at all times, but especially is this true when holiday seasons turn the thoughts homeward with a particular attraction. At training fields as well as at combat centers, good food and pleasant surroundings with diversion are of untold value in producing mental and physical fitness. The Government furnished ample food. The mess was good or bad according to the officer in charge.

On December 26, Col. Bingham left the Third Aviation Instruction Center. His departure was greatly regretted. But we congratulated ourselves upon having such an efficient officer as Maj. Lamphier, as his successor. On December 27, the following letter was received from Col. Bingham by the surgeon in charge of the laboratory. It is inserted here because it is a tribute to the deep interest, to the efficiency and to the great value of the work accomplished by all of the officers of the laboratory and by the flight surgeons.

> Before leaving this post, I want to take the liberty of telling you how greatly I have appreciated the cooperation and aid which the Medical Research Board has given us during the past four months. It was certainly a most fortunate circumstance for me that you should have arrived just at the beginning of my administration here. That we should have been able to break records in graduating pilots in October under a heavy strain and at the same time reduce the number of accidents and increase the morale of the aviators was due in such a large measure to your wisdom and counsel, that we are all of us under a great debt of gratitude to you. Please express to the members of your staff my sincere admiration and hearty appreciation of their great service in helping American aviation to be successful.
>
> Sincerely yours,
>
> Hiram Bingham,
> *Lieutenant Colonel, Air Service.*

On December 27, the laboratory was most honored by the presence of Prof. Spearman of the British research committee, who made an official visit to study our laboratory methods. He was so full of

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enthusiasm and he had had such broad experience that he could give us information that was most helpful and valuable.

On January 6, 1919, a letter dated October 8, 1918, was received from Gen. Foulois. The last stage of its journey must have been made by the "Snake Limited." In the letter, Gen. Foulois suggested the advisability of getting 12 physical directors overseas as soon as possible.

On January 6, the first contingent of French fliers—five in number—arrived at the laboratory for examination. They were a fine and interesting group of men. All of them had been at the front several years though engaged in different types of work—ranging from combat flying to night bombing—and they had received many citations. One member of the group had flown in Russia and in Roumania.

From January 6, 1919, until the various units of aviation medicine left this center on February 19, their time was spent in completing examinations, in studying records, in devising new forms of apparatus, and in making the necessary arrangements for departure. This routine was broken on January 20, by a pleasant visit from Gen. Patrick who was, as always, most interested in the work.

Col. Boggs, Col. Wilmer, and Lieut. Col. Rowntree were selected as delegates to attend an Inter-Allied Medical Aviation Conference at Rome on February 15. An attack of influenza prevented Col. Wilmer's attendance. At this meeting a permanent organization was formed under the name of the "Societé Scientifique pour l'Etude Medicale Aeronautique."

CHAPTER II.

AVIATION MEDICINE AND THE FLIER.

In the preceding chapter, the main endeavor has been to give a general survey of the organization of the work of aviation medicine in the A. E. F., with some of the incidents connected with its development.

The work itself fell under three principal heads: (1) The selection of the flier; (2) the care of the flier; and (3) investigations relating to the flier.

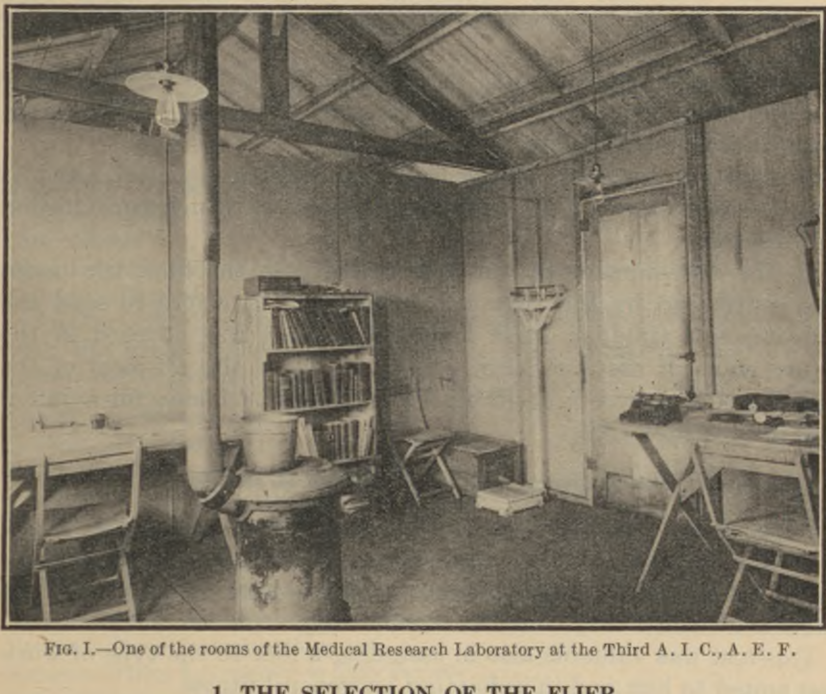

FIG. I.—One of the rooms of the Medical Research Laboratory at the Third A. I. C., A. E. F.

1. THE SELECTION OF THE FLIER.

This problem was much the same as it was in America. But the A. E. F. was not equipped with examining boards, so the research laboratories took on this function. Only one difference was encountered. Whereas in America all applicants for flying chose the Air Service, it was soon learned that here many observers were assigned to this duty, in many instances, in spite of their preference for other branches of the service. This made a material difference in their attitude both toward the examination and toward the service.

2. CARE OF THE FLIER.

A. Reexamination of Fliers.

This consisted in a careful, general and special medical overhauling, by the laboratory personnel, of the men who were either referred by the training department, or by the flight surgeon, or who had been returned from the front for special study.

Following each examination the board met (the flight surgeon, and the heads of the various departments of the laboratory being present), decided the treatment necessary, referred the case to the hospital, recommended leave or sick leave, prescribed glasses, returned the flier to flying status, or grounded him as the case demanded. In this connection, the work was greatly facilitated through an order from headquarters which authorized the commanding officer of the post to grant leave or sick leave upon the recommendation of the board.

A ward of the hospital was turned over to the board, which gave the opportunity for carrying out surgical procedures, and for the medical care of sick fliers.

In addition, members of the board and laboratory staff acted as consultants to the camp hospital in all cases in which consultation was desired.

In the development of the work relative to the flier, the board was confronted by the very serious problem of where to send the convalescent, tired, or stale men. This need was covered in the future plans of the Air Service to open, under the auspices of the Red Cross, chateaux in desirable districts for rest homes for aviators who needed such care.

B. Classification Examination of Aviators in Relation to Altitude.

Fliers were examined by the rebreathing test, as occasion arose, to determine their ability to withstand the effects of low oxygen; and their instructors or commanding officers were advised as to the altitude at which they could work efficiently.

This test was valuable also in assigning a flier to the type of work best suited to him and in indicating his general fitness.

C Education of Fliers in Matters Relating to Health and Efficiency.

Talks were given from time to time by members of the board, laboratory staff, and flight surgeons. In addition, a series of articles upon such subjects were published in the "Plane News," among them "The relation of physical condition to fatalities," "Training essential to fitness," "Spirit levels of the brain," "The value of physical exercise," "The effect of altitude in aviation," "The nerves of the aviator," "The eye and aviation," "The effect of altitude on the eye," "Qualifications of observer and pilot." The importance of training and of clean living were emphasized, and the warning sounded that indispositions that seemed trifling on the ground, frequently assumed serious proportions in the air. It was sought by every possible means to drive home the axiom that only the fit should fly.

D. Extent, Growth, and Character of Work.

The extent, growth, and character of the work is described in the following reports. Monthly reports are submitted for the Third Aviation Instruction Center, because the basis of classification underwent a great change with the signing of the armistice. Whereas prior to that time every effort was made to retain men in the service, even when minor operative procedures and rest were involved, subsequently, only those absolutely physically fit were graded "A." It was the policy to send all others to the United States as soon as possible and compatible with the exigencies of transportation.

September, 1918.—Summary of board recommendations—124 cases.

Return to active duty at once		25
Number grounded		9
Leave for rest	9	
Leave and further examination and treatment	6	
Leave after hospital treatment	2	
Leave after hospital treatment and release by ophthalmological department	2	
Leave after release by otological department	4	
Release from active duty for 1 week or less—rest	3	
		26
Not fly until reexamined	2	
Not fly until rebreathing test	1	
Not fly until released by otological department	3	
Not fly until released by ophthalmological department	6	
Not fly until hospital observation and treatment	16	
		28
Return to flying, but get corrected goggles	5	
Return to flying, but take eye-muscle exercises	2	
Return to flying, but further examination	5	
Return to flying, but rebreathing test	1	
Return to flying, but referred to flight surgeon	2	
Return to flying, but to a field in the States	1	
		16
Not indicated in record (Oct. 4, 1918), temporary owing to want of laboratory		20
		124

Number grounded:

No. 26. Sick in acrobatics; convergence insufficiency.
No. 59. Temperamentally unfit.
No. 68. Temperamentally unfit.
No. 85. Valvular lesion; divergence excess.
No. 8. Hyperthyroidism, Class D by hospital.
No. 87. Hypertension; poor balance sense.

Number grounded—Continued.
- No. 96. Temperamentally and physically unfit.
- No. 72. Vertigo and nausea.
- No. 182. Vertigo and nausea.

Why referred for examination:

To see if in condition	39
In air—dizzy, nausea, sick	22
Stale, nervous, tired	22
Physical condition—headaches, dizzy nausea	29
Poor flying	4
Eyes	8
	124

609 EXAMINATION, SEPTEMBER, 1918. (FORM 1.)

Number examined	22
Passed	12
Disqualified	5
Disqualified until operation	5

[Rebreathing test. September, 1918.]

Number examined	1

October, 1918.—Summary of board recommendations—147 cases.

Return to active duty at once		24
Number grounded		7
Suggest transfer to observation		3
Leave for rest:		
Sick leave	7	
Further examination and treatment	6	
After hospital treatment	2	
After hospital treatment and release by ophthalmological department	1	
After hospital treatment and release by otological department	2	
		18
Not fly until reexamination	5	
Not fly until released by ear department	8	
Not fly until released by eye department	3	
Not fly until hospital observation and treatment	16	
Not fly until nasal or tonsil operation	17	
Not fly until released by ophthalmological and otological departments	7	
		56
Return to flying, but get corrected goggles	7	
Return to flying, but get wrist brace	1	
Return to flying, but take eye-muscle exercises	7	
Return to flying, but suggest ferrying	1	
Return to flying, but referred to flight surgeon	4	
Return to flying, but further examination	5	
Return to flying, but tonsillectomy at convenient time	11	
Return to flying, but tonsillectomy and eye exercises	2	
Return to flying, after overcoming hypersensitiveness to motion	1	
		39
Total		147

Grounded:
- Present condition disqualifies for flying, No. 137.
- Sent to Hospital 20 for observation and treatment, Nos. 154, 130, 164.
- Anxiety neurosis return to America, No. 179.

Grounded—Continued.
Temperamentally unfit for flying, No. 155.
Irreparable nasal condition, No. 171.

Why referred for examination:

To see if in condition	37
To see if in condition after accident	10
Physical condition—headaches, dizzy, nausea, or stomach	39
In air—dizzy, nausea, or sick	13
Stale, nervous or tired	12
Poor flying	20
Eyes	14
Ears	2
Total	147

REBREATHING TEST. OCTOBER, 1918.

Number examined		20
Number rated A	7	
Number rated B	4	
Number rated C	5	
Number rated D	3	
Number not rated	1	
		20

609 EXAMINATION, OCTOBER, 1918. (FORM 1.)

Number examined		96
Qualified		53
For observers only		2
Aerial navigation		5
Qualified after operation		22
Disqualified:		
Vestibular findings	1	
Tonsils	2	
Nose and tonsils	1	
Eyes and tonsils	2	
Tonsils and physical condition	1	
Nasal condition	2	
Equilibrium	2	
Eyes	4	
Urine	2	
Rebreathing	1	
Psycho-motor instability	1	
Incomplete	2	
		21
		96

November, 1918.—Summary of board recommendations—267 cases.

Return to active duty at once			174
Number temporarily grounded (Class B)		55	
Medical for:			
Bronchitis	2		
Cardio-vascular	2		
Nervous instability	2		
Physical instability	2		

Medical for—Continued.			
Staleness	4		
Convalescent, influenza	6		
Convalescent, pneumonia	1		
Convalescent, jaundice	1		
Abscess teeth	1		
Varicocele (painful)	1		
Glossitis, dissecting	1		
Old fracture, cervical vertebra	1		
Chronic pleurisy	1		
Bursitis (shoulder)	1		
		26	
Eye for:			
Astigmatism	2		
Convergent insufficiency	4		
Hyperopia	2		
Retrobulbar neuritis	1		
Lack of stereoscopic vision	1		
For goggles	4		
		14	
Ear for:			
Hypersensitive labyrinth	4		
Chronic tonsilitis	1		
Deviated septum	2		
Chronic rhinitis	1		
Sinusitis	1		
Incomplete (sick in chair)	1		
		10	
Neurological for:			
Temperamentally unfit	2		
Nervous instability	1		
Nightmare	1		
Tremor, marked	1		
		5	
Number permanently grounded (Class C)			14
Medical for:			
Heart lesion	1		
Tuberculosis suspect	2		
Physical instability	2		
Neuro-circulatory asthenia	3		
		8	
Eye for:			
Diplopia	1		
		1	
Ear for:			
Hypersensitive to motion	2		
Hypersensitive to motion (car-sick type)	1		
Vertigo	1		
		4	
Neurological for:			
Temperamentally unfit	1		
		1	
			14
Suggest transfer as observer	1		
Not to fly, referred to hospital	6		
Not to fly, recommend leave	11		
Not to fly, returned to mechanic's status	1		

Not to fly, above certain altitudes	2		
Hold for observation	1		
Hold for rebreather	1		
Record incomplete	1		
		24	24
Total			267
Why referred for examination:			
Monitors, complete examination of			70
Pilots returned from front			10
Physical condition, headache, fainting, dizziness, etc			32
In air, dizzy, nausea, or sick			24
Poor flying, including acrobatics			7
Poor landings			11
To see if in condition after accidents			11
To see if in condition after shot down by enemy			1
To see if in condition for court-martial			1
To see if in condition for flying this field			16
To see if in condition after sick leave			39
To see if in condition for advanced flying			23
Stale, nervous, and tired			8
Tuberculosis suspect			2
Eyes			11
Ears			1
Total			267

REBREATHER TESTS.

Number examined		38
Number rated A	15	
Number rated B	11	
Number rated C	12	
		38

609 EXAMINATION (FORM 1).

Number examined		45
Number qualified	27	
Number qualified for day work only	1	
Number qualified after operation	13	
Number disqualified:		
Eyes	3	
Hyperthyroidism and tonsils	1	
		45

December, 1918.—Summary of board recommendations—207 cases.

Returned to active duty at once		123	
Number classed "A" who should have leave		15	
			138
Number temporarily grounded (class B)			66
Medical for—			
Neuro-circulatory asthenia	8		
Bronchitis	1		
Staleness	6		
Convalescent (pneumonia)	7		
Hyperchlorhydria	1		
Fracture	1		
Sinus arythmia	1		

Number temporarily grounded—Continued.			
Medical for—Continued.			
Gunshot wounds in combat	2		
Malaria (enlarged spleen)	1		
Hyperthyroidism	1		
Convalescent ("flu")	8		
Hernia	1		
		38	
Eyes for—			
Poor vision	5		
Convergent insufficiency	5		
Hyperopia	1		
Eye strain (altitude)	1		
		12	
Ear, nose, and throat for—			
Ethmoiditis	1		
Operation nasal occlusion	1		
Hypersensitive labyrinth	4		
Chronic tonsilitis	3		
Frontal sinusitis	3		
Chronic rhinitis	1		
Pharyngitis	1		
		14	
Neurological for:			
Temperamentally unfit	2		
		2	
			66
Number permanently grounded (class C)		3	
Medical for—			
Syphilis	1		
Pyuria	1		
		2	
Neurological for—			
Temperamentally unfit	1		
		1	
			3
Total			207
Why referred for examination:			
Pilots returned from front			110
Testers			6
Monitors			1
For classification			15
For promotion			1
In air, fainted			1
In air, nausea and headache			3
Physical condition, headache, dizziness, sick, etc			8
Poor landings			3
To see if in condition after accidents			3
To see if in condition after sick leave			33
To see if in condition for advanced flying			16
To see if in condition to be monitor			1
Nervousness			2
Eyes			3
Ears			1
Total			207

DECEMBER, 1918, REBREATHING TESTS.

Number examined		103
Rated A	50	
Rated B	34	
Rated C	8	
Not graded	11	
		103

DECEMBER, 1918, 609 EXAMINATION (FORM 1).

Number examined		1
Qualified	1	
		1

January, 1919.—Summary of board recommendations—23 cases.

Returned to active duty at once			18
Number temporarily grounded (Class B)		5	
Medical for:			
Anemia following hemorrhage	1		
Tachycardia	1		
Injury following crash	1		
			3
Ear for:			
Hypersensitive labyrinth	1		
Accessory sinusitis	1		
			2
Total			23

January, 1919.—Rebreathing tests.

Number examined		16
Rated A	9	
Rated B	4	
Rated C	3	
		16

Report of all examinations made at the Medical Research Laboratory No. 2, Second Aviation Instruction Center, Tours, France, for the months of November and December.

During the months of November and December, 158 officers have been examined at the Medical Research Laboratory No. 2, at the second aviation instruction center, as follows:

No. 609 examination (Form 1)	48
Reexaminations (Form 4)	18
Rebreathing examinations	92

Of the observers from the front, 66 were examined, and of these, 52 underwent detailed examination.

I. Of the No. 609 (Form 1) examinations made, the following were—

Accepted	31
Disqualified	17
	48

The disqualifying conditions were found on—

IV. Endocrine system	1
V. Circulatory system	3
VII. Hernia	1
VIII. Genito-urinary systems	2
XIV. Hearing	1
XV. Nose	6

XVI. Tonsils 2
XX. Equilibrium 2
XXI. Visual acuity 6
XXIV. Accommodation 2
XXV. Convergence 4
Probably remediable 5

II. Of the 18 reexaminations (Form 4) the men were referred to the laboratory for the following reasons:

General examination 5
Influenza 3
Diarrhea 1
Nervousness 2
Cough and sore throat 1
Eye examination 1
Injury to leg 1
Age 1
Grippe, stale 1
Frontal sinusitis 1
Gastritis 1

Total 18

After examination of these 18 cases, the recommendation of the Medical Research Board is as follows:

To duty 5
Grounded 5
To hospital 2
Two weeks' leave 3
Class B nasal operation 1
Temporary rest (advised by ophthalmological department) 1
Not indicated 1

Total 18

Of the 66 observers from the front given the rebreather examination, the grading is as follows:

Department.	A (1).	B (2).	C (3).	D (4).
Psychology	32	21	13	....
Physiology	30	25	10	1
Clinical	50	13	2	1
Ophthalmology	38	27	1	....
Final	21	30	13	2

In considering the preliminary examination of the 92 cases that underwent the rebreather test, the following is noted:

1. The clinical department graded them—

Class A 78
Class B 11
Class C 3
Class B:
(*a*) Neuro-circulatory asthenia 10
(*b*) Diarrhea 1
Class C:
(*a*) Valvular heart lesion 3

2. The ophthalmological department graded them—

Class A	75
Class B	16
Class C	1
Class B:	
(*a*) N. P. C. faulty	5
(*b*) N. P. A. faulty	2
(*c*) Visual acuity faulty	4
(*d*) Exophoria	4
(*e*) Esophoria	1
Class C:	
(*a*) Red-green color blindness	1

3. The nose and throat department graded them:

Class A	70
Class B	17
Class C	2
Not examined	3
Class B:	
(*a*) Chronic frontal sinusitis	1
(*b*) Hypertrophied tonsils	2
(*c*) Cryptic tonsils	2
(*d*) Deviated septum	6
(*e*) Ethmoiditis	1
(*f*) Hypertrophied turbinates	4
(*g*) Post-operative catarrh	1
Class C:	
(*a*) Atrophic rhinitis	1
(*b*) Deviated septum	1

3-A. Equilibrium:

Class A	74
Class B	1
Class C	6
Not examined	11
Class B:	
(*a*) Hypersensitive	1
Class C:	
(*a*) Nystagmus 12–12	1
(*b*) Nystagmus 15–15	1
(*c*) Nystagmus 38–42	1
(*d*) Rt. pp. –0.1. Left pp. 0.0	1
(*e*) Rt. pp. –0.0	1
(*f*) P. P. –½–½	1

The following classification is A for those that have no discoverable defect. B for those who have a temporary or easily remedied defect. C for those who have a permanent defect or one requiring long treatment.

Number of cases receiving A in all departments	50
Number of cases receiving one or more B	33
Number of cases receiving one or more C	9
Total	92

Summary of board recommendations—Second Aviation Instruction Center and Third Aviation Instruction Center—786 cases.

Returned to active duty at once	369	
Grounded (temporarily Class B)	288	
Grounded (permanently Class C)	38	
Leave recommended	73	
Suggest transfer as observer	4	
Referred to hospital	8	
Suggest transfer as mechanic	1	
Not to fly above certain altitudes	3	
		[1] 784
TEMPORARILY GROUNDED (CLASS B).		
For medical	130	
For eye	38	
For ear	33	
For neurological	7	
Department not indicated	20	
Sent to hospital	32	
Tonsil operations	28	
		288
PERMANENTLY GROUNDED (CLASS C).		
For medical	19	
For eye	4	
For ear	8	
For neurological	7	
		38
609 EXAMINATIONS (FORM 1).		
Qualified	125	
Disqualified	47	
Disqualified until operation	40	
		212
REBREATHER EXAMINATIONS.		
Class A	159	
Class B	64	
Class C	32	
Class D	3	
Not graded	12	
		270

E. Record Blanks.

In order that the work instituted in medical aviation should yield its full value, the question of the best form of permanent records was closely studied—not only our own, but those of our allies. On the whole, the British triplicated copy system seemed the simplest and the most satisfactory. Some of the existing forms were revised and new forms were introduced for use in the A. E. F. (See Appendix.) Blank 609, used for recording the results of the examination of the candidates for entrance into the service in the United States, was improved upon, particularly in relation to the medical history of the case and from the standpoint of internal medicine. After these changes, it became the new admission blank, Form 1. The reex-

[1] Two recommendations not given.

amination blank, Form 3, was gradually developed, as experience in the A. E. F. dictated the needs, and it met the needs of the service admirably.

Members of the Medical Research Board sat upon the official accident board of the Third Aviation Instruction Center, and as a result, the accident blank was developed. It has proven very satisfactory, for it covers all the information about the history of the accident, the condition of the plane and of the motor before use, questions relating to training and the prevention of accidents, the cause of the accident, the responsibility involved, and the condition of the flier from a medical standpoint before and after the accident. It facilitates greatly the statistical study of the accident problem. Blanks for use in conference with fliers or observers returning from the front were also devised. This record aids in the correlation of the results of the medical examination with the man's actual experiences. The record blank which shows in chart form the flier's resistance to oxygen want, and his ability to stand altitude, was devised and used in America. It was so excellent that no improvements have suggested themselves. The envelope was supplied to inclose the airman's complete medical history, including admission, examination, reexamination, flight surgeon's report, and altitude classification. These papers accompanied the flier from station to station, or to a hospital, being always lodged with the executive officer and, therefore, always available. A set of these forms with the envelope will be found in the appendix.

F. The Flight Surgeon.

The flight surgeon is the sine qua non in the organization for the care of the flier. Thoroughly grounded in internal medicine, the efficient flight surgeon must possess some knowledge of the general principles of physiology and of psychiatry, and he must be able to make certain important eye and ear examinations. In addition, he must be familiar with the modern methods of hygiene. With a deep and interested devotion to his work, he must be unselfish, approachable, adaptable, gentlemanly, possessing, at the same time, the firmness to give him the requisite authority. Not too old, he must know and appreciate young men and their problems, and it is essential that he should fly. In training centers he must be able to impress the instructors with the fundamental fact that he is there to help not only the student fliers, but the monitors, as well, in all their problems; and in this way to do his part in raising the morale, and in promoting the general efficiency of the field. For the removing of a man from flying, when he is not fit to go up, is not a loss of time—it may save a plane as well as a valuable life.

A flight surgeon (Maj. Hampton) was appointed to the Third Aviation Instruction Center, and several other flight surgeons were detailed for assisting in this work. In addition, a flight surgeon (Maj. Perry) was assigned to duty at the Second Aviation Instruction Center, and another flight surgeon (Maj. Blakesley) was assigned to duty at the Seventh Aviation Instruction Center.

At the Third Aviation Instruction Center, sick call was held twice daily for fliers. Simple ailments were cared for, while those requiring a careful, exhaustive examination were referred to the laboratory. As stated before, the flight surgeon met with the board, and the student was returned to duty, sent to the hospital, or leave was recommended, as circumstances required. But the flight surgeon had power to recommend leave without a laboratory test, when the illness or the passing indisposition was well defined. In every sense, the welfare of the flier was constantly considered. The flight surgeon lived with the students, messed with them, and knew them personally. He was always on hand when his advice or other services were needed. His attention was always centered on matters pertaining to the maintenance of mental and physical health, thus producing efficiency. In the organization of the mess, recreation, reading rooms, gymnasium, sports and games, he cooperated with all interested. With a thorough knowledge of the special medical problems of aviation, and gifted with thorough kindness, common sense, and desire to help, he did much to stimulate the best in the fliers, and to increase the morale of the school. Nothing will illustrate this better than the following letter:

HEADQUARTERS THIRD AVIATION INSTRUCTION CENTER,
A. P. O. 724, AMERICAN EXPEDITIONARY FORCES,
December 26, 1918.

From: Commanding officer.
To: Maj. Robert R. Hampton.
Subject: Commendation.

You have been for some months flight surgeon at this center, a school of approximately 1,000 flying officers. It has been your duty as the sole flight surgeon of the post, and the first flight surgeon in France, not only to attend to the physical well-being of these officers, but also to act as their general adviser in matters of a personal and business nature. As such it is my firm belief that your efforts along these lines have in a great way tended to uplift the morale of the flying officers undergoing training at this center, and to maintain a constant spirit of fellowship, confidence, and devotion. Your labors, even more so because of their unique character, deserve the highest commendation.

HIRAM BINGHAM,
Lieutenant Colonel, Aviation Service.

The following is an extract from a lecture to flight surgeons by Capt. John B. Powers, Medical Corps:

Duties.—He should hold sick call every day. This is for the purpose of keeping in touch with the flier's physical condition and to enable the flight surgeon to become acquainted with affairs which he might not be able to discover in any other way. Personally, I do not believe the flight surgeon should prescribe or treat except for minor ailments when the patient reports for sick call or in quarters. In regard to those who are sick in the hospital, while the flight surgeon should keep in touch with his men, he should not attempt to treat them there, because of possible conflict with the hospital authorities.

The flight surgeon should make a point of seeing each flier every day, either on the field, at mess, or in quarters, because he may recognize conditions to which the flier may pay no attention.

The flight surgeon should keep in intimate touch with the flight commander and with the records of the flying office. He should consider himself as a member of the staff of the flight commander in an advisory capacity, and he must gain the confidence of the flight commander.

The flight surgeon should spend as much time on the flying field as possible, watching for defects in flying, such as bad landings, uncertainties of action, etc., and keep a record of each. For instance, a flier may start to the ground as if he is going to land, but instead he circles around the field. Still he does not come down although one can see that he expected to do so; but instead he goes around the field again without coming down and repeats this three or four times. When he finally does come down, the flight surgeon should get hold of him, because something of importance in regard to his nervous system, etc., that is just beginning to appear, may be discovered by prompt investigation.

The flight surgeon should make repeated examinations of his men to determine their continued fitness for flying. The frequency, of course, of these examinations will depend upon the amount of flying that is being done. These examinations should be not only physical but mental as well. Because it comes on earlier in some than in others, the possibility of so-called "air staleness" should always be borne in mind.

The flight surgeon should make a report in detail on every crash that occurs, stating the exact cause, extent of damage to machine, and whether pilot was injured or not; if injured, the degree and probable recovery, etc. If the accident was due to some mental or physical defect of the pilot, the defect should be corrected at once if possible; but if it is not remediable, grounding him at once should be advised. When in doubt, grounding should be advised while the man is being studied closely. No chance should be taken, for it may mean death to one or more men upon whom the Government has spent a large sum in training.

The flight surgeon should see that his men have plenty of proper and suitable exercise. He should impress upon the fliers the fact that they must regard themselves much in the light of athletes, and that they must bear in mind the rules laid down for the training of athletes—regular hours and habits, temperance in all things, plenty of sleep, good food, comfortable quarters, etc.

Furthermore, the flight surgeon should see that they have recreation of the right kind, for in no case is the old saying truer than in the case of the flier, that "all work and no play makes Jack a dull boy." Besides this, wise recreation will make them happier and better satisfied, and more amenable to discipline.

Upon every flight surgeon I would like to impress the following brief words of advice: Be sure to attend to your work promptly. When you promise to do a thing for a man, do it at once. Keep your own work up, and it will help to keep up all of the work. Show interest in your work. If interest lags, it is your fault, and the sooner you recognize it the better. Let the men know you have their interests at heart, and you will succeed with them.

Be kind, courteous, and considerate to the other medical officers of the post. Do not ask them to do what is your job; do not make a nuisance out of yourself. You have your work to do, and they have theirs. Remember that the post surgeon is a man of importance as well as yourself, and he has the interests of the hospital or infirmary, or both, at heart. He is responsible, and he is jealous rightly of his authority. Keep your work separated from the other medical work on the post or field, and you will lessen chances of friction. I say these things because I know of friction that has occurred, and often because of the fact that the flight surgeon did not bear these things in mind.

Now as a last word: Appreciate your work thoroughly. Value your opportunities highly, for I know of no work where there is more chance to accomplish something worth while than that of a flight surgeon. Where efficient flight surgeons have been placed, good results have been shown by a marked reduction in fatalities. Get busy and do your utmost to reduce them to a minimum—for, after all, your function, in its final analysis, is to keep those mishaps and accidents that are due not to the machine but to the men themselves down to the lowest possible figure.

The hygiene of the flier is considered fully in Section IV of the chapter on physiology.

The value of the flight surgeon has been abundantly proved in the training schools of the United States and in France; but the signing of the armistice prevented the full realization of the hope that flight surgeons would be placed where they would be of the greatest value—at every aerodrome and balloon station at the front.

It can readily be seen that a skillful flight surgeon would have been very valuable at the aerodrome where Guynemer had his headquarters. That marvelous flier had shown increasing nervousness and physical unfitness for some time. In his delightful book, Mr. Driggs says, "A new Guynemer revealed himself to his friends and comrades. He became nervous, sick, and irritable. His comrades, unable to control their captain, telephoned to Paris, informing their old commanding officer, Brocard, that Guynemer was sick and in no condition to fly and imploring him to come back to the aerodrome to take their captain away for a much needed rest. He arrived about half an hour after Guynemer had left on his last flight."

Rickenbacker says: "It is plainly imperative that one keep one's self always fit and clear-minded. It is a matter of life or death to every air fighter—this quick-thinking, unburdened mind." His words in speaking of the fatal accident to Lieut. Kurtz are very illuminating: "I had noticed before starting that Lieut. Kurtz appeared nervous, but did not give the matter any great consideration. The explanation was given by a brother officer, who had come with Lieut. Kurtz to the squadron. Before starting on his last flight, Lieut. Kurtz had confided to him that he was subject to fainting spells when exposed to high altitudes, and the only thing he was afraid of was that he might be seized with such a fit while in the air. Alas, his fear had been only too well founded. But what a pity it was he had not confided to me, his flight commander."

After a flight of over 15,000 feet, Lieut. Kurtz was making a turn over an adjoining field, when his Nieuport dropped into a vrille, crashed, and caught fire. Experience has shown over and over again that a flier will confide in his flight surgeon when he will be silent with his commanding officer.

During the latter part of September and the first part of October the visits to various aerodromes in the zone of advance made very apparent the need there of specially trained medical men. There was usually a medical officer attached to each squadron, and, therefore, at each field there would be three or four altogether. They were, as a rule, a fine body of young men—bright and eager to serve. But their want of knowledge of the special problems of medical aviation lay heavily upon them, and they welcomed the plan of instructions in these problems. They usually lived together, but apart from the fliers. They felt a lack of confidence in their own judgment of a flier's fitness, and therefore were not keen to be thrown with the men. They feared to take a flier from duty, and, conversely, they dreaded to keep him flying when they had a feeling of uncertainty of his real condition. This lack of confidence in their own judgment rather engendered a feeling of uncertainty on the part of the fliers. Altogether, there was not the team work and feeling of mutual confidence that would have existed if the medical men had been thoroughly familiar with the technical and medical problems of flying. There is no other part of the military establishment in which team work adds more to general efficiency than at the flying fields.

If the armistice had not occurred so early the purposed laboratory at Columbey-les-belles would have been the place at the front where the flight surgeons, in case of doubt, could have sent a flier for a very thorough examination.

The chief war functions of the Medical Research Laboratory were to furnish accurate, practical knowledge to the flight surgeon and to all who were concerned in the care of the flier, that the greatest efficiency might be given the service in the maintenance of physical and mental fitness, with a resultant economy of planes and prevention of unnecessary expenditure of valuable young lives. The men who were brought to France for work in the laboratory and as flight surgeons, had already shown their special training, their practical experience in flying, and their enthusiasm engendered by the fascination of the Air Service. In America, a brilliant flight surgeon had given his life to the service, and there was not a man in the group in France who was not willing to do the same.

Personnel for flight surgeons at the front could have been taken from this group that had come to France in response to the cable asking for men who were experienced in aviation medicine. In addition to this selected personnel it was planned to take from the aerodromes the medical men who seemed best suited to this work and those who desired further training and to send them to the School of Aviation Medicine, established in connection with the main laboratory at the Third Aviation Instruction Center. The plan for this school had been made almost immediately upon our arrival in France; for experience had already shown that the special mental and physical problems of the flier would require more than ordinary professional training in the men who were to be the successful medical advisers at the flying schools and at the combat centers. The faculty of the school was composed of the Medical Research Board, the laboratory staff, and representative flight surgeons. The school that had just opened so auspiciously with three medical officers as students, was brought to a close by the cessation of hostilities.

3. INVESTIGATIONS RELATING TO THE FLIER.

A. Study of More Important Medical Problems.

An attempt was made to study all the more important medical problems confronting the pilot in the pursuit of his duties. In order that first-hand knowledge might be acquired members of the board have made flights of various kinds, having gone through all the acrobatics in order to better appreciate the mental as well as the physical effects. These flights included such acrobatics as loops, renversements, virages, vrilles, and altitude work up to 18,490 feet. One of the laboratory staff, Capt. Floyd C. Dockeray, Sanitary Corps, trained as a pilot and has been brevetted a R. M. A.

Throughout the work two things were kept constantly in mind: First, the practical or clinical side, arrived at subjectively through conference with the fliers and their instructors, and through actual flights by members of the board; and, second, the fundamental processes underlying the sensations produced, many of which could be more or less accurately reproduced in the laboratory. Throughout the work, a systematic effort was made to obtain a true grasp of the problem, reproduce it in the laboratory when possible, and to determine the fundamental factors concerned. In this work there was frequent recourse to conferences with instructors, testers, and pilots from the front. As a rule they were found to be particularly intelligent and cooperative. While the work of the board dealt mostly with physical conditions and physical responses, it was evident that the psychological features constituting "grit," played a leading rôle in success or failure. Personality studies were made in a large proportion of the cases. Psychological, as well as physical, fitness is essential. Obviously, a perfect physical specimen might be useless as a flier; and, conversely, sheer "grit" and nerve might compensate for certain physical defects. Some of the tests in use determined, to a certain extent, perseverance and will power. Many of the fliers grounded by the board were classified as temperamentally unfit, while physically they were found to be in good condition.

B. Altitude and the Use of Oxygen.

The effects of altitude and the artificial administration of oxygen received deep consideration. Flights were made with and without oxygen on alternate days. Records were made of the same individual prior, and subsequent, to these flights in relation to steadiness, function of eye muscles, effect on blood pressure, pulse rate, etc., the efficiency of the pilot during the trip having been tested by his ability to use the camera gun. It is regretted that the vital necessities of war precluded more extended work in this field.

C. The Examination of Monitors and Testers of the Third Aviation Instruction Center.

It was deemed desirable to determine the fitness of the men engaged in the instruction of aviators. Consequently, most of the monitors, instructors, and testers of the Third Aviation Instruction Center, reported to the Medical Research Laboratory and were examined and classified physically, psychologically, and from the standpoint of withstanding the effects of altitude. In all, 78 such men were examined, most of whom were found to be unusually fit compared to the student flier. They constituted a striking group even among men as carefully selected as the American fliers were.

D. The Valuation of Tests Utilized in Studying the Flier.

With the signing of the armistice the group from England and some members of the ophthalmo-otological group came to Issoudun, the former group bringing much information concerning the methods employed by the British in their work with the aviator. The completion of the laboratory made available much greater facilities for work, while the return of the flier from the front through the Second and Third Aviation Instruction Centers, afforded opportunity for the investigation of the men who had been successful. This made possible the correlation of laboratory findings with the result of the crucial test of experience. Consequently, the board requested that groups of fliers should be cleared by the research board before returning to America and that pilots returning from the front should bring with them statements from their squadron commanders concerning their ability in actual military operations.

In all, 186 fliers from the American squadrons on the front were examined in this series. Of these, 66 were observers who were examined at the Second Aviation Instruction Center, and 120 were pilots who were examined at the Third Aviation Instruction Center. In addition, 12 French fliers were sent to the Third Aviation Instruction Center by the French Government for special examination. These men were all between the ages of 21 and 35 years, and they had had 220 to 1,163 hours flying in total, and 100 to 500 hours over the lines. They had all been in altitudes of 3,000 to 6,000 meters. With the exception of one who was suffering from sinusitis, they were all acceptable physically and mentally. Two of them experienced discomfort on being turned in the chair and, as a group, they were somewhat more sensitive to motion stimulus, as shown by the rotation chair, than the average American flier. Because of long service, there was a larger percentage of staleness than in returning American fliers. In relation to altitude classification, 7 were graded A, 3 should not fly above 15,000 feet, and 2 above 8,000 feet.

The usual routine in studying the men from the front comprised the following: A conference was held with the flier that covered his training, his work, his experiences at the front, and his specific and general observations; then he was given a medical examination which included the eyes, the ears, the general condition, and the personality. His reaction time was studied, the tactile, visual, and auditory reaction times being taken with the D'Arsonval apparatus. The English tests were applied, and postural changes recorded. He was tested on the rebreather and classified from the standpoint of his ability to withstand the effects of altitude. Finally, he was photographed, when possible, both in profile and in full face. In this way, a complete permanent record was obtained covering his training, his work at the front, the opinion of his commanding officer concerning him and his work, his medical condition, his fitness, mental and physical, the results of the English, American, and French tests, and the greatest altitude at which he could do efficient work.

E. Nausea, Vomiting, and Vertigo as the Result of Flying.

"The hypersensitive-to-motion type of flier." About 10 per cent of all the aviators who applied or were sent to the Medical Research Board, gave a history of being hypersensitive to motion. They complained of having been nauseated, of having vomited, or of having been dizzy in the air to a greater or less degree. Many of these cases were referred to the board by the monitors at the acrobatic fields. This group of men was subjected to special study. Many of them gave a previous history of having been sensitive to swings, merry-go-rounds, or riding in cars, and unusually so to motion at sea. Many of them showed hypersensitiveness to motion as indicated by prolonged nystagmus or vertigo, marked falling and past-pointing in the chair. A few of those who were most hypersensitive in their air work showed no corresponding indications in their labyrinthine examinations. It also became apparent that a certain type had been able to overcome this sensitiveness and were "lachéd" from the acrobatic fields. Certain pilots, for whom grounding was considered at first, had subsequently left this post finished and efficient fliers. In combat, in which relativity of position plays a great rôle, evidences of hypersensitiveness reappeared in some fliers. The board was impressed with the fact that hypersensitiveness to motion could be overcome through practice in some cases. One of America's foremost aces is credited with having been a vomiting type while under training in the early days of the Third Aviation Instruction Center. Vomiting seems to be less serious than vertigo in this connection.

F. Accidents.

The statistical and analytical studies that have been made of the accidents in the Air Services are so important that a separate chapter has been devoted to their consideration.

G. Conferences with American Combat Pilots.

The excellent report by Maj. Patten and Maj. Hyde upon their conferences with American fliers from the front is given in a condensed form. The full report covers the question of age, previous education, sports, training, present rank, organization, sector of operations, effects of altitude and cold, requirements for a successful combat pilot, use of goggles, balance mechanism, opinions regarding exercise, tobacco, alcohol, attitude toward the work, causes of accidents, staleness, etc.

Herewith you will find tabulated report and conclusions, the result of the examination of 100 aviators of the United States Army. These officers have had considerable experience as chasse pilots, and it is believed they are representative of their branch of the Service. Throughout these conferences, we have followed a line of questions submitted to us for that purpose, and have presumed to add to that certain conclusions at which we have arrived. It has been our endeavor not to make these questions leading, and it is believed their answers reflect as nearly as possible the opinions of the different pilots on the subjects considered.

From these conferences, it is concluded that the combat aviator should be young. The majority of the evidence indicates that the age should be from 18 to 25 years. It is of advantage to select the cadet in his adolescent or developmental period, before the habits of life are too firmly fixed, before his nervous system and physical energy are impaired by the strenuous demands of present-day life. At this age he learns more quickly, and what he acquires he reacts to in a natural manner that is almost instinctive, all of which is most essential to the combat aviator. With youth we have confidence and aggressiveness. It is the time of action, not the age of conservatism and deliberation. It is only fair to mention, however, that the oldest officer interviewed by us was 35 years and 3 months of age, that he had been 40 hours over the lines, had five combats, and was credited with two enemy planes.

Of all the physical attributes, vision is most important, both for offensive and defensive chasse work. The consensus of opinion of the officers interviewed was that the eyes should be absolutely perfect in every particular to successfully do the work and to withstand the strain to which they are subjected.

Here it is necessary to state that there is a difference between good eyesight and being able to see well. It was brought out in the conference that every pilot must learn to see in the air, that his ability to pick up objects improves with practice, which is an intuitive interpretation of what one sees. This is called "air sight," and the longer he flies over the lines the better it becomes. Some pilots, however, are unable to develop this power and are obliged to give up or be shot down. This, perhaps, is mental and not visual. Many instances have been cited in which a new pilot has been shot at, or shot down, without seeing the enemy. The above emphasizes the necessity of a long period of training over the lines for our pilots before they go into actual combat, as it is a noteworthy fact that most of our pilots who were killed, lost their lives in the first few patrols over the lines. If they successfully return from the first few "shows," they are thereafter comparatively safe.

Most officers were of the opinion that color vision was of little importance to a chasse pilot, but when more closely questioned it was brought out that it was of importance in following the topography of the country, etc.

Regarding the interpretation of "how men fly," the composite conclusion is that flying is balance, and balance is a correlation of sensation complex received, subconsciously interpreted, and automatically executed in coordinate muscular movements, maintaining orientation in space—the eyes for lining up the ship with the horizon; the ears for the sound of the motor and sing of the wires; the skin for the feel of the force and direction of the air; the deep muscular and joint sensations for interpreting the feel of the "joy stick," the warp of the rudder and gravity and centrifugal force sensation; and the vestibular apparatus for sensing the direction of motion.

Absolutely normal hearing is not necessary to the flier, for flying; but when questioned closely, all admitted it would be better to be normal for the following reasons: The early detection of motor trouble would aid the flier in seeking a favorable landing place or restrain him from going into combat with a defective engine, thus perhaps saving pilot and machine from useless destruction; the hum of the wires are of some use in determining flying speed and posture of the ship; and the first intelligence of the approaching enemy has often been through the hearing of their machine gunfire, especially so if the pilot's observation has been at fault.

Ten per cent of our returned pilots stated that they disliked the work or believed they were unfitted for it. It is regretted that these officers ever represented the United States over the lines and it will always be a question what proportion of the lost pilots belonged to this class. It is quite possible that a large percentage of the cadets killed in training (with a diagnosis of "bad flying judgment"), belonged to this type. It is believed that a considerable number of these cadets could have been eliminated from the Service entirely, or transferred to some other branch early in their aviation career if they had had the benefit of the observation of a medical man especially trained in the problems of aviation. This special medical care and attention could with benefit have been extended to the Front.

H. Conferences with Observers From the Front.

Capt. Cary's interesting report upon the conference study of a group of observers who returned from the Front through the Second Aviation Instruction Center is given in brief.

A conference was held with 89 observers returning from active duty on the Front. These men were questioned as to their training, experiences at the Front and what they considered to be the prerequisites of the successful observer. Their answers were usually of from three to five in number. These answers were collected and it was found that the 89 men gave 59 different answers.

It will be noted in studying the following list of answers that some were repeated several times. (Only those answers are classified that contain the opinion of five or more observers.)

Group 1.—Prerequisites.

Answers.	Number of times repeated.
Be cool and be able to use his head	33
Be physically fit at all times	25
Be possessed of very good eyesight	21
Be able to reach decisions quickly, be alert and mentally quick	21
Be possessed of plenty of nerve	18
Be able to use common sense	8
Be possessed of a keen sense of observation	8
Be free from imagination; honest	7
Be ingenious and resourceful	6
Be well educated	6
Have a good spirit	5
Have a good sense of direction	5
Be able to use machine gun well	22
Get the best training and know his job	10
Should develop ability to keep a mental picture of their sector in mind	10
Must learn to put his heart in his work	9
Should learn what to look for and see accurately	9
Should have good training ground faces (know their business)	9
Have confidence in the plane and pilot	6
Keep in good condition	5
Should learn to read maps and find landmarks	5

As the good observer is unquestionably above the average type of man, it was thought that some light would be shed on the subject if his previous occupation were investigated. With this in mind, 64 officers who had been observers were questioned and their occupation before entering the Army noted. These various occupations were tabulated and the men in each group were classed: Good, fair, or poor, according to their ability as an observer. (This list is given, although it is too small to allow any conclusion to be drawn from it.)

The classification of occupations.

Occupation.	Number.	Good.	Fair.	Poor.
Farmer	2	2	0	0
Engineer	10	7	2	1
Salesman	4	1	3	0
Lawyer	7	3	3	1
Newspaper man	3	1	2	0
Manufacturing	4	1	2	1
Students	14	5	5	4
Miscellaneous (clerk, mine promoter, insurance investigator)	7	3	1	3
Auto business	2	1	0	1
Architect	3	1	0	2
Banker or broker	[1] 3	....	0	2
Teacher	4	0	2	2
Total	63	26	20	17

[1] One broker.

These men were also questioned as regards the influence of age on the observer, and the consensus of opinion was that the observer should be older than the pilot, but that he should not be too old, as the older men were more apt to be nervous than the younger ones. The majority believed that the ages should range between 22 and 30 years, although some favored 25 and 30 years, while others placed the lower limit at 20 years.

The attitude toward the work is an important matter, for (as will be remembered) one of the prerequisites of an observer is that he must have his heart in his work. Several have expressed their belief that the Air Service should be voluntary, and that a man should never be drafted into it. This is substantiated by the fact that all the observers who were drafted into the work from other branches of the service against their wishes, did an inferior type of work. Of 89 observers questioned, 12 preferred other work; of these 3 were A, or good men, and in each instance, their desire was to become a pilot, consequently their work was good. But of the other 9 there was not an A man, and with one exception, they were all C, or poor observers. The above must speak for itself.

With very few exceptions, all observers stated that vision was of primary importance and most essential to the success of a mission; for, as one of them put it, "if you can't see what you are expected to, your mission is of no use," and "if you don't see clearly, your information is of little value." They state that a man may have lenses ground into his goggles, but that often the goggles are either broken or blown off in the air.

The ears (and by ears is meant in this connection the whole pneumatic mechanism including the eustachian tubes) are of importance and means should be furnished for their proper care; for, as one observer said, "50 per cent of the observers and pilots in the Ninetieth Aero Squadron had trouble with their ears." This is more or less constant among squadrons that live in surroundings which predispose to head colds. The observer suggested that it would be of great benefit if each squadron medical officer were equipped with the proper instruments and ability to cope in a simple way with these conditions.

With very few exceptions all the men agreed that they were none of them in good physical condition, and that secretly they would have welcomed some type of competitive exercise. This was more important on the days they did not fly as on flying days the work of maneuvering the machine-gun in combat and of straining against the propeller wash was quite enough exercise for the average. These men all said they would have been in better condition had they been able to do systematic exercise, but were nearly unanimous that they did not want drilling.

The observers agree that staleness is a mental and physical depression brought about by the monotony of constantly being kept on the aerodrome with long hours in the air. It is characterized by loss of appetite, general debility, and dread of the morrow. With this goes jumpiness and loss of ambition. One observer stated that it was very contagious, and another, that it depended a good deal on the attitude of the Commanding Officer. This staleness was evident in some of the men that have come back from the Front as is evidenced in a resumé of the following histories:

No. 70.—A bombing observer, who was trained in France and who has been on the Front since April 17, 1918. He was 24 years old and had (previous to entrance into the Army) been a student. He "crashed" the first night of the St. Mihiel drive, and then was run into by another plane in landing. He had had several narrow escapes but was never actually wounded although he only came out of a "vrille" just off the ground with a full load of bombs. He is a good type and has been classed A in conference. He is now, however, nervous and high strung and does not sleep well. He finds it very difficult to occupy himself and worries a good deal about getting home. It is difficult to suggest a remedy which will meet his situation. His objective symptoms are nervousness, tremulous tongue and fingers, and very active tendon and superficial skin reflexes. His direct and consensual light reflexes are active. He has been advised to live temperately.

The next history is No. 73, an aerial observer who was classed C in conference, and doesn't care for air work although he was on the active Front for nearly three months. He got a position on the ground in liaison work with the Infantry. He is 21 years and 7 months old and previous to entrance into the Army was a student preparatory to being a mining engineer. He is decidedly temperamental, and a bit too much dependent upon his environment for the real pleasures of living. He looks tired, his hands and tongue are a trifle tremulous, his knee jerks, and consensual light reflexes are very active. He does not enjoy his work particularly and is anxious to get into another branch of the service.

The first history typifies the man who has made good and who has gone "stale" through conscientious effort, while the second history is typical of the man who was not cut out to be an observer and who had become hypersensitive nervously, due probably to not being able to live up to his job.

Chapter III.

DEPARTMENT OF PHYSIOLOGY.

Maj. E. C. Schneider, Sanitary Corps.

Section I.

THE EFFECTS OF HIGH ALTITUDE UPON AVIATORS AND THE ALTITUDE CLASSIFICATION EXAMINATION.

It is a well-established fact that high altitudes exert a profound influence on the human body. As long ago as 1590 d'Acosta described symptoms of high altitude sickness. The more exact scientific investigations of the conditions pertaining to life at high altitudes began about 75 years ago. These investigations at first had a purely scientific aspect in which the physiological effects of altitude on man and other animals, were considered. With the coming into prominence of aviation a knowledge of the effects of altitude assumed practical importance.

As soon as an attempt is made to interpret the physiologic phenomena of altitude in terms of their causes difficulties arise. Contradictory theories have been published. The reason is to be found in the complexity of the factors which enter into the environment at high altitudes. Among the climatic variables are the low atmospheric pressure, with its low partial pressure of oxygen, the sunshine, low temperature and humidity, the high winds, and the electrical conditions of the atmosphere. It has been found difficult to study these factors one at a time, but with the use of the pneumatic cabinet it is possible to eliminate all factors except the lowered barometric pressure, and also to study the added influence of other altitude factors. The consensus of opinion held to-day is that the physiologic effects noted at high altitudes are due to the lack of oxygen resulting from the lowered partial pressure of oxygen.

It is suggested that as one listens to the expression of opinions among aviators and "ground" officers who mingle with the fliers, one might consider the subject of altitude influence exhausted. However, a patient listener soon discovers such diversity of opinion that he becomes convinced that opinions are not backed up by experience and keen observation. There is a need for experimental study of the effects of altitude upon aviators, and a need for a popular educational campaign of instruction regarding facts as distinguished from opinion. The necessity of attention to the technical and other duties of a flight may, in itself, suffice to divert the aviators' notice from physical symptoms, unless they become very unpleasant; and further, it is well known that one of the most important effects of oxygen starvation is a dulling of the intellect and an unwarranted sense of well being and security.

As the war progressed the altitudes to which aviators were forced to go became greater and greater. At the close, altitudes were commonly reached on the front which were, before the war began, impossible to attain because of the inadequacy of the airplane and its motor. But it should be here emphasized that flying at or above 18,000 feet is the exception rather than the rule.

Unfortunately toward the close of the fighting period the shortage of airplanes and the urgency of the campaign did not permit men on active service to do "graduated flying." An aviator physically incapable of withstanding very high altitudes was expected to do his full share of work, no matter what the altitude. This, then, definitely raises the question: Are there dangerous altitude effects?

The majority of American aviators have had only one or perhaps several high altitude flights. Most of the training was secured at altitudes under 5,000 feet, while only one altitude flight was required during instruction, and in that, immediately the maximum altitude was attained, the ship was nosed downward. Among 150 pilots who were questioned on returning from service at the front the vast majority had made only one so-called altitude flight. The maximum altitude was 22,000 feet and an average maximum of 19,465 feet was recorded.

One hundred of the aviators who had been on active service at the Front when questioned regarding discomforts of altitude replied as follows: 32 per cent declared they had never suffered any inconvenience, 18 per cent that they suffered from shortness of breath alone, 10 per cent from cold and shortness of breath, 2 per cent from headache and shortness of breath, 6 per cent from headache, and 12 per cent from feelings of physical exhaustion and mental depression. Attention is called to the fact that this is a very good showing for the fact that there is an altitude influence. The scout pilot (these men belonged to that class) enjoys comparative immunity from general high altitude effects in that he does not maintain great altitudes for long. The actual fighting, with very few exceptions, takes place at 15,000 feet or very much lower.

ALTITUDE SYMPTOMS.

Noticeable While in the Air.

The symptoms experienced during flying at high altitudes may be observed on men when placed under the influence of reduced atmospheric pressure in the pneumatic or low pressure chamber. Low-pressure chamber observations made on a large number of men, show a remarkable variation among individuals in their capacity to withstand lack of oxygen, and also that the disturbances caused by oxygen want, vary in character in different individuals. No symptom, or group of symptoms, is universal.

Even an experienced clinician or physiologist will fail to feel altitude effects under 10,000 feet, but at 12,000 feet they are often evident. However, many aviators have tolerated 18,000 feet so well that they have been unconscious of the adaptive changes that have occurred in their bodies.

From an altitude of 12,000 feet and up, the following symptoms may occur:

(*a*) *Shortness of breath* (*dyspnoea*).—This is extremely common but varies in degree. Very few aviators breathe through the nose above 12,000 feet. Breathlessness is usually noticed at 15,000 feet and is exaggerated by muscular exertion and by cold.

(*b*) *Periodic breathing is occasionally reported.*—Birley personally experienced Cheyne-Stokes breathing at 20,000 feet, which was relieved by breathing oxygen. One case is on record in which the periodic breathing came on at 18,000 feet in so violent a manner as to prevent the pilot from keeping his controls steady and, continuing as he descended, made it very difficult for him to land.

(*c*) *Sleepiness.*—The flier gradually becomes dull and sleepy, he has no distress, and so insensibly becomes inefficient that he does not realize his condition. The same experience occurs in the low pressure chamber in which individuals who have gone to sleep revive when given oxygen, and declare it their opinion that they have been efficient or at least awake.

It is probable that aviators who claim to feel perfectly fit at high altitudes may in reality have been quite inefficient and sleepy. Sleepiness is a common symptom that is often not recognized by the airman.

(*d*) *Impairment of intellect and judgment.*—This also is a condition usually overlooked by the airman and with it there is often an unwarranted sense of security and well being. Birley reports an interesting case of this. A pilot met an enemy patrol at 18,000 feet. "He did not realize his danger, but waved his hand to them in spite of the protests of his observer."

Birley continues: "Observers on high photographic reconnaissances frequently get muddled and fog their plates. They are often unaware of their mistakes and indignantly attribute the bad results to some fault of the camera."

(*e*) *Impairment of vision and hearing.*—This also is a result that comes on gradually and insensibly. Schroeder in his altitude flight to 28,900 feet recorded this experience as follows: "When I reached

25,000 feet I could hardly hear my motor run and I felt hungry." He then took oxygen and kept on until it gave out, when he experienced impairment of judgment. "But the lack of oxygen was affecting me, I was beginning to get cross, and I could not understand why I was only 29,000 feet after climbing for so long a time. I remember that the horizon seemed to be very much out of place, but I felt that I was flying correctly and that I was right and the horizon was wrong."

(*f*) *Muscular weakness.*—This is noticed chiefly by observers who find it hard to manipulate a camera when above 15,000 feet. Muscular paralysis has been experienced at extremely high altitudes.

(*g*) *Headache.*—This is usually frontal and often sudden in onset. McCudden in his book "Five Years in the Royal Flying Corps" says of his first high flight, "at last I got up to 11,000 feet, the highest I had yet been, and I got quite a headache over it, for I was not used to high flying in those days." At another time after going as high as 18,500 feet he said: "I landed at Dover after having been up nearly two hours and was kept company by a splitting headache for the rest of the day."

Headache is frequently an after effect of low oxygen, and it may persist for some hours.

(*h*) *Fainting.*—Some cases of sleeping may be confused with this. We have met several fliers of long air experience who believe that if an individual makes frequent flights at high altitudes he will sooner or later have the experience of fainting while in the air. Some feel faint and dizzy, but do not faint.

Altitude Symptoms Noticed after Landing.

Definite after effects are observed in all men who have been exposed to a marked oxygen want for any length of time.

(*a*) *Fatigue.*—This is quite noticeable after all kinds of low-oxygen experiences. We find it common in individuals who have been in the low-pressure chamber for an hour or more at pressures corresponding to altitudes of 16,000 to 20,000 feet. All flying is fatiguing, but the condition is much more pronounced after a flight above 15,000 feet.

(*b*) Respiration often becomes subnormal both in rate and depth and may show periodicity.

(*c*) Some believe they find evidence of circulatory fatigue in lowered blood pressures and connect the fatigue with this.

(*d*) The persistent headache has already been referred to.

The war experience, especially that of our allies, has shown that much high flying without oxygen gradually undermines an individual's ability to tolerate altitudes. He therefore, progressively finds his "ceiling" getting lower. Men undergoing such an experience should be relieved from altitude work for a time, or a lasting effect may result which incapacitates for all flying.

ADAPTIVE RESPONSE TO ALTITUDE.

The human body is sensitive to the reduction in the available oxygen at high altitudes. While it may lose in efficiency as the altitude increases during an ascent, it nevertheless does have the power to adjust itself to the decrease in the oxygen supply of high altitudes. The ability to endure altitudes without loss in efficiency is dependent upon the ease and the quickness with which the adaptive adjustments are made. There are marked individual differences in this respect. Some men adjust so quickly and readily that they are not disturbed by heights which will render the average person quite inefficient. A few men fail entirely to respond to the altitude and become inefficient at relatively low altitudes.

The adaptive changes that occur in the body as the aviator ascends are for the purpose of providing an adequate supply of oxygen to the nervous system, heart, muscles, and other parts. (1) The breathing gradually, and usually unconsciously, becomes deeper, thus increasing the amount of air passing into the lungs each minute. (2) The heart begins to beat more rapidly, which causes more blood with its load of oxygen to pass to the organs each minute. (3) In some fliers, the red corpuscles and percentage of hemoglobin increase in the blood. This permits a unit volume of blood to carry more oxygen than normally. The more perfect these three reactions, the better will the man withstand altitude and the higher will he ascend with comfort and safety.

For each aviator there is an altitude beyond which he can not go without compelling his nervous system and muscles to work at great disadvantage because of insufficient oxygen. It will be then, that impairmant of vision, hearing, intellect, judgment, and difficulty in concentrating the attention will be experienced. If he is flying with a squadron in a formation he will begin to lag behind and by so much reduce the general level of efficiency of his group.

Flying at altitudes higher than those to which the body easily adapts itself entails a serious strain, probably on the central nervous system, which will eventually hasten the onset of flying staleness. Flying fatigue is by no means thoroughly understood, but unless proper care is taken it is accumulative and soon spells staleness. The effects are more marked in some individuals than in others.

Our altitude classification examination was developed for the purpose of determining the aviator's power to respond to the influence of altitude and to classify him as fitted for particular levels of flying.

Several respiratory tests have been developed for the purpose of determining the ability to react to the diminished oxygen of high altitudes. Best known are the rebreathing method, Flack's bag method, Dreyer's nitrogen dilution method, and Bazett's extra reserve factor. The value of the low pressure or pneumatic chamber for this purpose has been recognized for some time. Certain other

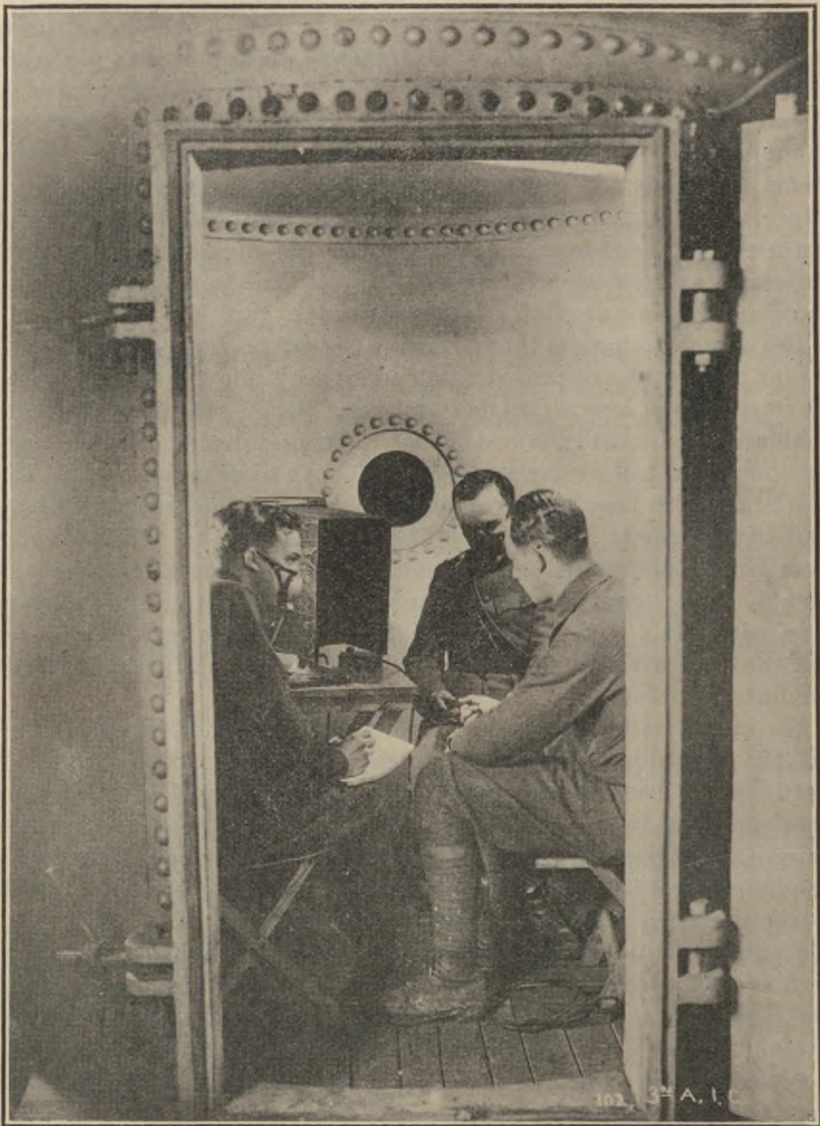

FIG. I.—Low pressure tank, Medical Research Laboratory, at the Third A. I. C., A. E. F.

"short-cut" methods have been suggested and will be discussed, along with Bazett's extra reserve factor, at another place in this chapter. Corbett and Bazett tried out, but did not find practicable, a method of breathing through a long tube to increase the dead space.

We have given each method, except the last mentioned, a trial and have come to a definite opinion as to the value of each. The Flack bag method subjects the candidate to oxygen want for too short a period of time and does not permit of observation on the sequence of the adaptive responses. The Dreyer method proved to be very satisfactory, but the apparatus was a constant source of annoyance, requiring frequent recalibration and checking up of the oxygen-nitrogen mixture. We have found commercial nitrogen to vary so much in composition that each tank used required chemical analyses for oxygen. This necessitated laborious calculations for corrections that were necessary for proper interpretation of data.

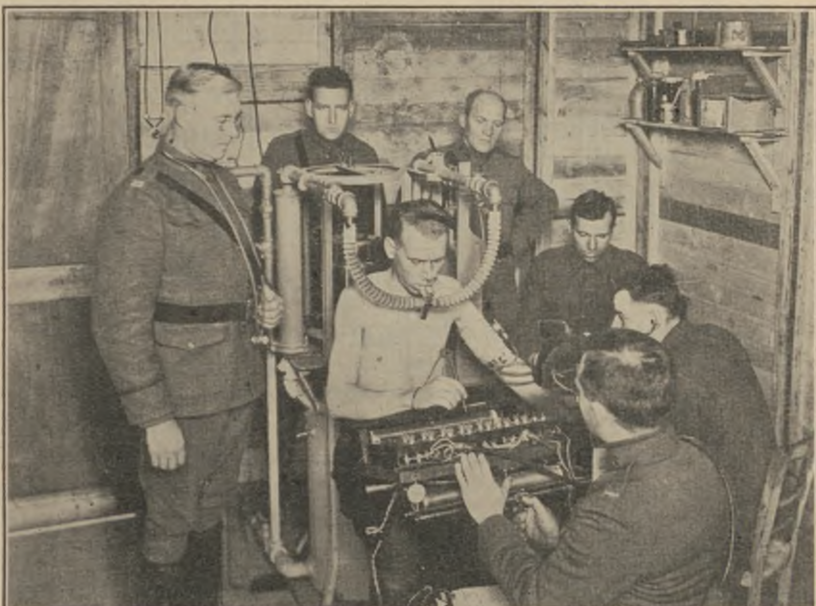

FIG. II.—Rebreathing test of aviators at the Second A. I. C., A. E. F.

The low chamber method permits of exactness of control and elimination of complicating factors. It is an expensive method that lends itself well to exact scientific study but not to routine observation.

The rebreathing method is not ideal but gives conditions of work that are easily controlled and modified. The Henderson rebreathing apparatus is sturdy, control and adjusting devices are simple, and repairs are easily made.

THE REBREATHING APPARATUS.

The rebreathing apparatus employed in all our routine tests of the aviator's ability to withstand low oxygen, is known as the Henderson-Pierce rebreathing machine. It consists of a tank T (Figure III) of about 80 liters capacity. The volume of air used is determined by the amount of water run into it. The man under examination continually rebreathes the air of the tank through the inspiratory and

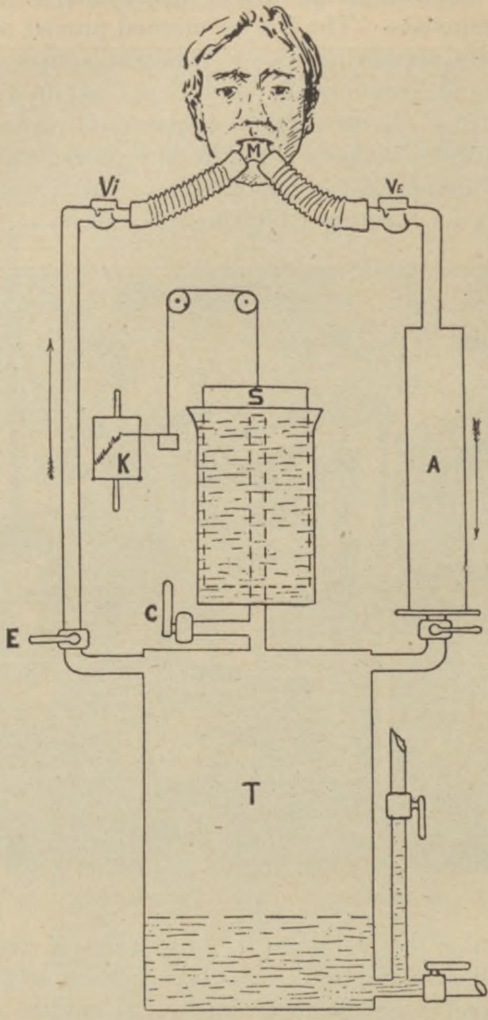

FIG. III.—The rebreathing apparatus employed in all routine tests of the aviator's ability to withstand low oxygen. It consists of a tank, *T*, of about 120 liters capacity. The volume of air is determined by the amount of water that is run into it. The man under examination continually rebreaths the air of the tank (a clip is placed on his nose) through the inspiratory and expiratory valves, *Vi* and *Ve*. The oxygen is thus consumed and reduced. The exhaled carbon dioxid is taken up by sodium hydroxid in the absorber, *A*. The movements of respiration are recorded by the spirometer, *S*, connected to a smoked drum, *K*. As the oxygen is consumed and the air volume is thus reduced, the spirometer falls and the graphic record on the smoked drum rises. At the end of the test a sample of air is drawn from the tank and analyzed as a confirmation of the oxygen consumption and of the oxygen percentages (that is, altitudes) indicated by the graphic record.

expiratory valves, Vi and Ve. The exhaled carbon dioxide is taken up in the absorber A by solid caustic soda cast in thin shells so as to expose a large surface to the action of the air. In order to maintain the contained air at approximately atmospheric pressure and to allow for changes in volume, a wet spirometer, S, carefully counterbalanced is mounted on the tank and communicates freely with its interior through a vertical pipe. A stylus attached to the counterweight records the movements of the spirometer, which are those of respiration, upon a smoked drum K. At the end of the test a sample of air is drawn from the tank and analyzed to determine the oxygen percentage reached, which can be translated roughly into terms of altitude.

Because of a shortage of water at the Third Aviation Instruction Center in France the rebreathing machine was slightly modified. In order to renew the air in the apparatus an electric fan, obtained from a vacuum cleaner outfit, was attached by a T tube to the expiratory pipe, Ve, and was used to aspirate the air from the machine. A perfect renewal with fresh air could be obtained in two or three minutes. Water, to supply the volume lost by the absorption of oxygen during rebreathing, was run into the tank when needed, from a reservoir suspended from the ceiling and connected to the tank by rubber hose. At the close of each test the surplus water was again drained into the reservoir.

THE CLASSIFICATION EXAMINATION.

The rebreathing machine was so adjusted that the average test was between 25 and 30 minutes in duration. During the test physiological and psychological observations were made and the condition of the aviator closely watched by a clinician. By the physiologist the rate and per minute volume of respiration, pulse frequency, and systolic and diastolic pressures were observed for each subject. These data gave valuable evidence as to when the subject first responded to the reduction in oxygen, and as to the efficacy of his adaptive responses.

The psychological tests determined the effects on attention and motor coordination, and showed how well the subject preserved his efficiency under low oxygen.

The methods and the interpretations of the data of the rebreathing test are given in detail in the Manual of the Medical Research Laboratory. Experience in the States showed clearly that some men are so sensitive to oxygen want and compensate so well in their breathing and the circulation of the blood that they endure to as low as 6 per cent of oxygen. On the other hand others fail to compensate in one or both of these functions or compensate inadequately, and therefore do not endure so low an oxygen. All gradations between failure to compensate and adequate compensations down to 6 per cent of oxygen were found among aviators examined under the low oxygen of the rebreathing test. From the data obtained during the rebreathing test it becomes possible to determine approximately the maximum altitude to which an aviator may safely ascend.

In order that our study of A. E. F. cases may be more clearly followed, a statement of our early experiences with the rebreathing test is given.

THE BREATHING WHEN UNDER PROGRESSIVE DECREASE OF OXYGEN.

The rate of breathing often remains constant throughout the rebreathing test. The majority, however, show an increase of from two to four breaths per minute at between 8 and 6 per cent of oxygen. Poor types may show a decided increase in frequency.

An increase in the per minute volume of breathing occurs in all who respond well to decreased oxygen. At percentages of oxygen between 8 and 6 an increase of 5.5 liters and more may be expected in an excellent response. A respiratory volume response of 1.5 liters gives an insufficient lung ventilation for comfortable toleration of such low oxygen as 8 per cent.

It is the depth of breathing that ordinarily is increased by low oxygen. This increase in the tidal air may amount to from 20 to 128 per cent when the subject is under from 8.5 to 6 per cent of oxygen.

A good respiratory reaction to the gradual decrease in the oxygen of a rebreathing test is manifest in a slight increase in the depth of breathing which begins at 16 or 15 per cent of oxygen and continues progressively to increase until 12.5 or 9 per cent of oxygen is reached. From these percentages down to 8.5 and 6 per cent of oxygen, the total volume of breathing per minute increases much more rapidly; and the frequency may also increase from two to five breaths per minute. A total per minute increase in lung ventilation of at least 5.5 liters should occur at the lower percentages of oxygen.

THE HEART RATE UNDER DECREASING OXYGEN SUPPLY.

At high altitudes, or under low oxygen, the blood may be less saturated with oxygen than at low altitudes. If, therefore, when the blood contains less oxygen the rate of blood flow through the capillaries is increased, this would be a means of providing the tissues with the oxygen demanded for their activity. Such an increase in the flow of the blood stream can be obtained by increasing the per minute output of blood by the heart. This the heart ordinarily does by increasing the number of beats per minute.

In the rebreathing test there usually occurs an increase in the frequency of the heart beat. This is at first slight, but as the oxygen percentage decreases a greater increase in rate is likely to occur with each further decrement in oxygen. A very marked acceleration usually occurs when the oxygen has fallen to between 13 and 9 per cent. A total increase of from 15 to 40 and more beats in the heart rate, during a rebreathing test in which the oxygen is lowered in half an hour to between 7.5 and 6.5 per cent, constitutes a good reaction to oxygen want. A failure to respond by an acceleration of the heart rate to lowered oxygen means either inability to react to the low oxygen of high altitudes and early failure or that sufficient compensation is secured by the breathing and blood responses. Our experience indicates that failure to respond by an increase in heart rate is usually associated with poor toleration of low oxygen.

THE ARTERIAL PRESSURES UNDER DECREASING OXYGEN.

In the optimum type of response the systolic pressure remains unchanged until the oxygen has been lowered to between 14 and 9 per cent, after which, as the oxygen is further lowered, it gradually rises, ordinarily not more than 30 mm. Hg.

The best condition in the response of the diastolic pressure to a decreasing oxygen supply consists in an unchanged or slightly increased pressure throughout the test. Many men show a gradual, well controlled fall in the diastolic pressure during the terminal period when the systolic pressure is rising. A pronounced and rapid fall often occurs and is evidence of oncoming failure.

Three types of circulatory reactions to a gradually increasing oxygen want have been observed. The first, the optimum, in which the pulse rate accelerates, the systolic pressure remains unchanged or shows a terminal rise, and the diastolic pressure remains unchanged or rises slightly. The second, the controlled diastolic fall, in which the pulse rate accelerates and the systolic pressure rises as the diastolic pressure gradually falls. The third, the syncope or fainting type, in which after a period of poor, fair or excellent response to moderate decrease in oxygen, the diastolic pressure suddenly begins to show a marked and rapid fall, and soon thereafter the systolic pressure may also fall and the pulse rate slow.

Having a knowledge of what constitutes an excellent, fair or poor response to low oxygen, it becomes possible to classify men according to their physiologic responses.

In the A. E. F. the men were divided into Classes I, II, and III. The subject was rated I if his compensations in breathing and circulation were good and progressive to between 8 and 6 per cent of oxygen. He was rated II if the compensatory mechanisms showed decided insufficiency or failure between 10 and 8 per cent, and III if the failure occurred above 10 per cent of oxygen.

No limitations were suggested as to altitudes to which men of Class I should fly. It was deemed best to make the maximum flying altitude for Class II 15,000 feet and to confine the work for Class III to low altitudes, not above 8,000 or 10,000 feet. A few who for one reason or another might not fly at all were placed in Class IV.

THE A. E. F. EXAMINATIONS.

The number of altitude classification examinations made in the A. E. F. was small, because at first we were compelled to work in a cold room. The subject of necessity had to sit with the shirt open so that the clinician could use the stethoscope to listen to the heart, and the arm had to be bare for blood-pressure determination. We felt such exposure to cold was unfair to the men and so only made an occasional test until we had moved into the laboratory.

A total of 290 men were given the rebreathing examination; among these, pilots from the front, 90; observers from the front, 92; monitors, 52; French aviators, 12; and officers referred by instructor and flight surgeon, 44.

An analysis has been made of the results of 290 cases in which the ratings of the physiologist and psychologist have been compared with the final rating. The results are given in the table below:

TABLE I.

Class.	Physiological.		Psychological.		Final.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
I	153	52.8	153	52.8	125	43.1
II	92	31.7	79	27.2	100	34.5
III	33	11.4	52	17.9	56	19.3
IV	3	1.0	0	0.0	5	1.7
Not rated	9	3.1	6	2.1	4	1.4

The final ratings are in about the same percentages as were those of an analysis of 374 examinations made at the Mineola Laboratory. In that group there were the following percentages: Class I, 40.5; Class II, 34.6; Class III, 20.3; and Class IV, 4.8.

In Table I the "not rated" group contained two men who refused to continue when about halfway through the test, and for two more men the test was unfair because the carbon-dioxide absorber was not working properly. There were five men not rated by the physiologist because at the time they were found inefficient by the psychologist the physiologic responses were still doing well. The psychologist likewise withheld several ratings because the subject was removed for physiologic reasons, such as oncoming syncope.

Five of the cases were rated IV and disqualified for flying by the clinician for heart abnormalities.

The physiological and psychological ratings were not in as complete agreement as the data in Table I indicates. They agreed that 126 were Class I, 45 Class II, and 24 Class III. The final rating was always that of the lowest rating given by any one of the three departments, clinical, physiological, and psychological.

. A detailed physiologic study of the types of reaction to low oxygen encountered among these 290 men, would be out of place here. An analysis of the records of the men from the Front supplied the details here given.

Respiration responses.	Class I.	Class II.
	Liters.	*Liters.*
Average increase in per minute volume	4.8	3.4
Largest increase in volume	19.8	8.9
Least increase in volume	.5	.1
Average volume per minute at the end	15.5	12.3
Greatest volume per minute at the end	27.8	19.0
Least volume per minute at the end	8.4	6.6
Average volume per breath at the end	1.1	.8
Greatest volume per breath at the end	2.4	1.4
Least volume per breath at the end	.5	.4

The striking feature is that the tidal air—that is, volume of a single breath—in the men who reacted well was decidedly increased, from an average of 480 c. c. to 1,100 c. c. in men in Class I. Shallow breathing does not ventilate the lungs well because of the dead space. With deeper breathing a greater proportion of fresh air reaches the alveoli of the lungs and therefore a larger supply of oxygen reaches the blood.

Only about 26 per cent of the cases showed an increase in the rate of breathing, while about 50 per cent breathed less frequently. Those who did not change the rate or decreased it obtained the larger tidal volume.

The observations that aviators who have experienced dyspnoea at high altitudes have been able to overcome it by educating themselves to breath more deeply and slowly, is explained by our data. The habit of slow and deep breathing constitutes a valuable asset for high altitude flying.

There were no cases of very shallow breathers among our subjects. The greatest frequency of breathing observed was 24 breaths per minute. This man's compensation to low oxygen was made by a decrease in rate and an increase in the volume of tidal air.

Not a man declared by the clinicians to be normal failed to show the increase in the per minute volume of breathing. Three who failed to have an increase in the depth of breathing and only increased the rate by one or two breaths became inefficient so early that they were rated in Classes II and III by the psychologist.

The pulse rate responses were as follows:

	Beats.
Class I:	
Average increase	37
Greatest increase	77
Smallest increase	6

	Beats.
Class II:	
Average increase	33
Greatest increase	54
Smallest increase	9
Class III:	
Average increase	32
Greatest increase	41
Smallest increase	22

During our early experience with the rebreathing test we were disposed to consider an acceleration of more than 50 beats as a sign of poor toleration of low oxygen. Some of the above men with efficiency well maintained down to 6.5, or even 6 per cent of oxygen, showed an early acceleration and a steady rapid rise to the end. Experience has shown that it is impossible to predict how well a subject will do by noting the time the pulse begins to respond and the degree of its response. As noted above, Class I compensations were made by as great an acceleration as 77 beats and as few as 6 beats. Efficiency under low oxygen depends upon an adequate supply of oxygen for the tissues, more especially for the nervous tissue. The burden of providing this oxygen supply is divided between the respiration, circulation, and the blood. In some men the burden falls heaviest on the circulatory mechanism and in others on the respiratory. The interplay of these mechanisms varies with the individual, so we are now of the opinion that a high pulse rate acceleration is not in itself a bad sign.

The blood pressures grouped themselves according to the types of our earlier experiences. About 80 per cent of the men in Class II and III gave the fainting type of reaction. Corbett and Bazett believe that individuals whose diastolic pressures are normally below 60 mm. Hg are incapable of standing high altitudes. The majority of all men examined by us who had a diastolic pressure below 60 did poorly under the low oxygen test. There were, however, three with diastolic pressures of 54, 58, and 58 who made excellent compensations and maintained efficiency down to 8, 7, and 6 per cent of oxygen.

There has been a disposition to look upon a normal systolic pressure of 130 mm. Hg. or more in young men as a contraindication for flying. Among the 47 men from the front who made the Class I rating 13 had a normal systolic of from 130 to 158 mm. These men not only reacted very well to low oxygen but also passed without adverse comment through the hands of the clinicians.

THE REBREATHING EXAMINATION AS A TEST FOR "STALENESS."

There have been many incidents observed during the training of cadets and among fliers at the Front, that have suggested that aviators who have "gone stale" are very sensitive to low oxygen and particularly liable to syncope when in the air. In the laboratory we have seen men with temporary indispositions, such as may follow a bad cold, recent illness, lack of sleep, alcoholic excess, etc., do poorly in the rebreathing examination who at some other time when feeling fit had compensated very well.

In view of these observations a study of two groups of men may be emphasized. There were 22 aviators (see Table IV) among the men returning from the front who were considered by the several medica departments of the laboratory as temporarily unfit for flying. In the altitude classification examination there were rated Class I, 12; Class II, 7; and Class III, 2, and not rated, 1. There was also another group (see Table V) of 22 aviators who claimed to feel "tired" and "stale" but with whom the clinician found nothing wrong. In the low oxygen test they were rated as follows: Class I, 9; Class II, 10; and Class III, 3. From these observations it appears that men may be physically below par and feel tired and yet react very well to the action of low oxygen, as judged by their physiologic and psychologic responses and efficiency.

Among 46 men who were rated low in the cardio-vascular efficiency tests for fatigue and staleness, there were 23, or 50 per cent, rated Class I in their response to the low oxygen rebreathing test.

The explanation of the occasional poor showing made by men who normally react well to the action of low oxygen, is not yet at hand. The war has focussed attention on "staleness," "effore syndrome," and "neurosis" with the result that we now realize that there are many conditions included under each and that there are many overlaps. An analysis and reclassification of our knowledge of these abnormalities are needed in order that the specific problems may be then investigated.

The rebreathing low oxygen test was perfected to determine the ability of the human organism to respond to the decreasing oxygen tension of high altitudes. It has been shown that normal men react to deficiency of oxygen, and that all do not have the same power of adjustment.

There is a remarkable variation among individuals in their capacity to withstand lack of oxygen. Some compensate well, others inadequately, and others not at all. The test should be employed for searching out those unfit for flying by reason of inability to respond to altitude, and for approximating the altitudes safely tolerated. Physical fitness it appears must be measured by other tests. Altitude fitness can, we believe, be measured by the rebreathing test. For the present, at least, we believe emphasis should not be given to the test as an aid in searching out staleness.

The rebreathing altitude classification examination has shown that some aviators react so well to the action of low oxygen tensions that they would have almost a complete immunity from discomfort at altitudes of 18,000 and even 20,000 feet.

The examinations made in the A. E. F. seem to indicate that the proportion of Class I, II, and III men remains fairly constant, even during flying under the stress of combat service.

Section II.

EFFICIENCY TESTS.

In discussing the available efficiency tests the writer has no desire to advocate one particular test or group of tests. The purpose of our study has been to give each a fair trial in order to fix upon those tests that most definitely and regularly indicate fatigue and the degree of physical fitness or unfitness. The value of some reliable test, easy of application, is well recognized by all who have watched the aviator from day to day and witnessed accidents that were the result of wear and tear that had gradually reduced the flier's physical fitness and thereby his flying ability.

It is certain that an aviator's disinclination to fly must have its basis upon some temporary defect of body or mind. Men often remain silent and do not confess their disinclination to fly fearing that they will be accused of having "cold feet." Tests that reveal such defects, and do so without a questioning of the patient, and that can not be doubted because of opportunity for "faking" by the patient, are needed by the flight surgeon and others having to do with the physical welfare of the aviator.

It is our purpose, therefore, to ask the plain question regarding each test used: Does it or has it seemed to indicate the physical state of the man tested? If the advocated tests fail to give the evidence desired this should be known so that search for a reliable test may be continued until the needed method is found.

Some simple test should be devised by which the incipient stages of accumulating fatigue may be detected.

ENGLISH TESTS.

In England, under the guidance of Lieut. Col. Martin Flack, a set of simple physiologic tests were devised to indicate subjects who were likely to suffer from discomforts in the air, such as headache, giddiness, fainting, dizziness, nausea, vomiting, pressure in the head, blood rushing to the temples, palpitation of the heart, etc.—symptoms which might be due to lack of proper oxygenation of the blood and likely to render the man unfit for flying.

The tests grow in number with experience and the application of them was extended to detect flying stress or fatigue. More recently Flack has stated that he believes them to be of use in determining the physical efficiency of an individual. He emphasizes that these tests are not designed to supplant the work of the clinician in any way and when a man is reported as physically unfit on these tests it does not mean that the work of the physician is finished but that it is beginning. If the subject does not come up to standards then the psychologist, neurologist, cardiologist, or general physician will find something is wrong with him. The tests, it is believed, give indications for such overhaul.

In a complete physiological examination seven distinct sets of observations are made upon the pilot. These include (1) the response of the pulse to a standard exercise, (2) time the breath is held in seconds after a full expiration and full inspiration, (3) a combination of 1 and 2 after the standard exercise, (4) vital capacity, (5) extra respiratory reserve as represented by the factor respiration rate multiplied by ventilation per minute divided by the vital capacity, (6) expiratory force, and (7) the fatigue test. The value of the tests depends on all being carried out in the same way on all occasions.

The technique as adopted is as follows:

(1) The response of the pulse to exercise. The subject standing before a chair places one foot upon the seat of the chair and steadily raises his whole body to the height of the seat five times in 15 seconds, one foot being retained on the chair throughout. With the subject still standing, the examiner continues to count the pulse in five-second intervals, and notes the acceleration and the time taken to return to the previous rate.

(2) In holding the breath the subject in a sitting position is instructed to expire once as deeply as possible, and then inspire fully and hold the breath as long as possible with the nose clipped or held. He may allow some air to escape if the breath has been too full but care must be taken that none is taken in. The subject is watched and the degree of suffusion of the face, etc., noted. The reason for giving up should be carefully noted and any abnormal answer recorded.

(3) The third is a combination of the first two tests. Having the pulse response and breath holding, then the time the breath can be held after the standard exercise is taken.

(4) In measuring the vital capacity the subject is asked to fill his chest and blow hard through a meter, taking precautions against overblowing the meter. The type of meter is important, its capacity should be such that it can not easily be overshot. Note should be made as to whether the subject experiences difficulty in blowing, suffusion of the face, and breathlessness. In routine work two or three determinations should be made.

(5) The extra respiratory reserve factor has been secured from the respiration data taken with the subject wearing a nose clip while breathing through a system of inspiratory and expiratory valves

connected with a meter or spirometer, the rate and volume per minute being recorded.

(6) For the determination of the expiratory force a U-tube manometer filled with mercury, with an adjustable millimeter scale, is used. The subject is asked to blow up the column steadily as high as possible and not to swing it up by the momentum of the mercury. In case it is suspected that the subject is not doing his best the scale of the manometer is turned away and he is asked to repeat. The two determinations will not agree if he has not been trying. In the test the blowing power of the cheeks may be ruled out by holding the cheeks with a hand. Generally the cheeks make little or no difference in the reading.

(7) The fatigue test is another with the U-tube manometer. The subject is asked to empty the lungs, take a deep breath, blow the mercury to the height of 40 mm. and hold it there without breathing for as long as possible. The nose should be clipped. During the test the pulse is counted each interval of five seconds that the mercury is sustained and for the period until it returns to normal after the subject stops blowing. The normal pulse rate should be determined in five second intervals immediately before the test is made.

The interpretations given of the data obtained from the above tests may be summarized as follows:

(1) In a good subject the increase in the pulse rate after exercise is about 20, and the time of return to normal 15 to 25 seconds. "A pulse of 60 to 72 little raised by exercise (10 beats per minute), returning to normal in 10 seconds, is in our opinion a good sign, generally associated with excellent physique and good stability of the nervous system." It is also maintained that an increased rate of over 25 and a return period of over 30 seconds are points calling for careful consideration of the subject's cardio-vascular system.

(2) The breath holding test was designed to show whether there was "oxygen want" and thereby whether the individual was likely to do well at high altitudes. It has been maintained that all candidates for aviation should be able to hold the breath a minimum, in three times, of 45 seconds. They found that good pilots manage 60 seconds or more. If dizziness, blurred vision, etc., occur under 40 seconds the candidate is rejected.

The test also was shown to have other significance. "The man without resolution, for example, will give up early."

(3) The application of the test of holding the breath after regulated exercise has been used to give information of "oxygen want" or lack of tone in doubtful cases. Candidates who can not hold the breath 20 seconds after graduated exercise should be rejected and those who can not hold 30 seconds be held for further study and observation. In the unfit the breath holding power comes down after

exercise while the fit man may possibly hold his breath as long as before. Good pilots after exercise hold at least 40 seconds, generally between 50 and 60 seconds.

(4) A minimum vital capacity of 3,000 c. c. has been fixed by the commissions board of England. The standard appears to take no account of the size of the individual. It is maintained that for high flying no one with a capacity below 3,400 c. c. be accepted unless he can hold his breath for more than 45 seconds.

(5) Bazett suggests that men with a large vital capacity, a low consumption of air per minute and a slow respiratory rate tolerate high altitudes better than others. The advantage is called extra reserve and is roughly measured by a factor—

$$\frac{\text{respiration rate} \times \text{ventilation per minute}}{\text{vital capacity}}$$

A low figure, it is believed, indicates a good type. A figure of 30 has been taken as the standard, those above this being relatively bad. The average figure for the good type is 24.1, for the bad 46.3, and for the uncertain 36.8.

(6) Tests 6 and 7 are believed to be valuable in "assessing" flying stress and also in determining the fitness of candidates for flying. The expiratory force test (6) is also thought to be a measure of the tone of the abdominal wall. The average normal is about 105 mm. Hg. It has been found that pilots suffering from flying stress can often only blow 40 mm. Hg. If the test is about 80 the pilot is considered only suitable for low flying and if much below is probably in need of a rest from flying altogether.

(7) Regarding the significance of the "fatigue test" it has been pointed out that it appeals to the sporting spirit, and the individual endowed with this is likely to do better than the one who is not. Determination is undoubtedly an important factor, so the test is in some respects a psychological one. According to one hypothesis the test is an indication of the tone of the respiratory center. The average normal time of many cases is 50 seconds. Below 40 seconds is considered unsatisfactory and indicates that probably the subject is fit only for limited flying or is in need of rest. Pilots broken down from stress of service had an average of about 25 seconds.

It is believed that the counting of the pulse during the period when the 40 mm. Hg. is sustained affords valuable indication of the degree of stability of the cardiomotor center. "Generally speaking, it may be stated that, starting at the fifth second, there is in the normal individual a steady rise in the rate of the pulse, or a fairly marked rise, which is sustained most of the time." "A large rise in rate, for example from 72 to 132 or 144, is, generally speaking, unsatisfactory." In case of flying stress with cardiovascular symptoms the characteristic response seems to be for the pulse to rise quickly during the fifth to the tenth or fifteenth second, and then to fall to normal or even considerably below normal.

It should be here emphasized that the claim is not made that each test is capable of rigid application. It is the combination of the tests that is important.

The fact that the first indications of "fatigue" are associated with the loss of power to sustain 40 mm. Hg., and also frequently with a diminished capacity to hold the breath, suggests the tentative explanation that the first stage in the onset of flying fatigue is due in many cases to an altered tone of the respiratory center. This leads later to a diminution of the vital capacity, supplemental air, and loss of expiratory force. Defective respiratory ventilation then brings about lessened oxygenation of the body, which reacts upon other systems, particularly upon the circulatory and nervous systems.

APPLICATION OF THE TESTS IN THE A. E. F.

Normal standards have been determined in England by the examination of healthy pilots. In Table II we have compared these with averages obtained in the A. E. F. for three groups of fliers: United States aviators returned from the front after the signing of the armistice, monitors from the Third Aviation Instruction Center, and a small group of French aviators.

TABLE II—*Group averages.*

Group.	Vital capacity in c. c.	Time breath held in seconds.	Expiratory force in mm. Hg.	Time in seconds holding 42 mm. Hg. by blowing.
119 U. S. aviators from the front	4,390	71	123	51
50 Third A. I. C. monitors	4,213	60	113	48
12 French fliers	4,000	72	126	50
Average obtained by English	3,800	66	110	52
22 fit R. A. F. squadron officers and commanders	4,062	67	112	52
24 fit pilots of R. A. F. home defense	3,940	72	119	50
23 R. A. F. cadets at random	3,823	69	106	51

It will be seen that the vital capacities and the respiratory force averages for our three groups are above the standards, while in the power to hold the breath the monitors fall below the standard, and in the "fatigue" test the three groups are slightly below standard. That the monitors, in ability to hold the breath and to sustain the column of mercury in the "fatigue" test, fall below the usual standard of the fit aviator is shown by the averages given for R. A. F. squadron officers, home defense pilots, and cadets.

For the purpose of obtaining an understanding of the distribution of a typical group of young men in these respiratory tests, the three groups were placed together and redivided to show the normal variations. They distribute themselves as follows:

Breath holding.

Seconds.	Number of cases.	Percentage.	Seconds.	Number of cases.	Percentage.
20 to 29	1	0.6	90 to 99	18	9.9
30 to 39	13	7.1	100 to 109	5	2.7
40 to 49	18	9.9	110 to 119	1	.6
50 to 59	26	14.3	120 to 129	6	3.3
60 to 69	41	22.5			
70 to 79	32	17.6	Total	182	100.0
80 to 89	21	11.5			

Highest .... seconds.. 128
Lowest .... do.... 29
45 seconds or less .... 22 or 12 per cent.

Vital capacity.

Cubic centimeters.	Number of cases.	Percentage.	Cubic centimeters.	Number of cases.	Percentage.
2,800 to 3,499	15	7.8	5,500 to 5,999	2	1.1
3,500 to 3,999	58	30.0	6,000 to 6,499	3	1.6
4,000 to 4,499	57	29.8			
4,500 to 4,999	39	20.4	Total	191	100.0
5,000 to 5,499	17	8.9			

Greatest vital capacity .... c. c... 6,620
Smallest vital capacity .... c. c.. 2,800
Below 3,400 c. c .... 13 or 6.8 per cent.

Expiratory force.

Millimeter.	Number of cases.	Percentage.	Millimeter.	Number of cases.	Percentage.
60 to 69	2	1.1	150 to 159	4	2.7
70 to 79	6	3.4	160 to 169	10	5.6
80 to 89	20	11.2	170 to 179	7	3.9
90 to 99	25	14.1	180 to 189	9	5.0
100 to 109	17	9.5	190 to 199	1	.5
110 to 119	28	15.7	200 to 209	1	.5
120 to 129	18	10.0			
130 to 139	19	10.6	Total	178	100.0
140 to 149	11	6.2			

Highest .... mm.. 208
Lowest .... mm.. 62
80 mm. or less .... 5.6 per cent

Fatigue test.

Seconds.	Number of cases.	Percentage.	Seconds.	Number of cases.	Percentage.
10 to 19	1	0.6	70 to 79	14	7.9
20 to 29	11	6.2	80 to 89	4	2.3
30 to 39	26	14.8	90 to 99	1	.6
40 to 49	49	27.8	100 to 109	1	.6
50 to 59	48	27.3			
60 to 69	21	11.9	Total	176	100.0

Highest .... seconds.. 103
Lowest .... seconds.. 15
40 seconds or less .... 42 or 23.8 per cent.

Among the 190 men under consideration the individual differences range in vital capacity from 2,800 to 6,620 c. c.; in ability to hold the breath from 29 to 128 seconds; in expiratory force, or power to blow up a column of mercury, from 62 to 208 mm.; in ability to sustain a column of mercury at 40 mm. during breath holding from 15 to 103 seconds.

The Minimum for Normal.

From a study of men who failed in aviation in England a minimum for normal has been established. This was found to be for vital capacity 3,400 c.c., for the ability to hold the breath 45 seconds, for the power of expiratory force 80 mm. Hg and for the endurance of the "fatigue" test 40 seconds.

Among the American fliers that were under observation 13 or 6.8 per cent had a vital capacity less than 3,400 c.c., 18 or 9 per cent could not hold the breath 45 seconds, 7 or 3.8 per cent could not blow (respiratory force) the mercury column above 80 mm., and 38 or 21.6 per cent failed to sustain the mercury column at 40 mm. for 40 seconds.

Among the 190 fliers examined there were 54 or 28.4 per cent who fell below standard in one or more of the tests. Of these 35 or 18.4 per cent were below in only one, 15 or 7.9 per cent were below in two, and 4 or 2.1 per cent in three of the tests. Not a man fell below the minimum standard in all of the tests.

All of the men were examined by the internist, neurologist, ophthalmologist, and ear, nose, and throat expert. Of the 35 below the minimum standard in only one test, eight, or about 23 per cent, were found by the medical experts to have something wrong. The ailments included two with tonsil and nasal infections, two were neurological cases, one had extrinsic ocular muscle weakness, and three were described by the internist as stale but no definite findings were recorded.

Among the 15 aviators below the minimum normal, in two of the tests only three, or 20 per cent, showed abnormalities; two had infected tonsils and one sinusitis. Of the four who were below in three tests one was passed as fit, by all, the second had chronic infection of the tonsils, and the other two were classed as stale, by the internist and neurologist. A total of 14, or 26 per cent, of the 54 aviators who were below normal in one or more of the English tests had ailments that were discovered in the medical overhaul.

THE RELATION OF THE ABILITY TO HOLD THE BREATH AND THE ENDURANCE OF LOW OXYGEN.

If the time the breath can be held should prove to be an index of a subject's power to respond to low oxygen it would provide a simple means of classifying aviators for altitude flying.

Flack has stated his opinion of the breath-holding test as follows: "The test was originally designed to show whether there was 'oxygen want,' and I still believe the test does show the subject who would suffer from 'oxygen want.' From my experience I found that people who were likely to suffer from 'oxygen want' would give up after a very short time in holding the breath and would almost invariably return an abnormal answer. A normal answer would be that the subject 'had to give up,' 'felt he would burst;'

an abnormal answer that the 'blood rushed to his head,' 'things became blurred,' etc. The deduction then is that the breath-holding test on an individual would be an idea as to whether he was likely to do well in the air. As the results appeared to show that poor breath holding could not last in the air, the breath-holding test was adopted at the Royal Air Force Commissions Board. In my opinion it is preventing people going into the air force who would not do well."

In the United States Manual of the Medical Research Laboratory from an analysis of 50 cases the following conclusion was drawn: "The length of time the breath was held did not give an indication of how low in oxygen the subject would go on the rebreathing apparatus. Fin. and Be., who fainted at 9.8 per cent (20,000 feet) and 9.2 per cent (21,800 feet), respectively, held the breath longer than the average. An., who managed only 40 seconds, withstood 6.8 per cent oxygen (28,400 feet), and W., who held only 29 seconds, endured low oxygen down to 7.5 per cent (26,000 feet)."

There are 143 cases, among the aviators examined in the A. E. F., in which the data are satisfactory for a comparison of breath holding and the reaction to the low oxygen of the rebreathing test. Ten of these men were able to hold the breath only 45 seconds or less. From their responses to the low oxygen they were classified as follows:

Number of cases in Class I	6
Number of cases in Class II	3
Number of cases in Class III	1

There is no limit placed on the altitudes for Class I; the second group, Class II, should not fly above 15,000 feet; and Class III not above 8,000 feet.

An analysis of the records of 87 men from the front gave the following results:

	Seconds.
Class I: Average time of breath hold	78
Highest	128
Lowest	30
Class II: Average time of breath hold	73
Highest	122
Lowest	41
Class III: Average time of breath hold	75
Highest	91
Lowest	59

From 44 monitors:

Class I: Average time of breath hold	63
Highest	99
Lowest	32
Class II: Average time of breath hold	63
Highest	99
Lowest	31

	Seconds.
Class III: Average time of breath hold	60
Highest	72
Lowest	45

The average time for breath holding for all men rated was Class I, 74; Class II, 71; and Class III, 63 seconds. These differences are too small to suggest that breath holding gives a satisfactory index of ability to tolerate altitudes.

The class differences are not constant and in one direction, as would be expected if a relationship existed between breath holding and low oxygen. Table III contains selected cases from Class I which show that men (Nos. 73, 77, 80, 110, and 154) of limited ability in breath holding often compensate to decidedly low oxygen. Our experience shows that had the breath-holding test been applied to eliminate men, five exceptional men (Nos. 73, 77, 80, 110, and 154) whom other tests showed to be fit would have been lost from our service. Two of these men had flown over the front, one had been credited with five and the other two official enemies; the other three being instructors at the Third Aviation Instruction Center, with a credit of 350 to 750 flying hours and altitude flights to between 16,000 and 20,000 feet.

In Table III are four cases, Nos. 55, 85, 109, and 127, in which fainting or complete inefficiency occurred at oxygen percentages varying between 11.1 and 10.3 and whose breath holdings were 99, 59, 68, and 91 seconds.

TABLE III.—*Relation of vital capacity and breath holding to oxygen want.*

No.	Rated by physiologist class.	Rated by psychologist class.	Lowest oxygen percentage reached.	Time breath held in seconds.	Vital capacity in c. c.
R. 64	I	I	7.7	53	3,680
R. 73	I	I	7.4	44	3,780
R. 76	I	I	7.6	62	3,420
R. 77	I	I	6.4	39	3,880
R. 79	I	I	7.6	60	3,610
R. 80	I	I	7.5	32	4,400
R. 83	I	I	7.3	59	3,630
R. 88	I	I	7.1	66	3,980
R. 100	I	I	6.5	60	3,690
R. 110	I	I	7.7	42	4,020
R. 121	I	I	6.7	60	3,600
R. 154	I	I	6.0	30	4,600
R. 36	II	III	8.6	31	4,600
R. 43	II	III	9.5	63	5,190
R. 49	II	III	9.0	53	4,700
R. 55	II	III	10.7	99	4,800
R. 60	II	III	8.4	68	4,180
R. 61	III	III	9.3	71	4,900
R. 70	III	III	9.3	72	3,670
R. 85	III	III	11.1	59	3,900
R. 84	III	III	7.3	52	4,220
R. 90	III	III	9.9	58	3,490
R. 98	II	III	9.0	41	5,170
R. 112	II	III	9.4	55	6,620
R. 107	II	III	9.9	60	3,950
R. 109	III	III	10.3	68	3,830
R. 127	III	III	11.3	91	4,680
	II	III	9.7	69	5,000

No. 55 was fit but had never been higher than an altitude of 10,000 feet. No. 85, who had been at the front, and was found to be stale by the neurologist, complained of being tired and reported breathlessness at moderate altitudes. No. 127 had ethmoiditis and was not fit. No. 109 had been at high altitudes (18,000 feet) and had five months' experience at the front. He was, however, a heavy smoker and complained of being tired after flights at more than moderate altitudes.

In an earlier study of 50 men the influence of exercise on the power of holding the breath and the relation of this to the endurance of low oxygen was considered. No definite advantage over breath holding without exercise was evident.

Granted that the rebreathing low-oxygen examination gives satisfactory evidence of ability to compensate to low oxygen and high altitudes, the above evidence indicates that breath holding can not be used as an index of ability to respond to altitude.

VITAL CAPACITY AND LOW OXYGEN.

An analysis of 144 cases has been made with a view of determining whether the vital capacity test gives an indication of ability to respond to low oxygen. If an individual requires a large amount of air per minute, as in physical exertion or at high altitudes, it is evident that he may require a large vital capacity. We have found a few men who, when under 7 or 6 per cent oxygen, breathed 2,000 to 2,400 c. c. of air per breath. It is obvious that an individual of small chest might be limited to rapid rather than deep breathing in order to secure sufficient ventilation of the lungs when at altitudes comparable to such oxygen tensions as these. The Commissions Board of England has fixed upon 3,000 c. c. as the minimum vital capacity. They suggest that no one with a capacity below 3,400 c. c. be accepted unless he can hold his breath more than 45 seconds.

Among our subjects the vital capacities distribute into the three altitude classes as follows:

	Number of cases.	Percentage.
Class I:		
3,400 c. c. or less	1	1.1
3,400 to 3,999 c. c	22	24.7
4,000 to 4,999 c. c	54	60.7
5,000 to 5,999 c. c	11	12.4
6,000 c. c. or more	1	1.1
Total	89	100.0
Class II:		
3,400 c. c. or less	2	5.1
3,400 to 3,999 c. c	17	43.6
4,000 to 4,999 c. c	16	41.0
5,000 to 5,999 c. c	3	7.7
6,000 c.c. or more	1	2.6
Total	39	100.0
Class III:		
3,400 c. c. or less	....	....
3,400 to 3,999 c. c	5	31.3
4,000 to 4,999 c. c	8	50.0
5,000 to 5,999 c. c	2	12.5
6,000 c. c. or more	1	6.2
Total	16	100.0

A larger proportion of the men in Class I had a vital capacity of 4,000 c. c. than those of Class II. Class III contains too small a number to make comparison satisfactory.

The average vital capacity for Class I is 4,340, Class II 4,060, and Class III 4,550 c. c. From all figures for Classes I and II it appears that a vital capacity of 4,000 c. c. or more may insure better toleration of low oxygen and high altitudes.

A study of the 16 men rated III (see Table III), who either failed to compensate to the decreasing oxygen or were limited in the power of response, shows that there are marked exceptions to the rule that a large vital capacity is favorable for air work. The man (R. 112) with the largest vital capacity, 6,620 c. c., became completely inefficient at 9.4 per cent oxygen and would have fainted had he not been restored to air immediately. One subject (R. 55) with a vital capacity of 4,800 c. c., failed at 10.7 per cent oxygen and another (R. 127) with 4,680 c. c., was unable to respond to stimuli at 11.3 per cent oxygen.

In contrast with these may be cited three instances of men with small vital capacities, in which the compensations to low oxygen were excellent. The first with a vital capacity of 3,180 c. c. remained quite efficient down to 8 per cent oxygen; the second, vital capacity 3,490 c. c., compensated down to 7 per cent; and the third with a vital capacity of 3,670 c. c. reached 6.7 per cent oxygen.

Bazett examined an English aviator, a small man, with a vital capacity of 3,200 c. c., who was an excellent scout pilot. This man brought down 14 Huns during the next 18 days.

Our experience does not include men with both a small vital capacity and a short period of breath holding.

It appears from the above data that the vital capacity when taken alone does not give evidence as to a subject's ability to respond to low oxygen and altitudes.

EXTRA RESERVE FACTOR.

Bazett, from experience with respiratory tests for ability to stand high altitudes, concluded that a relationship exists between the respiratory rate, the amount of air breathed per minute and vital capacity, and a man's power of enduring oxygen want. He established an artificial factor which seems to give some idea of the ability of the individual to stand high altitudes. This factor is expressed by the value $\frac{\text{respiratory rate} \times \text{ventilation per minute}}{\text{vital capacity}}$. The factor is based upon certain reasonable physiological assumptions, namely, that a slow respiration, a large vital capacity, and a low ventilation rate, all indicate a reserve for use at high altitudes.

From the examination of three groups of aviators, good, bad, and uncertain at altitudes, he found the average factor for the good type is 24.1; for the bad, 46.3; and for the uncertain, 36.8. He accepts 30 as the standard, those above this being relatively bad. Among the good type 24 per cent had a factor greater than 30, while 71.5 per cent of the bad and 47.3 per cent of the uncertain were above this figure.

We have sufficient and satisfactory data from 123 of the American aviators who took our altitude classification test for calculating the Bazett's extra reserve factor. During the rebreathing test the respiration rate, the volume of breathing, and the time in half-minute intervals were recorded on a kymograph. From these tracings we have calculated the respiratory rate and the per minute volume of ventilation during the first four minutes of the test.

The results of these comparisons of the reserve factor and the rebreathing altitude classification give the following distribution:

	Number of cases.	Number factor 30 and below.	Number above factor 30.	Per cent above 30.
Class I	64	41	23	35.9
Class II	43	8	35	81.4
Class III	16	3	13	81.2

The average reserve factor for the 64 men in Class I was 31, and out of this group for the 41 in which it was 30 and less, it was 24.5. This last figure is almost the same figure, 24.1, Bazett found for the good type. The average factors for Classes II and III were 40.7 and 36, respectively. On eliminating from each the cases with a reserve factor of 30 or less the averages were 44.5 and 39. The reserve factor fails, therefore, to indicate the different abilities for low oxygen adaptation among the Classes II and III.

A study of the cases in Class I with a factor greater than 30 brought out the fact that each responded normally and well by increased breathing and acceleration of the pulse rate down to oxygen percentages varying between 7.8 and 6.2.

There were 8 men in Class II who gave a reserve factor less than 30. Four of these the psychologist found reached a point of complete inefficiency at percentages of oxygen ranging between 9 and 8.2; the remaining four gave the fainting type of reaction at about the same oxygen percentages.

Three men in Class III had low reserve factors, 18.9, 24, and 24.9. The first, who had the largest vital capacity, 6,620 c. c., found among our subjects fainted at 9.4 per cent oxygen; the second, whose circulatory adaptation was poor, was, according to the psychologist, completely inefficient at 11.3 per cent; the third man was of the fainting type and became inefficient at 8.4 oxygen.

The reserve factor seems therefore to be as effective for selecting those bad at adapting to low oxygen as its author found it to be for selecting those bad at altitudes. The weakness of the method errs in the safe direction, that is, it fails less frequently in selecting those who do poorly under low oxygen than those of the good type. It should only be used as a substitute for more exact methods when an emergency exists where a number of men must be passed upon hurriedly.

THE U-TUBE FATIGUE TEST.

Inasmuch as one hypothesis put forth is that this test gives an indication of the tone of the respiratory center, the results of the tests were compared with the altitude test ratings. The discrepancies between the two ran about as in the breath-holding test. Eighteen men who held on less than 40 seconds divided equally into two groups. Nine were rated I in ability to respond to a gradually decreasing oxygen, the other nine were placed as follows: Class II, 6; and Class III, 3. Birley after using the test in the field in France with the Royal Air Force concludes that "The above results do not warrant the assumption that high flying per se, at any rate at the stage at which pilots and observers are nowadays withdrawn from the line, produced an altered tone of the respiratory center of such a character as to be demonstrable by the manometer tests."

CLINICAL FINDINGS AND STALENESS.

The great need in aviation, and it may be added in industry, is some test or set of tests, which will detect fatigue and the accumulated injurious effects of stress. A search for a reliable test is still on. It is of interest to examine the English tests and incidentally the rebreathing and other tests from this standpoint.

Our data have been compared with the findings of the internist, neurologist, opthalmologist, and ear, nose and throat department. Among the American aviators returned from the front after the signing of the armistice 22 were considered as temporarily unfit for flying by the several medical departments. The data on these men are tabulated in Table IV. In the aggregate these men show up very well in the English tests. Their averages were for vital capacity 4,260 c. c., breathhold 72.3 seconds, expiratory force 122.1 mm. Hg., "fatigue" 50.9 seconds, reserve factor 30.9. The response of the pulse rate during the hold in the "fatigue" test was normal in all but four. Not a man was below the minimum standard in power to hold the breath or in expiratory force. In the "fatigue" test four fell below the minimum standard of 40 seconds. One had a vital capacity below standard.

TABLE IV.—*Found unfit by clinical departments.*

Number.	Clinical finding.	Rebreathing classification.		Pulse rate.		Crampton index.	Time breath held in seconds.	Vital capacity in c. c.	Expiratory force in mm. Hg.	Time holding 40 mm. Hg. by blowing in seconds.	Pulse during fatigue tests.	Reserve factor.
		Physiology.	Psychology.	Reclining.	Standing.							
512	Internist	I	I	84	104	45	87	4,850	102	38	Good	17
531	do	II	III	90	132	28	68	4,000	136	41	Slowed	25
579	do	I	II	92	120	0	52	4,900	114	56	Good	23
581	Throat	I	I	70	84	58	72	3,180	84	38	do	
591	do	II	II	96	108	55	51	4,300	112	32	132	23
596	Neurologist	I	I	70	84	63	65	3,900	186	40	Good	35
645	Internist	I	I	64	74	88	80	4,210	144	55	do	40
624	Neurologist	I	II	76	90	68	66	3,720	112	36	do	40
650	Neurologist and internist	I	I	78	104	53	62	4,130	122	55	132	29
653	Internist and neurologist	I	I	80	112	50	94	5,000	188	77	Good	28
658	Internist	I	I	105	105	115	84	4,340	118	74	do	25
660	do	I	I	100	112	30	67	5,800	122	48	do	16
661	do	I	II	84	90	83	78	3,920	86	50	do	33
673	do	II	II	72	82	78	101	5,000	148	59	do	33
675	do	I	I	70	90	85	76	3,780	110	51	do	33
676	Ear and neurologist			80	102	88	73	3,760	114	45	do	23
680	Internist	II	II	78	114	78	62	3,200	100	40	do	50
688	do	I	I	76	90	38	65	4,600	118	52	do	29
699	do	I		80	105	79	73	4,290	114	50	do	25
701	do	I	II	84	102	98	79	4,190	128	62	144	37
Brady	do	I	I	68	88	55	66	3,830	88	55	Good	57
Brewer	do	II	III	68	72	55	69	4,990	138	66	132	29
Average				80	93	63	72	4,260	122	51		31

In the low-oxygen altitude classification test nine of the group were rated as inferior, being placed in Classes II and III.

Among the men returning from the front there were also 22 who claimed to feel "fed up," tired or stale, but with whom the clinician found nothing wrong. Data from the altitude examination and the English tests for this group have been tabulated in Table V. They average higher than the "unfit" group. These averages are for vital capacity 4,350 c. c., breathhold 76 seconds, expiratory force 128.5 mm. Hg., "fatigue" test 55.4 seconds, and reserve factor 30.4. The pulse during the hold of the "fatigue" test was good in all but two. One subject was below the minimum standard in the breathhold and "fatigue" test and one in the respiratory force. The low-oxygen altitude rating gave the following grouping: Class I, 9; Class II, 10; and Class III, 3.

A group of 20 men who showed up unusually well in the English tests is given in Table VI for comparison with the "unfit" and "complaining" groups. This picked group averaged in vital capacity 4,340 c. c., breath-hold 92.3 seconds, expiratory force 137.9 mm. Hg., "fatigue" test 69.3 seconds, and "reserve factor" 35.4. No. 701 was found to be stale by the internist and No. 490 complained of being worn out. In the altitude, or low oxygen, test they were rated Class I, 8; Class II, 11; and Class III, 1.

From our experience with the so-called English tests we conclude that they do not give a reliable indication of how well a man will respond to diminished oxygen tensions, such as are encountered in flying to high altitudes. We recognize that the reserve factor may measure in a crude way the ability to stand high altitudes.

As regards the value of the English tests in detecting fatigue and staleness we offer the opinion that it is too early to pass upon them. The subjects examined by us were freed from the stress and anxiety of fighting, from patrol and observation flights and had had time to recuperate. Birley, working with English aviators at the front, found that pilots and observers whose conditions warranted their transfer to England for a rest preserved a comparatively high degree of physical fitness as judged by the tests. He believes that the tests afford valuable information in assessing temperament and in individual susceptibility and reaction to shock. He found that they did not prove useful in searching out psychopaths, individuals who never feel confident in the air and sooner of later reach the hospital with well developed anxiety neurosis.

It is the writer's opinion that the tests require too much voluntary attention and hearty cooperation on the part of the patient. The results are not capable of physiological interpretation unless they represent the best effort the patient can put into each test. Indifferent subject and listless observer both vitiate the results. Determination

TABLE V.—*Claimed to be "stale" and "fed up."*

Number.	Rebreathing classification.		Pulse rate.		Crampton index.	Time breath held in seconds.	Vital capacity in c. c.	Expiratory force in mm. Hg.	Time holding 40 mm. Hg, by blowing in seconds.	Pulse during hold.	Reserve factor.
	Physiology.	Psychology.	Reclining.	Standing.							
492	II	II	65	78	65	59	3,570	100	56	Good	78
490	I	II	96	96	90	76	4,300	132	66	do	52
552	III	III	80	84	95	59	3,900	178	36	do	34
567	II	II	75	112	41	61	3,750	70	60	132	33
605	I	II	78	84	78	92	4,900	116	97	Good	34
619	II	II	60	80	70	87	3,970	160	78	do	28
635	II	III	90	90	128	60	3,950	122	45	do	26
641	I	I	72	82	63	113	5,000	118	42	do	24
647	I	I	88	102	50	82	5,070	108	49	132	29
656	I	I	72	88	100	85	4,060	182	70	Slowed	32
657	I	I	76	94	78	66	4,670	188	45	Good	29
663	II	II	78	88	88	51	4,230	118	31	do	26
665	I	I	62	78	55	75	4,500	120	54	do	22
669	II	II	50	68	63	66	3,590	92	52	do	23
670	II	II	80	96	70	68	4,000	118	52	do	19
671	III	III	64	80	60	91	4,680	140	61	do	24
677	I	I	72	112	40	80	4,780	96	55	do	20
691	I	II	72	76	100	84	5,200	174	69	do	45
693	I	I	76	102	83	30	4,600	114	23	do	24
694	I	I	80	108	65	66	4,460	138	54	do	26
697	I	I	78	104	28	128	4,300	110	70	do	25
720	II	II	70	82	75	91	4,430	130	54	do	25
Average			74.4	90.4	72	76	4,350	128.5	55.4		30.4

TABLE VI.—*Above the average.*

Number.	Rebreathing classification.		Pulse rate.		Crampton index.	Time breath held in seconds.	Vital capacity in c. c.	Expiratory force in mm. Hg.	Time holding 40 mm. Hg, by blowing in seconds.	Pulse during hold.	Reserve factor.
	Physiology.	Psychology.	Reclining.	Standing.							
490	I	II	96	96	90	76	4,300	132	66	Good	52
605	I	II	78	84	78	92	4,900	116	97	do	34
619	II	II	60	80	70	87	3,970	160	78	do	28
623	II	II	8?	96	53	90	3,700	90	54	do	48
625	III	III	64	68	75	68	3,830	110	63	do	35
637	II	I	52	80	45	73	3,640	112	62	Slowed	62
639	I	....	80	84	95	96	4,150	166	78	do	34
640	II	II	72	96	80	92	4,640	108	52	Good	36
642	II	I	82	110	45	96	4,540	170	59	do	29
646	....	II	75	100	39	104	5,180	116	74	do	16
654	I	I	80	102	63	105	4,300	105	67	do	50
656	I	I	72	88	100	85	4,060	182	70	Slowed	32
664	I	I	72	92	55	84	4,330	164	66	Good	31
678	I	I	88	108	45	120	4,400	142	85	do	22
681	I	I	68	84	85	121	3,800	174	77	do	55
687	I	I	54	72	98	81	5,410	128	68	Slowed	24
692	I	I	66	76	78	120	4,650	120	85	Good	35
721	II	I	66	96	38	106	5,200	134	68	do	26
720	II	II	69	88	56	71	3,620	122	55	do	31
701	I	II	84	102	98	79	4,190	128	62	132	37
Average	....	....	73	90.1	69.3	92.3	4,340	137.9	69.3	....	35.4

to do one's utmost is an important factor. The tests are in some respects psychological, since if a man determines to hold the breath until discomfort is pronounced it can be done or he may give up with the first feeling of effort. To sustain the mercury column in the "fatigue" test requires some skill and a proper set of the lips may ease the performance so much that ten to twenty seconds are added to the length of the hold. The expiratory force test, if well done, requires great effort and the height of the blow often depends upon the ability to coordinate the contraction of chest and abdominal muscles. One often improves his record appreciably after several performances. The mental attitude of the patient may make or mar these tests. If the patient wishes a vacation, knowing that a poor showing in the tests indicates fatigue and need of a rest, he can easily imitate the "all in" man.

Section III.

CIRCULATORY EFFICIENCY TESTS.

The cardio-vascular changes associated with body posture and exercise have been considered by many experts in physical education and by clinicians to furnish important tests of cardiac and vasomotor efficiency. It has been assumed that fatigue relaxes the tone of the circulatory system and that the degree of action is indicated in changes in pulse rate and arterial blood pressures. A body damaged by disease, overwork or unhygienic living, or weakened by dissipation, or by inactivity, also undergoes a loss of tone which will be manifest by the circulatory changes when the subject is examined in the reclining and standing postures or after exercise. The degree of loss of tone or injury is also estimated by the extent of reaction to selected forms of exercise.

During brief or moderately prolonged periods of exercise the arterial blood pressure is raised and the heart rate accelerated. These changes occur very promptly after the exercise is started, the increase in heart rate preceeding the increase in pressure. The amount of increase in both depends on the degree of effort and on the rapidity and length of the exercise. When the exercise is stopped, there is a rapid fall of pressure and pulse rate. A primary fall in pulse rate usually precedes the fall in pressure; but unlike the latter, the pulse may remain for some time above its original rate and only gradually return to the normal level. The sudden and primary fall in the pulse rate is frequently separated from the secondary fall by a period of stationary rate. After short periods of exercise the pulse rate usually becomes subnormal for a period of time, varying with the kind of exercise. After fatiguing and exhausting exercise the pulse rate returns to normal slowly, and only rarely passes into the subnormal stage. Comparison of the pulse rate in athletic and non-athletic individuals after a particular exercise shows that the acceleration and the time of return to the normal are greater in the nonathletic persons.

The systolic pressure after exercise, like the pulse, usually goes subnormal. It quickly returns to normal in the well trained but remains subnormal for some time in the physically untrained person. The amount of increase in the pressure is about equal in athletes and nonathletes, but the athlete normally has the higher initial pressure.

When the body is in the recumbent posture the heart is not worked as hard as when one stands. The heart rate and the systolic blood pressure are ordinarily increased for the standing position. In perfectly normal vigorous men the systolic pressure will rise from 8 to10 millimeters of mercury upon assuming the standing position. The pulse rate on the average accelerates about eight beats per minute.

Crampton found that in an individual weakened by dissipation, overwork, lack of sleep, etc., the systolic pressure on standing tends not to rise but to fall, because the splanchnic area fails to increase its vasotone; and that the heart rate rises in proportion to weakness, as much sometimes as 45 beats per minute. He balanced mathematically the systolic pressure and pulse rate against each other to prepare a percentage table which expressed numerically the vasomotor tone. The 100 mark indicates a perfectly efficient working of the vasomotor system under test, the zero is approximately the point where the person's circulation is inadequate to maintain the needs of the body in the erect posture.

Means of measuring fatigue, staleness and weakness are suggested by the above statements. A pulse rate more rapid than the average in the reclining and standing postures, a large acceleration and a slow return of the pulse rate to normal after exercise may mean fatigue and weakness. A systolic pressure that fails to rise but falls when the subject stands, and a pressure that remains above the normal for a considerable time after exercise may likewise indicate weakness. A low rating on Crampton's vasomotor tone index should also furnish evidence of staleness.

THE METHODS USED.

We required the candidate prior to examination to avoid doing physical work. For examination he was placed on a comfortable couch, a Tycos sphygmomanometer was adjusted over the brachial artery, after which he rested for 5 minutes. The heart rate was then determined by counting the pulse for 20-second intervals. Counting continued until two successive intervals gave the same result. The arterial pressures were then determined by auscultation, the diastolic pressure being read at the fourth phase. The candidate next stood, the heart rate was counted in 20-second intervals as before until it reached the "standing normal" when it was recorded and the arterial blood pressure then taken.

The candidate next standing before a chair placed one foot upon the seat of the chair and raised his body to the height of the seat five times in 15 seconds, one foot being retained on the chair throughout. With the subject still standing the arterial pressures were immediately determined by one observer while a second counted and recorded the pulse rate in 15-second intervals for 2 minutes. At the end of the 2 minutes the arterial pressures were again read.

The question of suitable exercise was discussed. McCurdy has pointed out that speed exercises such as his knee-raising test give a more uniform increase in heart rate than the strength exercises such as hopping 100 feet, squatting or trunk bending. We used the stepping upon the chair for two reasons. It was used by the English Army and it gave a simple and definitely controlled exercise. For purposes of comparisons we also had a small number of men do the knee-raising test in which the knees are alternately raised 20 times in 10 seconds (10 times for each knee).

From a study of English aviators Flack and Bowdler conclude that with the stepping-upon-the-chair exercise an increased heart rate of over 25 beats and a return period of over 30 seconds are points calling for careful consideration of the candidate's cardiovascular system. They believe that a rest rate above normal, especially if influenced by respiration, should not be regarded as necessarily throwing doubt upon the functional efficiency of the cardiovascular system. A pulse of 60 to 72 raised little by exercise (not over 10 beats per minute), returning to normal in 10 seconds, is, in their opinion, a good sign, generally associated with excellent physique and good stability of the nervous system. While a diastolic pressure below 70, with a pulse pressure greater than 50 is regarded as strong evidence that the cardiovascular system is unsuited for air work.

Birley, working with the English aviator at the front, found the average pulse rate for officers permanently unfit for flying was somewhat higher than that of fliers in the home establishment. The average standing pulse rate was for pilots and observers in the home establishment, 85; for officers permanently unfit for flying, 100. A study of concussion cases averaged (*a*) granted sick leave and returned to duty, 74; (*b*) evacuated sick to England, 79. With regard to blood pressures he states that they are too variable to allow of any very definite conclusions being drawn. The chief points of interest are that all groups had a high average for systolic pressure—Home establishment, 123; all concussion cases, 127; permanently unfit for flying, 130 mm. Hg. Secondly, there were a large number of abnormal pressures. The abnormality tends considerably more toward high pressures than toward low. The high readings were in no case associated with arterial or renal changes and were looked upon as an indication of the strain of active service. In high-flying pilots he found a pulse rate below rather than above the normal and a normal pulse pressure.

THE EXAMINATION MADE IN THE A. E. F.

The Pulse Rate in the Reclining and Standing Positions.

Among several hundreds of cases who underwent the circulatory tests about 170 were also put through the low oxygen altitude test and the English efficiency tests. A special study has been made of this smaller group. Below are tabulated the data from 148 cases showing the distribution in pulse rates for the horizontal and standing positions. It should be noted that the lowest rate is not equal to the minimum frequently observed in healthy individuals. Athletes in Oxford had rates, which may be considered normal, that ranged between 44 and 90; and a study of medical students at Cambridge gave a range between 47 and 90. Our data taken from aviators follows.

Pulse rates while in the reclining position (148 cases).

Rates.	Number of cases.	Per cent of cases.	Rates.	Number of cases.	Per cent of cases.
50 to 54	4	2.7	80 to 89	33	22.4
55 to 59	6	4.1	90 to 99	12	8.1
60 to 64	19	12.8	100 and up	3	2.0
65 to 69	22	14.9			
70 to 74	30	20.2	Total	148	100.0
75 to 79	19	12.8			

Highest rate	105
Lowest rate	50
Average	74.2

Pulse rates during standing (148 cases).

Rates.	Number of cases.	Per cent of cases.	Rates.	Number of cases.	Per cent of cases.
60 to 64	2	1.3	95 to 99	17	11.5
65 to 69	7	4.7	100 to 109	23	15.5
70 to 74	9	6.1	110 to 119	10	6.7
75 to 79	21	14.4	120 to 129	2	1.3
80 to 84	29	19.6	130 and above	1	0.7
85 to 89	7	4.7			
90 to 94	20	13.5	Total	148	100.0

Highest rate	132
Lowest rate	68
Average	89.4

A reclining position pulse rate above 80 is considered too rapid for the man in perfect physical condition. Almost a third, 32.4 per cent, of our cases had a rate of 80 and above. A "standing normal" does not, as a rule, exceed 95. But 35.8 per cent of these men had a rate of 95 and above. The pulse rates for the reclining and standing postures indicate that about a third of the men examined were fatigued or not in the best physical condition.

The Systolic Pressure in the Horizontal and Standing Position.

The distribution of the systolic pressure for the two positions was as follows:

The horizontal position (148 cases).			Systolic pressure during standing (148 cases).		
Pressure in mm. Hg.	Number of cases.	Per cent of cases.	Millimeters.	Cases.	Per cent of cases.
90 to 99	2	1.3	100 to 109 mm	17	11.5
100 to 109	26	17.5	110 to 119 mm	46	31.1
110 to 119	55	37.3	120 to 129 mm	32	21.6
120 to 129	45	30.4	130 to 139 mm	35	23.6
130 to 139	17	11.5	140 to 149 mm	15	10.2
140 to 149	1	.7	150 to 159 mm	3	2.0
150 to 159	2	1.3	Total	148	100.0
Total	148	100.0			

Highest systolic pressure, reclining position ... mm. Hg.. 150
Lowest systolic pressure, standing position ... mm. Hg.. 98
Average ... mm. Hg.. 117.9
Highest systolic ... mm. Hg.. 154
Lowest systolic ... mm. Hg.. 100
Average ... mm. Hg.. 123.4

If it be accepted that the normal systolic pressure for young men of aviator's age ranges between 100 and 125 mm. Hg, then 35 men, or 23.6 per cent, had in the reclining position a pressure above normal, and 54, or 36.5 per cent, were above normal while standing. These were 28, or 18.9 per cent, with a reclining posture systolic pressure below 110 mm., while in 12, or 8.2 per cent, it was below the normal for the standing position. Birley found a considerable percentage of high altitude English pilots with subnormal blood pressures.

There is ordinarily a difference between the systolic pressures of the reclining and standing positions. The differences in our subjects, when the standing pressure was compared with that of the reclining position, were as follows:

	Number of cases.	Percentage of cases.
A fall of 1 to 11 mm	26	17.5
No change	19	12.8
A rise of 1 to 10 mm	70	47.4
A rise of 11 to 20 mm	28	18.9
A rise of 21 to 30 mm	2	1.4
A rise of 31 to 35 mm	3	2.0
Total	148	100.0

In vigorous men a rise of systolic pressure occurs when the erect posture is taken. A fall in pressure is regarded as evidence of poor condition or weakness. According to this criterion 26, or 17.6 per cent, of our cases gave this evidence of weakness.

Crampton's Vasomotor Tone Index.

To estimate the vasomotor tone, the pulse rates and systolic pressures of the horizontal and standing positions are required. A subject may sometimes show weakness by a decrease in blood pressure and at other times by an increase in heart rate and vice versa. In rating a decrease in pressure of 1 millimeter of mercury was found to be equivalent to an increase in the heart rate of approximately two beats.

Just what constitutes a poor record has not been determined. We may assume, however, that 50 or less means a poor vasomotor tone. Among the group of subjects here considered 32, or 21.6 per cent, had a vasomotor tone index of 50 or less; a percentage which corresponds fairly well with that of the criteria above considered.

The Pulse Rate after the Standard Exercise.

It is generally assumed that in vigorous physically fit men the rate of heart beat does not accelerate as much during a given exercise as in men out of training and, therefore, physically "soft." Furthermore, in the physically fit the rate returns to normal quickly, while in the less strong a higher rate is maintained for some time after exertion.

The change in pulse rate immediately after the standard exercise for our subjects was as follows:

Change in rate.	Number of cases.	Percentage of cases.
Subnormal	4	2.7
No change	4	2.7
Rise 1 to 10 beats	62	41.9
Rise 11 to 20 beats	58	39.3
Rise 21 to 25 beats	10	6.7
Rise 26 to 48 beats	10	6.7
Total	148	100.0

An acceleration of more than 20 beats occurred in 20, or 13.5 per cent, of the men. Accepting the suggestion that 25 or more constitute an excessive acceleration we find only 10, or 6.7 per cent, give this evidence of unfitness.

The return of the pulse rate toward normal was followed for two minutes after the exercise. The counting was done in 15-second intervals. Assuming that when we found it to be normal in the third interval of 15 seconds that it came back within 30 seconds, there were 61 men who returned within the 30 seconds considered normal by Flack and Bowdler. At the end of two minutes 49, or 33.1 per cent, were still above normal. In an analysis of 170 cases, cadets examined at Mineola and reported in the Medical Research Manual, we found at the end of the second minute that 33 per cent were above their "standing normal," 16.8 per cent normal, and 50.2 per cent subnormal.

The A. E. F. aviators had the following condition of the pulse rate at the end of two minutes:

	Number of cases.	Per cent of cases.
Subnormal	72	48.6
Normal	27	18.2
Above normal	49	33.1

A POINT SYSTEM FOR GRADING THE CARDIO-VASCULAR EFFICIENCY TESTS.

In order to sum up the data obtained from the circulatory tests a scoring system has been devised. This system is based in part upon a plan proposed by Dr. J. H. McCurdy for rating infantrymen in cardio-vascular and neuro-muscular efficiency. It is recognized that fatigue or derangement may be evidenced in the high heart rate during reclining; during standing; in the number of beats the heart rate increases when the standing and reclining postures are compared; in the acceleration in the pulse rate after exercise; in the time taken by the pulse to return to normal; and, lastly, in the rise or fall in the systolic blood pressure on standing. An arbitrary scheme for grading each of the above six points has been prepared. The values as assigned will be found in Table VII, parts A, B, C, D, E, and F. The final rating is obtained by adding the score for each of the six points rated, 18 being a perfect score.

The following illustrates the method of rating: Reclining pulse rate 72 = 2 points, pulse rate increase on standing 24 beats = 1 point, standing pulse rate 96 = 1 point, pulse acceleration after exercise 8 beats = 2 points, pulse returned to normal within 45 seconds = 3 points, systolic pressure rose 14 mm. on standing = 3 points. The subject made a total of 12 out of a possible 18 points. It should be noted that the number of beats the pulse increases on standing is rated on the basis of the reclining rate. In this example 72 occurs in the third line so the increase 24 is rated according to the third line in the third column of B. The same plan is used for the exercise increase, but it is compared with the standing and not the reclining pulse rate.

The 148 men previously considered are by this point system of scoring distributed as follows:

Efficiency score.	Number of cases.	Percentage.	Efficiency score.	Number of cases.	Percentage.
18-17-16	21	14.2	3-2-1	2	1.3
15-14-13	30	20.3	0	1	0.7
12-11-10	49	33.1			
9- 8- 7	28	18.9		148	100.0
6- 5- 4	17	11.5			

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TABLE VII.—*Cardio-vascular efficiency test tables of points for grading.*

(A) Reclining pulse rate.	(B) Pulse rate increase on standing.				
50- 60=3 points.	0-10 beats=3 points.	11-18= 3 points.	19-26= 2 points.	27-34= 1 point.	35-42= 0 point.
61- 70=3 points.	0-10 beats=3 points.	11-18= 2 points.	19-26= 1 point.	27-34= 0 point.	35-42= 0 point.
71- 80=2 points.	0-10 beats=3 points.	11-18= 2 points.	19-26= 1 point.	27-34= 0 point.	35-42=−1 point.
81- 90=1 point.	0-10 beats=2 points.	11-18= 1 point.	19-26= 0 point.	27-34=−1 point.	35-42=−2 points.
91-100=1 point.	0-10 beats=1 point.	11-18= 0 point.	19-26=−1 point.	27-34=−2 points.	35-42=−2 points.
101-110=0 point.	0-10 beats=0 point.	11-18=−1 point.	19-26=−2 points.	27-34=−3 points.	35-42=−3 points.

(C) Standing pulse rate.	(D) Heart rate acceleration immediately after a standard exercise.				
60- 70= 3 points.	0-10 beats=3 points.	11-20= 3 points.	21-30= 2 points.	31-40= 1 point.	41-50= 0 point.
71- 80= 3 points.	0-10 beats=3 points.	11-20= 2 points.	21-30= 1 point.	31-40= 0 point.	41-50= 0 point.
81- 90= 2 points.	0-10 beats=3 points.	11-20= 2 points.	21-30= 1 point.	31-40= 0 point.	41-50=−1 point.
91-100= 1 point.	0-10 beats=2 points.	11-20= 1 point.	21-30= 0 point.	31-40=−1 point.	41-50=−1 point.
101-110= 1 point.	0-10 beats=1 point.	11-20= 0 point.	21-30=−1 point.	31-40=−2 points.	41-50=−2 points.
111-120= 0 point.	0-10 beats=1 point.	11-20=−1 point.	21-30=−2 points.	31-40=−3 points.	41-50=−2 points.
121-130= 0 point.	0-10 beats=0 point.	11-20=−2 points.	21-30=−3 points.	31-40=−3 points.	41-50=−3 points.
131-140=−1 point.	0-10 beats=0 point.	11-20=−3 points.	21-30=−3 points.	31-40=−3 points.	41-50=−3 points.

(E) Return of pulse rate to standing normal after exercise.	
0- 60 seconds	= 3 points
61- 90 seconds	= 2 points.
91- 120 seconds	= 1 point.
2- 10 beats above at 120 seconds	= 0 point.
11- 30 beats above at 120 seconds	=−1 point.

(F) Systolic pressure, standing compared with reclining.	
Rise of 8 mm. or more	= 3 points.
Rise of 2-7 mm	= 2 points.
No rise	= 1 point.
Fall of 2-5 mm	= 0 point.
Fall of 6 mm. or more	=−1 point.

That there may be value in assembling the circulatory data under such a point system is indicated from an analysis of 54 cases of aviators who, when examined by the medical officers of the departments of the laboratory, were found to be ailing and physically below standard. The medical examinations included a study by the internist, neurologist, ophthalmologist, and ear, nose, and throat expert. The medical findings include a large variety of conditions, the majority being common to any group of men and in no way characteristic of aviators.

That which was of greatest interest in this analysis was the final efficiency score of each patient. The cases were distributed as follows:

Efficiency score.	Number of cases.	Percentage.	Efficiency score.	Number of cases.	Percentage.
18-17-16	0	0.0	3-2-1	9	16.6
15-14-13	3	5.6	0 or (−1)	2	3.7
12-11-10	3	5.6			
9- 8- 7	22	40.7		54	100.0
6- 5- 4	15	27.8			

Only six of the 54 cases had a score of 10 or better, while 88.8 per cent had scores ranging between nine and minus one. These figures seem to indicate that a score of nine or less is characteristic of physically unfit men.

Starting then with the assumption that a score of nine or less gives indication that the clinician may find something wrong with the patient, we have listed all men among the 148 considered in the circulatory test who had a low score. There were 46, or 32.4 per cent, with a score of nine or less.

The medical examiners working independently recorded abnormal conditions in 30 of the 46 men. Thus 65.2 per cent of the men who showed up poorly when scored by the cardio-vascular efficiency tests were in other ways found to be below standard. Two of the men were unfit because of excessive smoking and one had recently used alcohol too freely. The neurologist reported five as stale or nervous, the internist alone found five unfit, six were tonsil or local infection cases, and the remainder were found wrong by at least two of the medical departments.

It may be questioned whether the point system of scoring has been found to be more valuable than the Crampton Vasomotor tone index or than the use of exercise alone. In the unfit cases that we have studied the Crampton Vasomotor tone index has more frequently been above than below 50, while 25 per cent of these men had an index above 70. The advantage of the point system over the vasomotor tone index is found in the inclusion of four factors omitted in calculating the vasotone.

When the increase in the pulse rate after exercise is alone considered, the number of men singled out is much reduced. Out of the 20 men with an exercise acceleration of 21 or more beats, only 7 had a cardio-vascular efficiency score below 10, and the proportion found below normal by the clinician was much smaller. The time required by the pulse to return to normal after exercise also showed that a number of men, found by other examinations to be below standard, would have been passed without question by this test.

The point system for grading men on the basis of cardio-vascular efficiency tests can easily be applied by the flight surgeon. It is suggested that a score of nine or less gives reason for an overhaul of the patient by a clinician. Aviators with a low score might well be called back for further examination or observation. The scoring of cases should only be done to obtain an indication of condition and should not be considered as definite proof of efficiency or inefficiency. A poor rating suggests a search for a cause. If the cause is found, then apply the remedy which experience has proven most valuable.

TABLE VIII.—*Circulatory data on men from the front who exhibited a low score.*

No.	Pulse.			Systolic pressure in mm. Hg.		Diastolic pressure in mm. Hg.		Crampton.	
	Reclining.	Standing.	Exercise increase.	Reclining.	Standing.	Reclining.	Standing.	Index.	Score.
R 68	84	104	8	120	118	66	70	45	5
R 85	80	84	12	150	140	50	52	95	9
R 98	75	102	6	112	116	68	70	51	8
R 99	96	108	4	138	136	72	76	55	5
R 108	90	96	18	114	118	70	82	78	6
R 115	86	102	10	126	124	72	80	50	7
R 117	75	100	12	106	102	72	70	39	8
R 118	80	96	16	108	114	62	60	70	8
R 123	80	112	8	114	120	44	60	50	8
R 122	72	80	30	116	122	60	60	78	9
R 124	100	112	12	122	110	70	80	30	−1
R 130	105	105	35	110	126	84	88	....	2
R 82	92	120	8	132	116	50	50	0	2
R 60	90	132	0	118	127	60	72	28	4
R 78	75	112	0	98	103	60	58	41	7
R 131	82	96	4	118	116	74	76	53	8
R 134	78	114	14	110	110	70	74	30	4
R 143	80	102	14	112	128	60	72	88	8
R 144	82	110	6	114	116	72	76	45	6
R 145	88	108	8	122	120	70	72	45	4
R 148	76	90	14	124	116	74	74	38	7
R 155	84	102	8	122	140	72	80	98	8
R 157	78	104	8	122	116	74	78	28	7
R 160	84	96	16	118	136	66	70	100	6
R 161	72	112	−4	122	128	68	84	40	7
R 163	66	96	12	120	120	72	74	38	8
R 165	72	84	48	110	108	60	64	55	6
R 166	88	99	5	138	138	78	76	61	9
R 167	72	108	12	120	130	72	82	55	8
R 169	68	82	22	116	122	74	86	73	9
R 171	80	102	18	120	126	74	76	63	7
R 180	68	72	36	124	118	62	64	55	7
R 135	72	92	12	104	102	60	66	55	5
Average	81	101	13.2	118.8	120.9	67	72	59.1	6.38

In Table VIII have been assembled the more important circulatory data obtained in France from 33 American aviators soon after return from the front after the signing of the armistice. This is the group that received a low cardio-vascular efficiency score. It is of interest to compare these data with other records obtained from men apparently physically normal. The average pulse rate for the reclining position for the 148 cases was 74. In this group of low-score men it was 81. However, six of them had a rate of 74 or less. In the standing position the large group had an average pulse rate of 89, while the subnormal group averaged 101, and of these only five had a standing rate below 89. The systolic pressures do not show marked differences. The large group averaged, reclining 118 mm., and standing 123 mm. Hg. The averages for our subnormal group were, reclining 119 and standing 121 mm. The diastolic pressures were about the same for the two groups of subjects. About 23 per cent of the 148 cases had a diastolic pressure below 70 when standing, while at least 40 per cent were below during reclining.

Birley states that "It has been shown by Starling and his co-workers by the use of the heart-lung preparation that the heart is capable of responding within wide limits to changes in the mechanical demands made upon it so that it is difficult to imagine a more perfectly regulated machine than the heart. How wide these limits can be is demonstrated in the following tables, where high and low blood pressures are combined with fast and slow pulses in a seemingly random manner." Our experience confirms his opinion that the relationship of the rate of pulse and height of pressure follow no definite law. The arterial pressures seem to us, in themselves, to shed no light on the question of physical condition of the man.

CARDIO-VASCULAR AND ENGLISH EFFICIENCY TESTS.

It has been pointed out earlier in this chapter that the experience in the A. E. F. Medical Research Laboratory at the Third Aviation Instruction Center in France failed to show the English tests useful in giving hint that the patient was below standard physically. The group of 46 men rated below standard in the cardio-vascular efficiency tests gave the following results with the English tests: Vital capacity, lowest 3.2, highest 6.1, average 4.5 liters; breath hold test, lowest 32, highest 128, average 85.4 seconds; expiratory force, lowest 70, highest 188, average 124.5 mm. Hg.; "fatigue" test, lowest 31, highest 85, average 53.4 seconds. The average for each test in this group of men is above our group averages and above the English averages which have been recorded in Table II. There is a complete lack of parallelism in the results of the two sets of tests.

CARDIO-VASCULAR EFFICIENCY AND ENDURANCE OF LOW OXYGEN.

Since physical fitness has seemed to influence the ability of men to endure low oxygen it was thought that the cardio-vascular or other efficiency tests might be used to estimate the altitude that the aviator would tolerate.

A study of 130 aviators at Hazelhurst Field, Mineola, Long Island, N. Y., in which the Vasomotor tone index was compared with the physiological responses during exposure to the influence of the low oxygen of the rebreathing test, showed that Crampton's Vasomotor tone index did not give an indication of the subject's ability to withstand low oxygen. On checking the altitude low oxygen classifications of the 48 A. E. F. cases against their Vasomotor tone indices we again fail to find any relationship.

An examination of the data of the circulatory tests, separately and collectively, as in the "point system" for grading, also leads to the conclusion that a man may do poorly in these tests and yet respond well to oxygen want. Among 46 men with a cardio-vascular efficiency score of nine or less there were rated in the low oxygen test, Class I, 23; Class II, 14; and Class III, 7; and not rated, 2.

SECTION IV.

HYGIENE.

It has repeatedly been asserted that aviation medicine has as a primary function the task of keeping the flier physically and mentally efficient and alert. When the United States entered the war it was evident that medical men were not informed as to the nature of the wear and tear to which the body of the flier was exposed in the pursuit of this new occupation. That the ordinary standards of fitness for army service are not applicable in the case of a flying man was evidenced in the experience of our Allies. They found that even though the flier succeeded in avoiding accidents and was not injured or brought down by the enemy, nevertheless, the period of usefulness as measured by hours of air work was for the vast majority of men of short duration.

It is obvious that the first aim of the leaders in aviation medicine was to determine standards of fitness required in air work and to find the explanation for the physical and mental deterioration observed among aviators. This knowledge was sought by researches carried on in the laboratory and in the field. The problem was to discover what the body is doing during flying and what it is able to do. The application of the methods of physiology soon began to reveal answers to these questions, but the complete answer will yet require further years of careful study.

The facts as rapidly as discovered were passed on to a selected group of medical men whose business it became to apply this knowledge to the care of the aviator. From the field experience of these officers, many of whom were capable observers, and the collaboration between them and the experimentalist it has become possible to formulate a few definite facts on the hygiene of the aviator.

It is recognized that aviation medicine and hygiene are still in the making. There is no agreement as to whether there is a clearly defined aviator's sickness. Among the French, Ferry and Garsaux have described the "syndrome of aviator sickness." Flack and Heald, speaking for the English, state that there are symptoms and signs which may now be considered as due directly to prolonged air work at various altitudes. "The symptoms are not so definite or simple that anything in the nature of a definite air disease syndrome can yet be claimed for them; but the appearance and reappearance of them in overlapping groups is distinctly suggestive." A German writer, Hirschlaff, finds no conditions distinctive of aviation alone, although he admits that the flier may develop acute sickness when at high altitudes.

In the United States we do not admit an illness that appears only among aviators. It is recognized, however, that the flier's body is subjected to an enormous strain, the result of sudden change. He rises from the ground level to which he is adapted to great altitudes to which he must suddenly adapt himself to secure the requisite oxygen; from a state of equilibrium in orientation to one of instability; from a region of comparative warmth to one of extreme cold; from a state of comparative quiet to a motion that has the effect upon him of a gale of wind. In passing from one extreme to another physiological responses and adjustments of unusual rapidity must be made. These reactions often tax the adjusting systems to the utmost and presumably may overwork them.

Experience has shown that in sports such as cycling, rowing, automobiling, etc., in which the subject is subjected to great physical and nervous strain, the period of efficiency is limited. It is in these impossible to fix upon the exact duration of this period. It depends upon the physical endowment of the subject and the care that he gives his body. However, each athlete has his day, some lasting only a short period, some for months and even years. The strain in aviation, as it is pursued in war, demands more of the human mechanism than any other sport. It also follows, therefore, that the period of efficiency is limited. It may vary in length from a few months to a few years. The exact duration of this period will depend upon the effort demanded from the subject and the conditions under which the flights are made. Above all it will depend upon the mode of life of the aviator.

Just as the athlete is unaware of the causes operating to limit the period of efficiency and is unfamiliar with the symptoms and sensations that give hint of approaching staleness, so it is with most fliers. Ask the aviator what are the sensations experienced in the course of ascent and descent. He as a rule can not tell you much. Either his attention during flight has been so absorbed with the maneuvering of his ship and other details, or his power to make a subjective study of himself is so limited that he declares that he has never experienced air sensations and fatigue. Certain it is that the majority of aviators have failed to recognize the sensations due to altitude, possibly because as experienced by them they have been insignificant and transitory. There is a small group the members of which freely avow the feeling of malaise with which they have been affected at different altitudes.

The majority of athletes submit to the trainer's rules regarding food, the bath, sleep, and amount of exercise, but as a rule can not explain the value of each. So with the aviator; we must not expect him to know value in hygiene unless he has made a careful study of all factors.

In regard to the study of maintaining efficiency aviators assume four attitudes.

(1) There is a large group indifferent to the value of physical fitness. Corbett and Bazett, from a wide experience with English aviators at the front, write, "We have seen numerous pilots who appear hardly to have heard of physical fitness and have never learnt to take any sort of pride in their bodily health." Such men fail to recognize that the human body is a machine and that it needs attention and care. They indulge every whim. They are liable to smoke excessively, play cards all night if the game is interesting, use alcoholic liquors immoderately, and in other ways overtax the mechanism.

(2) A fatalism has made many careless. They believe each man has been numbered by fate and when that number is called the individual's work ends no matter how careful he may have been and what the condition of body and mind.

(3) A small number emphasize the need of protecting the body against the effects of wind and cold. They even would use oxygen to overcome the effects of high altitudes. If these are done successfully they believe the period of efficiency may be maintained over a long period of time.

(4) Another small group recognize that the human body is a machine. They believe that a healthy body will withstand the strain of flying and be ready to meet emergencies. Such men emphasize the value of a proper amount of sleep, of physical exercise, and moderation in the pleasures of life.

It is difficult to arouse young men to consider the problems of individual efficiency. The aviator is of that age when the bodily condition is at its best, and when he has not yet learned his limitations. He never stops to take account of stock. Filled with the energy and enthusiasm of youth, he frequently recklessly or unheedingly squanders his reserve of vitality. How to reach the individual aviator so as to secure his cooperation for efficiency has been a difficult problem. The daily life of every flier can not be personally supervised by the flight surgeon nor the physical trainer. Unless the individual understands the problem of efficiency and gives attention to those conditions of living that secure and maintain efficiency an early deterioration can with certainty be predicted.

That young men are not always in excellent physical condition was well demonstrated by the military medical examinations of men drafted or volunteering for military service. More than one-third, about 38 per cent, of the young men were rejected because physically and mentally they did not conform to the requirements.

Experience has shown that to maintain efficiency the aviator should obey the simple rules of personal hygiene. Even though he recognizes that the results of following the rules give high efficiency, the average individual finds these simple things irksome and that it requires strength of mind to follow them day in and day out.

The necessity for health comes from the fact that the aviator has need of all his physical energy and intelligence. Flying is a question of an active, well-balanced, decisive mind, and of sound, quick reflex actions. Not a thing can be left to chance. The aviator must be able to recognize at once the slightest difficulties with his machine. His senses must give him accurate information of changes in the rhythm of his motor, of the sing of air across the wires of the machine, and of his position in space. He must be master of his impressions and be ready to make prompt decisions in a calm, cool manner. His correcting movements should be made with precision and without exaggeration.

It is now clearly recognized that the aviator's reactions to stimuli are slowed down or disturbed by disease, worry, fatigue, after excess in alcohol, and after other excesses. A delay of a second or part of a second in correcting an error in difficulties in the air or in landing may mean all the difference between a crash and safety. Hence hygienic living is necessary to keep the body and mind in good condition. In addition excellent physical condition permits the body to react with more adequate compensations to altitude and cold.

As has been stated, good health and efficiency are maintained by applying the ordinary simple rules of personal hygiene. Since these rules are so ably set forth in many books on the subject, a lengthy statement of them is omitted here. The aviator's attention should be directed to the following topics:

One of the first essentials for good flying is a proper attitude of the mind. Nervous breakdown has been a frequent cause of failure among aviators. Fear and worry may temporarily or permanently make an individual unfit physically and mentally for flying. Fear removes the pleasure and interest of flying. It interferes with the judgment and decisiveness of the mind and causes movements of correction to be exaggerated and poorly coordinated. A nervous individual reacts in a variable and usually uncertain fashion. Fear frequently leads to frightful dreams during sleep. This disturbance of rest is a factor in fatigue which will be referred to later. Worry, like fear, exhausts the nervous system. It has been said that "to worry about the future is to dig your own grave; let the undertaker attend to that. The present is the servant of your will." Worry interferes with digestion and other functions. It also causes insomnia. In order to last long in aviation the individual must enjoy flying and lay aside fear and worry. Guilbert has written of the aviator: "The first thing that would be necessary to him is a great liberty of spirit. He should avoid family attachments and other liaisons too absorbing. He should accustom himself to react against anxieties and unpleasant conditions of all sorts. How can a pilot be a complete master of his apparatus if he is distracted in his mind and his thought is elsewhere?"

Regularity in living gives most certain assurance of health and efficiency. Physical trainers, from experience in the conditioning of men, have learned the value of regularity, and that this, with a proper balance of rest, work, and a careful selection of food, gradually bring the individual to top form.

Fatigue lowers efficiency in a measurable degree. Work and pleasure may when continued under fatigue cost more effort and greater injury than in normal life. Overwork, whether that of useful labor or that of excess in pleasure and alcoholism, injures health because of strain. It postpones rest beyond the point when rest can accomplish the needed repair. In the accumulated fatigue of overwork, organs, even though retaining the appearance of perfect health, may yet refuse to function properly. Among the evidences of fatigue may be nervous dyspepsia, nervous palpitation of the heart, nervous eyestrain, and other similar functional ills.

Proper sleep is most important. Eight hours is a good average. Only a few men can do efficient work on seven hours or less.

The alcohol problem, despite the opinion of many aviators to the contrary, is a grave one. All the belligerent nations found that in order to save men from drunkenness, from the inefficiency that comes from partial intoxication, and from venereal diseases that come from lack of self-control when under the influence of alcohol, it was necessary to reduce, and if possible, eliminate the use of alcoholic drinks. Unquestionably a number of serious crashes in France among American fliers occurred on the day following an evening of excessive use of alcohol. Alcohol may falsify sensations and predispose to foolish action.

Smoking when carried to such excess that it causes nervousness, palpitation of the heart, faintness, or double vision must be recognized as a cause of fatigue and loss in efficiency. Most aviators smoke too much. Few are honest enough with self to admit their limitation.

In this connection, the use of drugs needs mention. Many aviators when not feeling well use aspirin. Unless absolutely necessary, a man should not fly when he feels ill or unfit. Drugs do not render one fit, but only temporarily hide the symptoms of fatigue and illness.

The diet should be generous and nourishing. The habit of eating between meals, of using soft drinks, and the constant or frequent eating of confectionery cause the digestive disturbances so commonly seen among aviators.

Guilbert has pointed out that "It is never good to go up in an airplane without first having moved one's bowels and voided the urine, so as to avoid, in case of a serious fall, the rupture which may result in the intestine or bladder. The old adage of our fathers, 'Head fresh, abdomen free, feet warm,' should be observed in aviation more particularly than elsewhere." The bowels should also be attended to daily to avoid the intoxication which results from constipation. An added reason for voiding the urine is that the cold of high altitude leads to an increased formation of urine, and this causes distress when the flight is of long duration.

Physical exercise, judiciously employed, will do much to secure physical fitness and serve to avert the onset of staleness. It also trains the body to sustain the compensations needed during flying at high altitudes. It is now well known that the man who is in the "pink of condition" as a result of physical training is much more resistant to altitude sickness than the physically "soft" man. The ability to endure high altitudes comfortably and well is dependent upon adaptive changes in the breathing, the circulation, and the blood. These adaptive changes are similar to those resulting from the regular and consistent following of a program of physical training. The physically untrained individual breathes more frequently and shallowly than the trained man whose breathing is slow and deep. Shallow breathing does not ventilate the lungs effectively.

The habit of deep breathing can readily be cultivated by exercise but not so satisfactorily by voluntary effort. At a high altitude physical exertion makes a greater demand on the heart than the same amount of work does at sea level. However, in men in excellent physical condition the strain thrown on the heart is less than in the individual weakened by dissipation and fatigue. Consistent physical work increases the percentage of haemoglobin in the blood, and this is advantageous at high altitudes.

Experience with aviators in France demonstrated that certain diseases made for inefficiency; chief among these were the venereal diseases and chronic local infections. "The four great factors that produce human ineffectives, as judged by recent experiences in the draft, are defective eyesight, poor teeth, bad feet, and venereal disease." The aviator with a venereal disease should at once place himself under competent medical care. He should not fly until permitted to do so by the flight surgeon. The cold and the rush of air in flying predispose to infection in the head and throat. The aviator should, therefore, occasionally be examined to determine that teeth, gums, nose, and throat are in a healthy state.

Rowntree advises the aviator to consult the flight surgeon—

When he is ill,
When he is not feeling fit,
When he feels insecure in his work,
When his flying records are poor, and
When he has had an accident.

Rapid descent sometimes causes a heavy feeling in the head, a sensation of stopped-up ears, and sometimes pain in the ears and throat. This ordinarily can be avoided by several times during the descent blowing with the nose and mouth closed.

There are two ways for the aviator to meet the demands of flying: (1) To maintain the body in such a degree of fitness that it recognizes and responds properly to stimuli, that it quickly and adequately makes the adjustments necessary to supply the oxygen demanded for efficiency at high altitudes, and that the heat-producing and heat-conserving mechanisms respond adequately to the changes in atmospheric temperature. (2) To protect the body against the wind and cold by a proper use of clothing and helmets; to protect against the influence of altitude by providing a supply of oxygen.

We have discussed maintenance of efficiency above, and will now briefly consider protective measures.

Clothing worn while flying should not fit too tightly. That next to the skin should be made of wool, as this counteracts most advantageously the loss of heat. A combination suit, fur-lined, and fur-lined boots make a satisfactory outer covering.

Frostbites may be prevented by smearing the face and hands with a thin layer of vaseline. If the dryness of high altitudes causes parching and chapping of the skin, cracking of the lips, and dryness of the nose and throat, these also may be prevented by an ointment or spray of petrolatum, etc.

USE OF OXYGEN.

The use of oxygen during flights, especially when at very high altitudes, has been urged for reasons that are simple and definite. As the ascent is made the oxygen pressure of the atmospheric air rapidly becomes less. The freedom with which oxygen enters the blood from the lungs and passes from the blood to the tissues is determined by the oxygen pressure in the air and in the blood. The higher the oxygen pressure the more adequately will the tissue needs for oxygen be supplied; a fall in oxygen pressure may result in a tissue shortage of oxygen.

The human machine can adjust itself to some extent to the decrease in the oxygen supply of high altitudes. The adaptive changes that occur in the body as the aviator ascends are in some respects like those that occur during physical exercise. They involve the circulatory and respiratory mechanisms and the blood. The breathing becomes deeper and sometimes labored; the heart beats more frequently, thus circulating the blood more rapidly; and there may also be an increase in the haemoglobin of the blood. This increased work of the respiratory and circulatory mechanisms undoubtedly contributes to the fatigue of exercise and of flying. When adjustment is excessive, or inadequate, fatigue is more marked.

Flack and Heald summarize the beneficial results of using oxygen as follows:

(*a*) Mitigation of the fatigue always present after long flights.

(*b*) Abolition of staleness from long periods of flying at the front.

(*c*) Increase of mental alertness.

(*d*) Increase of muscular vigor.

(*e*) Amelioration of symptoms, such as giddiness, fainting, etc.

A brief survey of physiological experiments conducted in the pneumatic or low pressure chamber at the Medical Research Laboratory at Mineola, Long Island, N. Y., illustrates the effects of altitude and beneficial influence of oxygen.

When men are subjected to a reduced pressure equivalent to 18,000 or 20,000 feet, the breathing shows a well-defined increase in depth which results in an augmentation of from 20 to 128 per cent. If to a man who has such an increase in breathing oxygen is administered, there results an immediate quieting of respiration.

The effects on the circulation are equally marked. Altitudes of 18,000 and 20,000 feet may bring about an increase in the systolic blood pressure and invariably accelerate the frequency of the heart action by from 15 to 40 beats per minute. One subject at 20,000 feet had a systolic pressure of 140 mm. Hg. and a pulse rate of 112. One minute after he had received the oxygen the systolic pressure had dropped to 122 mm. and his pulse to 80.

The beneficial effects are evidenced by an immediate slowing of the pulse rate and these effects continue for several minutes after the oxygen is again withdrawn.

Two members of the Medical Research Laboratory by the use of oxygen withstood a rarefaction of the air equal to 34,400 feet without any trace of the respiratory or circulatory symptoms of altitude.

The lack of oxygen at high altitudes manifests itself in other ways than those mentioned above. The stethoscope reveals the fact that the heart sometimes labors as though the subject were exercising. There usually is some cyanosis. The ocular functions are often disturbed. The power of attention and discrimination may be reduced. Oxygen administration, once these conditions have developed, will immediately restore each organ to normal.

Experiments conducted for the purpose of determining the effect of low oxygen on handwriting and the ability to copy words show that at 18,000 feet in some subjects the handwriting becomes difficult to read; whereas errors in spacing, following the line, omission of words, etc., are more frequent. It was proven that the administration of oxygen for two minutes completely restored the handwriting and the accuracy of copying to normal.

From this evidence the conclusion follows that oxygen will at least mitigate the fatigue of high altitude flight, will increase muscular coordination and mental alertness, and maintain or restore clearness and accuracy of vision.

Maj. Rippon, Royal Air Force, Medical Service, England, examined two officers before and after altitude flights with and without oxygen and found by the use of fatigue tests that without oxygen the pilot returned both mentally and physically fatigued, while with oxygen there was little or no evidence of fatigue.

Testimony has been made by English commanding officers of fliers and observers that shows the regular use of oxygen increases length of service and amount of work.

The ——— Squadron, which, as you know, has been using the oxygen apparatus for months, is doing six times the amount of work that any other squadron is doing without oxygen.

There is no question that these men in my command who have used the oxygen apparatus are not by any means as tired as they used to be before they used this apparatus. Since the use of the oxygen the men have not complained of any headaches, fatigue (except what you might call ordinary fatigue), or vertigo.

Considerable after effects have been noted in individuals who have been subjected to the oxygen want while flying at very high altitudes. These, as has been pointed out, involve the respiratory and circulatory mechanisms. When oxygen is used during the flight these after effects do not occur. Birley found that the chief difference between individuals who have done their work at high altitudes as compared with those who have flown at low altitudes lies in the more frequent occurrence among the former of blood pressures below normal, with which is usually associated a rather slow pulse.

Unfortunately equality of service seems to have been the aim of aviation. Had it been recognized that all individuals are not and can not be endowed with equal capacity for response to the influence of low oxygen, and that many are incapable of sustaining the compensations day after day in that their "ceiling" gradually becomes lower, the use of oxygen would have been the rule rather than the exception. An aviator who can only compensate for moderate altitudes may fly with perfect safety to very high altitudes when supplied with oxygen. Furthermore, his "ceiling" then is determined by the power of his aeroplane and not by his physical limitations. If equality of service must be our aim then the need of supplying oxygen by artificial means becomes imperative.

Flying demands an individualism in a degree unknown in any other branch of the service. Individual initiative can only be maintained when the intellect and the sense organs remain in a high state of efficiency. Our low-oxygen altitude examinations have revealed that the power of attention begins to deteriorate in many men who belong in Class I at moderate altitudes. This, it is believed, gives an added reason for using oxygen.

Flack and Heald, writing on the value of oxygen to aviators at relatively low altitudes, stated that—

It is not suggested that one flight, whatever be its nature, is in itself deleterious, or, except in the case of great altitudes, calls in any way for the administration of oxygen, except to those totally unfitted to fly. But, from what has been written, it will be seen that the strain of flying will tell, sooner or later, upon the aviator through the cardio respiratory, nervous, or muscular mechanisms, the degree depending largely upon the individual—thus causing many of the failures in the field.

A question sometimes asked is whether the use of oxygen during a flight should be intermittent or constant. The studies in the low-pressure chamber show that after the beneficial effects of oxygen have been obtained and the artificial supply of oxygen is then cut off the effects last for from four to six minutes. However, within a minute after the oxygen is withdrawn the pulse rate will begin accelerating, at first only a beat or two, but with each added minute the acceleration is more pronounced. Respiration likewise soon again becomes deepened and protrudes itself into the field of consciousness. Intermittent use of oxygen would serve to keep the aviator efficient and alert. The action on circulation and respiration would be that of alternate periods of speeding up and slowing down. Just how fatiguing such alternating periods would be has not as yet been determined.

Flack and Heald believe that it would be a good practice to administer oxygen for a few minutes to all airmen after long flights at any altitude. This contention is supported by observations by Hill and Flack in which it was shown that in the fatigue of athletes oxygen inhalation increases the lasting power and decreases the fatigue, probably by maintaining or restoring the vigor of the heart. They believe that the fatigue which follows an athletic feat is mainly cardiac in origin and due to want of oxygen.

CHAPTER IV.

DEPARTMENT OF PSYCHOLOGY.

FLOYD DOCKARY, Captain, Sanitary Corps.

The aviators examined by the Psychology Department in the A. E. F. may be divided into two groups. The first group included (*a*) flying officers who had shown certain defects in flying, (*b*) those about to go on leave, (*c*) those who had recovered from illness or injuries, and (*d*) a few aspirants who applied for the regular Blank 609 examination. The second group included the monitors of the Third Aviation Instruction Center, and chasse pilots and observers, returning from the front after the armistice, who had proved their ability. Of these in the latter group, the monitors and chasse pilots may be considered a group of especially good fliers, for the commanding officer of the instruction center reported that the monitors had been selected because of their aviation aptitude. He considered them equal to the aces.

The examination of the first group was for purely diagnostic purposes with the assumption that the tests used were valid for the purpose. In this group, 131 officers and aspirants were examined either with the rebreather, or the reaction times, or both. In the case of the rebreathing experiment, the standards had already been determined at the Mineola laboratory. The reaction time tests were used with greater conservatism, depending upon the French standards as established by Dr. Nepper, in case a definite judgment of a man was necessary.

The second group, the selected men, was used solely as a means of finally testing and revising, if necessary, the methods of examination which we had employed. As they were all men who had demonstrated their ability as flyers, either at the front or at the instruction center, it was hoped that more definite data regarding the tests might be obtained.

The monitors were all in normal physical condition, on regular flying duty. With possibly a few exceptions, their attitude toward flying and toward the laboratory was good. There were two notable exceptions. One was particularly anxious to discontinue flying, and undoubtedly simulated unfitness. Another was one of the best flyers at the center, but he said he had no confidence in the work of the laboratory, and, therefore, did not cooperate satisfactorily in the experiments. The results of these and a few other doubtful cases, were omitted in the final consideration of the data.

From the pilots and observers returning from the front, after the armistice, it was more difficult to select men that could be relied upon as to their physical condition and mental attitude. They were all examined first by the medical department for general physical fitness. But practically all of them were feeling the effects of the work at the front and the trip back to the instruction center, which had included one day or longer in Paris. We must add to this the intense desire, now that the war was over and they were on their way home, to get there as soon as possible. All of those diagnosed by the medical department as unfit because of staleness or for other more specific reasons, have been considered separately. In addition, several who showed definite signs of being unable to do their best work at this time, were also placed in this group of unfit. On the whole, the attitude and willingness to cooperate was excellent.

As the work with the miscellaneous group contains no new material and the compiling of data at the Mineola laboratory will be more complete than the similar work in the A. E. F., this report will be confined more particularly to the study of the selected group.

The monitors and chasse pilots were examined in the laboratory at the Third Aviation Instruction Center. The tests consisted of a general physical examination, the standard rebreather, simple reaction times to visual, auditory and tactual stimuli, and a steadiness test. The observers were examined at the laboratory at the Second Aviation Instruction Center. In addition to the rebreathing test, a new test devised by Lieut. Isaacs for testing the speed, reliability and confidence of observers, was used.

The principal features of the results obtained with the rebreathing test, are those found when a comparison is made with the results obtained with cadets and flying officers in the United States. We may assume that, while those tested in the United States included many excellent men and men of long experience in flying, there were many inferior men who had not yet been eliminated. The more advanced the school, the fewer inferior men would we expect to find. The monitors and chasse pilots tested in the A. E. F., were all picked men, from whom all the inferiors, or unsuccessful flyers, had been eliminated. We may assume, therefore, that if the tests are capable of differentiating any marked mental characteristics, they may be shown by this comparison. The results obtained with the observers have been omitted, as certain complications in the management of the apparatus rendered these results unreliable.

TABLE 1.—*Numerical scores.*

	A.E.F.			United States.		
	Number cases.	*M.*	*P.E.*	Number cases.	*M.*	*P.E.*
Off by psychologist	110	−11.77	±0.96	2,395	− 8.05	±0.22
Off by clinician	20	−21.5	±2.74	947	−10.22	± .39
Total	130	−13.26	± .94	3,342	− 8.66	± .20

If we compare the numerical scores (Table 1) of the overseas group with those of the men tested in the United States, we find that the mean score of the former is somewhat lower. There was a considerable difference in the mean score at the different fields in the United States. One of the factors in this difference was due to the fact that some fields were for more advanced flyers, with the consequent elimination of many of the unfit. A more pronounced factor however, seemed to be the personnel of the various examining units. Some were over-cautious while others were too lenient in their grading. The mean numerical scores of each psychologist working in the United States, have been compiled at the Mineola laboratory. These range from -2 ± 1.16 to $-32.7 \pm .85$. If they are arranged in order of values, they range from 1 to 30. The mean score of the results in the A. E. F. correspond to the nineteenth place. One of the psychologists in the A. E. F. had also served at Hazelhurst Field and at Kelly Field. The mean of his scores at these two fields was -3.5 ± 1.13 and occupies fifth place in the series. It will be seen, therefore, that the selected group of fliers does not make a particularly good showing in numerical scores.

It has been assumed in all the rebreathing tests that the first attention and motor effects should appear at the same time; also, that the distinct attention and motor effects should appear together. As a matter of fact, actual experience demonstrates that in neither case is this the general rule. There is, however, some correlation between the time of appearance of the first effects, and a more decided correlation between the appearance of the distinct effects. (Table 1). Our correlation for the first effects is not as large as that in the United States, but our correlation for the distinct effects is practically the same. Our correlation of the length of the run, and the per cent of oxygen at the end of the run, is $-.40 \pm .053$, indicating that those subjects who continued longer reached a lower per cent of oxygen.

The most interesting feature of our results is the relatively late appearance of the attention effects as compared with the appearance of the motor effects. In the curves of Plates I and II, the distances on the abscissae represent the differences in minutes of the appearance of the attention and motor effects, and the ordinates the number of cases. Those cases to the left of the zero ordinate represent the cases in which the motor effect appeared earlier than the attention effect, and those to the right represent the cases in which it appeared later. It will be seen that the appearance of the first attention effects one minute after the first motor effects was most frequent, both in the United States and in the A. E. F. (Pl. I.) However, a decidedly greater per cent of monitors and chasse pilots show a delay of one minute or more in the attention effects, than is shown by the home group, except in the extreme. A comparison of the distinct effects (Pl. II) shows the same tendency.

Whether this difference between the two groups is due to a selective process, in which the inferior aviators have been eliminated from our group, or whether it is due to the more extensive training of the moni-

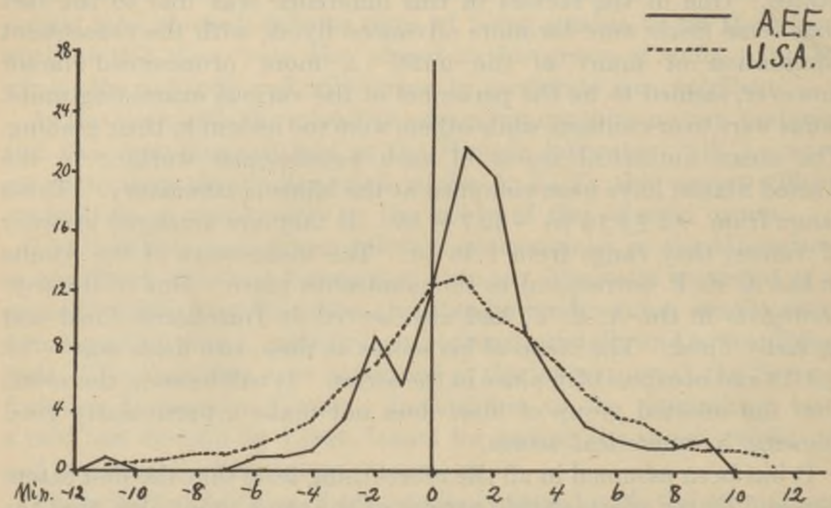


PLATE I.

tors and chasse pilots, it is impossible to determine from our data. It does, however, mark a distinct difference between our selected group and the more general group. It may be further noted that this delay of the attention effects was at the expense of the motor effects, as the mean numerical scores of the monitors and chasse pilots is not particularly high. It was observed in the early days of the rebreathing test that the subject could compensate for either the attention or motor by a greater concentration of effort upon one to the neglect of the other. Capt. Johnson has suggested that the difference noted in our results (Pls. I and II), might be due to a variation in our method of giving the directions to the subject, or to the unintentional lengthening in the time that the lamps, to which the subject reacted, were lighted. As the lamps were operated by buttons pressed by an assistant, slight variations were possible.

Both explanations are possible, though we are inclined to believe they did not play an important part in this particular case.

If further investigation should confirm our results—that the superior aviators possess greater powers of attention, or are capable of greater attention at the expense of motor effort—it would indicate that the rebreathing test might throw some light upon the qualifications of a good flyer in addition to his endurance of low oxygen.

As the French depended upon simple reaction times as almost the only psychological examination in the selection of candidates for aviation, it was recommended by the Medical Research Board that

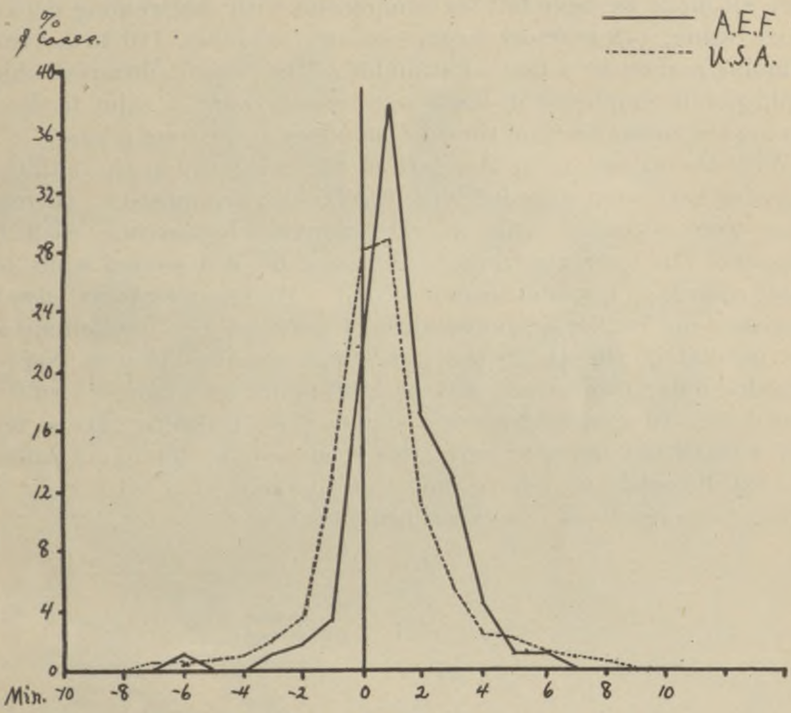


PLATE II.

the psychology department investigate the validity of these tests. The monitors and chasse pilots afforded good material for this investigation, as they were all men of proved ability. In addition, we were able to secure the rating of a large number of these men from the training department of the Third Aviation Instruction Center. The degree of correlation between their reaction times and the training department rating, should indicate the value of the tests.

The attempt was made to reproduce, as nearly as possible, the experimental conditions of the French methods as developed by Dr. Nepper. Owing to the fact that only 20 minutes were allotted to this department for special problems of this sort, reactions only to visual and auditory stimuli were attempted at first. Later, the time was sufficiently extended to permit the use of reactions to tactual stimulus also. It was also soon found that the reactions to the visual stimulus with our apparatus were invalid, due to the presence of a simultaneous auditory stimulus which could not be completely eliminated, and it was necessary to discard these results. Another difficulty in securing data from a large number of men for comparison was the fact that many of the men examined in the laboratory had not been at this center for instruction, and consequently were not rated by the training department. After these various eliminations were all made we have left for comparison with the training department rating, 148 reactors to an auditory stimulus, 110 to a visual stimulus, and 68 to a tactual stimulus. The results obtained which could not be employed in these comparisons were of value in determining the mean reaction times of monitors and chasse pilots.

With the exception of the part of the reactions to the auditory stimulus that were recorded with the Dunlap chronoscope, all reactions were recorded with the D'Arsonval chronoscope used by Nepper. The former records in thousandths of a second while the latter records in hundredths of a second. We have, however, always expressed our results in thousandths of a second, reading half spaces on the dial of the D'Arsonval as 0.005 second. Though Nepper recorded only 10 reactions with each stimulus, we made it a rule to record 25. In spite of Nepper's claims that 10 results gave as reliable a mean as a larger number, this is against the opinion of American psychologists who have done considerable work with reaction times. The results of our experiments confirm the latter view.

TABLE 2.

	Number of cases.	*M.*	*P. E.*	*σ*
Reaction time:				
Visual	148	197	±0.99	17.9
Auditory	192	155	± .95	19.5
Tactual	90	143	±1.76	24.7
Coefficient of variation:				
Visual	148	8.3	± .17	3.
Auditory	192	11.4	± .16	3.3
Tactual	90	13.4	± .23	3.5

TABLE 3.

Reaction type.	Class.	*M.*	*P. E.*	*σ*
Visual	Monitors	189	±2.98	23
	Chasse (fit)	197	±1.15	17
	Chasse (unfit)	205	±4.22	22
Auditory	Monitors	153	±1.54	19
	Chasse (fit)	157	±1.24	18
	Chasse (unfit)	158	±2.73	20

Table 2 gives the results of the monitors and chasse pilots combined. In the first part of the table are given the mean (M), probable error of the mean (PE_m) and the standard deviation of the mean (σ) for the entire group, based on the mean reaction times of each individual tested. The second part of the table shows the mean,

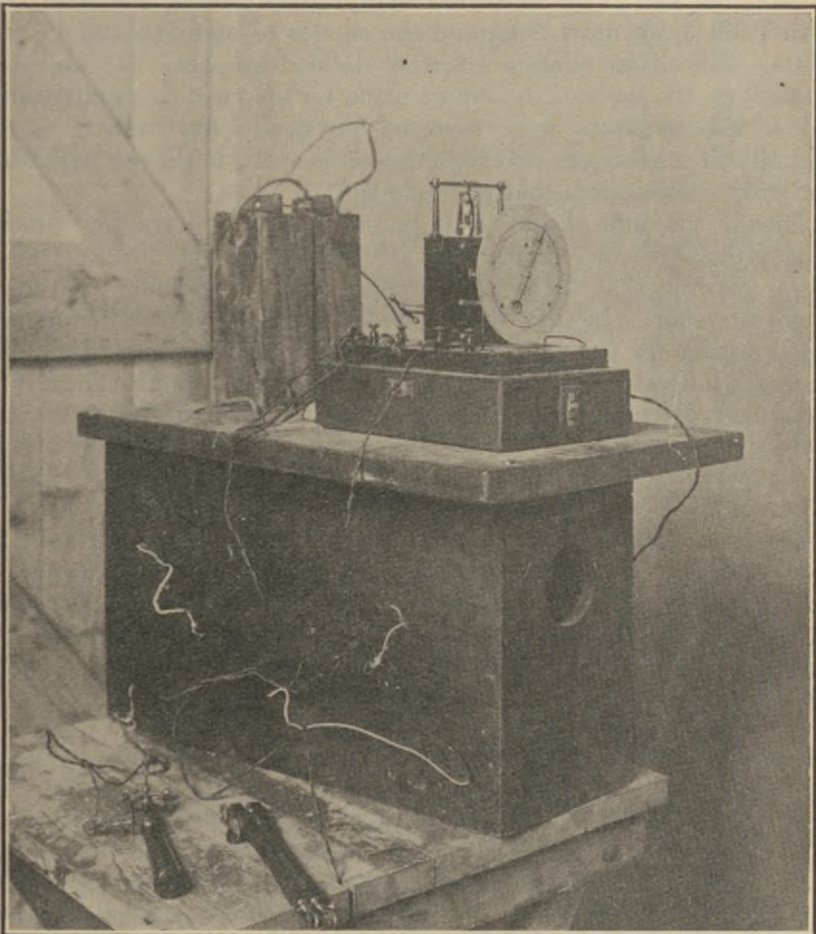


FIG. I.—D'Arsonval apparatus for recording reaction time.

probable error and standard deviation of the coefficients of variation of each individual from his mean reaction time.

The corresponding mean reaction times reported by the French[1] are 0.190 second for visual stimulus, and 0.140 second for auditory and tactual stimuli. They do not report definitely the amount of deviation from these means, except to say that more than 0.10 second

[1] Camus and Nepper, Recherches sur l'aptitude a l'aviation. Institute général psychologique, Extrait du bulletin nos. 1-3 17e Année, 1917.

lengthening in reaction time, was considered sufficient to bar a candidate. They also apparently considered 0.10 second as the maximum deviation of an individual from his own mean reaction time. It will be observed that our means are somewhat higher than the French, and that there is a wider deviation not only between individuals, but also in the separate reaction times of each individual.

In Table 3, we have separated the results of monitors and chasse pilots. The chasse pilots are further divided into the "fit" and the "unfit" on the basis of the report made by the medical department. All of the monitors were reported physically fit. Reactions to tactual stimulus are omitted from this table owing to the few monitors and unfit chasse pilots that are included.

Though the unfit chasse pilots present the longest reaction times, their probable error and standard deviation from the mean are also large, showing that there were probably some very long, and also some very short, reaction times included in this group. The longest reaction time for the unfit was 0.220 second for the visual stimulus, while the longest for either other group was 0.200 second. The unfit, as a whole, grouped only a little above the mean for the entire group, and three present mean reaction times as low as 0.130 second. The best reaction time for the fit was only 0.120 second. If we should eliminate those with reaction times above 0.200 second, as the French advised, we should eliminate only one of those recognized by the medical department to be unfit. It may be, however, that the medical examination was not infallible. But we would expect an error to be made in the other direction. The medical man might be expected in the ordinary methods of examining, to overlook certain defects rather than to emphasize them.

A further check upon the value of reaction times in the selection of aviators, is the comparison with their ratings in flying ability furnished by the training department. We should not expect too high a correlation, even though our test is a good measure of aptitude in flying; for, doubtless, the training department rating is frequently influenced by other factors, not directly related to flying aptitude. Strict observance of military forms, sociability, etc., can not be strictly eliminated from a rating of this sort. We might expect, therefore, that a man might be misplaced one or more classes in either direction, due to these irrelevant factors.

It was desired, for the convenience of handling the data, that the men be classified into 10 groups, according to general flying ability. Capt. Street, in charge of the training department, using all the records available in his office, performed this work for us. None of the men we examined fell in the last four groups, so there are practically six grades classified. The results of correlation of these ratings with the reaction times, and the coefficients of variation, of each individual, are given in Table 4.

TABLE 4.

Reaction type.	Cases.		r.	P. E.
Visual:				
R. T.	Total	110	0.065	0.058
R. T.	Fit	93	.113	.069
C.	Total	110	.136	.064
C.	Fit	93	.073	.070
Auditory:				
R. T.	Total	148	.106	.055
R. T.	Fit	132	.214	.056
C.	Total	148	.042	.055
C.	Fit	132	-.267	.046
Tactual:				
R. T.	Total	68	.075	.082
R. T.	Fit	60	.047	.087
C.	Total	68	.015	.083
C.	Fit	60	.128	.087

Correlation of T. D. rating with average reaction times (R. T.) and coefficients of variation (C).

The coefficient of variation is given, as it may be an index of stability or emotional control, as the French suggest. All the correlation values are small, but the fact that they all tend in the same general direction, with one exception, is significant. We would not expect a high correlation, due to the irrelevant factors that may influence the training department rating. We might, therefore, consider the correlations with auditory stimulus to be fairly high. Especially is this noteworthy when we consider the influence of the unfit in decreasing the correlation. This is to be noted in both the mean reaction time and in the coefficient of variation.

The correlations with reaction times to visual and tactual stimuli are extremely small and unreliable; but the number of cases when the unfit are eliminated are too small to make it possible to draw definite conclusions. The correlation with reactions to visual stimulus is higher when we eliminate the unfit, if we consider only the mean reaction time; but the correlation with the coefficient of variation is lower. In the case of the reactions to tactual stimulus, the results are reversed.

We may conclude, from the results here presented, that under more favorable conditions, and with a more accurate rating scheme, a fairly high degree of correlation between flying aptitude and simple reaction times might be found. It is our opinion, however, that simple reaction times alone should never be used in the selection of candidates. Mental processes undoubtedly involve elements that can not be measured by a simple reaction to a known stimulus which is attempted in the simple reaction experiment. It is possible that more complex reaction experiments, such as those that involve discrimination of varying degrees of difficulty, judgment, and other modes of association, may yield important results. Such experiments in the A. E. F., with the limited equipment and time at our disposal, could not be carried out satisfactorily. Experiments in choice reactions were attempted, but the results are too fragmentary to be of value.

A steadiness test was applied to 128 monitors and chasse pilots. This is a standard test in which the subject, while standing erect, is required to hold a stylus the size of a lead pencil in a small hole in a metal plate. The metal plate is adjusted so that it is on a level with the subject's eyes. The stylus is connected with one pole of

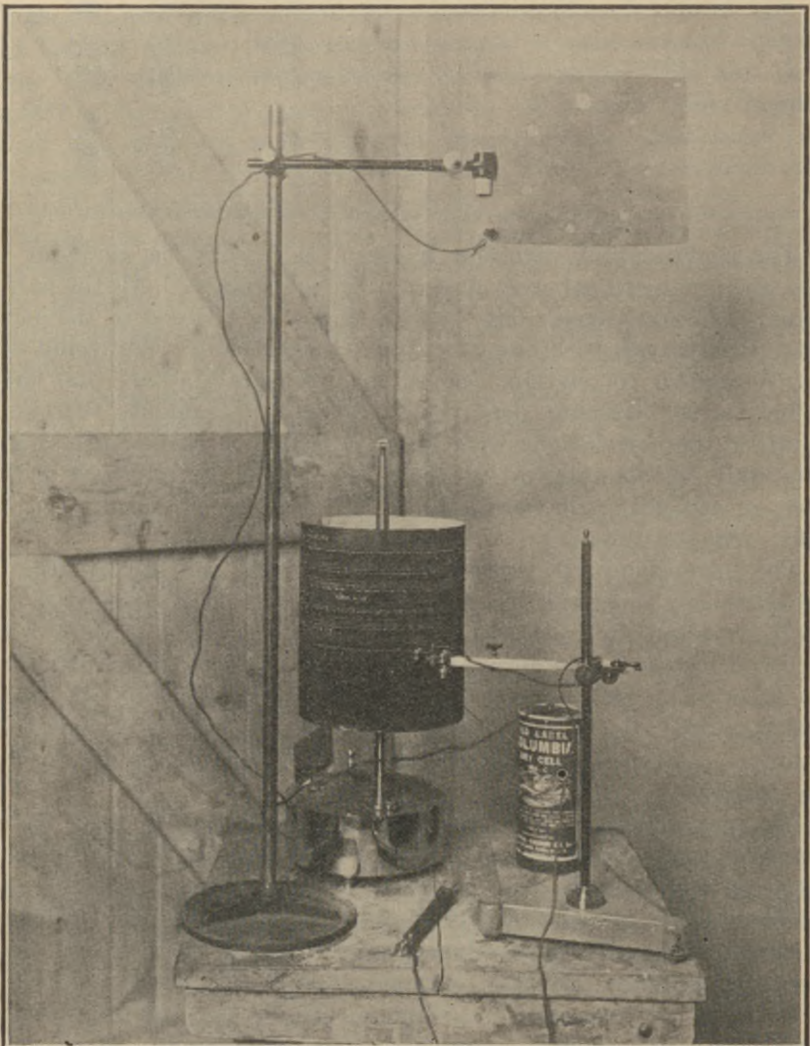


FIG. II.—Steadiness test apparatus.

the electric battery, and the plate with the other pole. Consequently, if the stylus is allowed to touch the edge of the hole, a contact is made. A recorder, which is connected in series with the metal plate, records the contacts. In our tests, the subject was required to hold the stylus in the hole one minute with his arm kept free of his body.

He was further instructed to attempt to breathe regularly and normally, as holding his breath might cause disturbance and unsteadiness before the end of the minute. Four holes were used, the smallest of which was twelve sixty-fourths of an inch in diameter.

In the treatment of the results, the records were arranged in five groups on the basis of the tremor shown in the smallest hole. Group 1 contains those records which show only a few scattering contacts, and group 5, those that show practically a continuous tremor. The others are distributed as accurately and evenly as possible in the intermediate three groups. It was not considered reliable to depend merely upon counting the number of contacts, as many records varied in other ways. Several contacts might occur very close together, or one contact might be maintained for a longer or shorter time. For this reason, it was necessary to estimate the values. The records with the larger holes are not taken into consideration, though doubtless they have a significance distinct from the fine tremor that shows only in the smallest hole. The arrangement into five groups gives the following distribution:

Group 1, 16 cases; group 2, 34 cases; group 3, 38 cases; group 4, 19 cases; group 5, 21 cases.

The best nine of the second group were selected and added to the first group, while the poorest four of the fourth group were selected and added to the fifth group, thus making 25 in each of the extreme groups. Of these it was found that the training department had rated 19 of those in the first group and 18 of those in the fifth group as follows:

Rating.	First group.	Second group.	Rating.	First group.	Second group.
1	1	0	5	2	7
2	5	2	6	0	0
3	9	3	7	0	0
4	2	5	8	0	1

To determine the relation between this rating and our grouping according to tremor, Pearson's cos Π method[3] was used:

$$r=\cos\frac{\sqrt{bc}}{\sqrt{ad}+\sqrt{bc}}\,\Pi,\quad P.\ E.\ r=\frac{1.1}{\sqrt{n}}$$

In this formula a represents the number of cases of very slight tremor (group 1) and high rating (1, 2, 3); b represents the number of cases of very marked tremor (group 5) and high rating (1, 2, 3); c represents the number of cases of very slight tremor (group 1) and low rating (4, 5, etc.); d represents the number of cases of very

[3] Whipple: Manual of Physical and Mental Tests, I, p. 48; Rugg: Statistical Methods Applied to Education, p. 294.

marked tremor (group 5) and low rating (4, 5, etc.). This distribution is shown in the following table:

	Rating 1, 2, 3.	Rating 4, 5, etc.	Total.
Group 1	a 15	c 4	19
Group 2	b 5	d 13	18
Total	20	17	37

Applying the formulae to these results, we get $r = .725 \pm .181$. This is a fairly high correlation, even when we consider the probable error (0.181) to be rather large. If we recall that it was assumed in the discussion of the correlations of reaction times, and training department ratings, that the rating probably did not represent accurately the flying aptitude of the men rated, because of the personal equation of the rating officers, the present correlation must be considered very high.

The British have found that tremor showed a correlation with aptitude in flying. According to Maj. Bowdler,[1] of 54 candidates who were accepted in spite of marked tremor, the ratio of success to failure was 2.8 to 1. Among 2,000 candidates who showed no abnormal signs, 7.6 per cent only were ultimately rejected.

According to Prof. Head,[2] "tremor may be indicative of chronic indigestion or of alcoholic excess; unsteadiness of the fingers, especially when they are abducted and brought together again, is a certain sign of lack of control. Tremor is not so much an indication of a neuropathic temperament as of a definite disturbance of function. * * * But, apart from alcohol, it is one of the commonest signs of stress of war service."

Prof. C. Spearman suggested a modification of the steadiness test, which has been adopted by the British with favorable results. The subject is required to draw a line lightly and deliberately across the greater length of a sheet of foolscap. While drawing a second line in the same way, a loud and unexpected noise is made near his ear. In referring to this test, the British report[3] states that in regard to the slight tremors, it "serves to differentiate the true significance of the tremor, and its general use is recommended in the examination of candidates."

There are many forms of steadiness test, both involving voluntary movement, as in Spearman's test, and involving restraint of movement, as in the test we employed. Judging from the results of the British investigators, and from our own results, similar tests should

[1] Report of the Air Medical Investigation Committee, Special Report, Series No. 28, 1919, p. 7 f.
[2] Henry Head, M. D., F. R. S.: "The Sense of Stability and Balance in the Air."
[3] Report of the Air Medical Investigation Committee, No. 2, 1918, p. 19.

be employed regularly in our Air Service. These results could be constantly checked with the records of the student flyers, and adapted, as seen fit, to give the most accurate diagnosis of a candidate's flying aptitude, or of the regular flier's present fitness to fly. No definite recommendations of the exact form of test to be used are given here, as there are so many possible modifications. The exact form of test to be used should be left to the present personnel of the psychology department of the Medical Research Laboratory.

One of the officers of the psychology department at the Third Aviation Instruction Center was asked by the training department to apply for regular instruction in flying in order that the psychology department might obtain a more definite understanding of the problems with which it was attempting to deal. This officer, when assigned to flying duty, ate at the flying officers' mess, reported at formations, and in every way possible conformed to the routine of flying training that a student flying officer undergoes. The complete R. M. A. course, including rouler, dual control, solo, acrobacy, and cross country, was taken. The types of machines flown were Nieuports, Avros, and DH. 4's. The highest altitude reached was 10,000 feet, and the longest cross country was about 150 kilometers. In addition to the experience in flying, he was able to meet more intimately hundreds of flying officers, who talked much more freely than they did when they came to the laboratory. In this way the personality of the aviators and their flying aptitude, as observed on the field, were studied. The principal psychological factors observed during the first weeks of training can be only briefly stated here.

It is well known to psychologists that in the acquisition of any complex act of skill there are often definite periods of lapse in improvement due to certain difficulties in adjustment of the organism and also to the change in the attitude of the learner. The former should be understood by the monitors and others directly in charge of the cadet's training, as it would be of assistance in preventing accidents as well as in judging the cadet's ability. The latter is largely influenced by the student's success, and also by the physical conditions surrounding him, such as quality of food, sleep, recreation, and the relation to his superiors. The writer could observe distinct set-backs in his own progress that were directly traceable to loss of sleep, due to restlessness. Also, the only time he experienced an approach to nausea in the air was following slight indigestion. He found it difficult on this day, after a "vrille," to level his plane again.

There are also times when the aviator does not "feel like flying," as he says. It is a common belief among aviators that he should not be compelled to fly at such times. There is no doubt that often this feeling can be overcome, but it is equally certain that it should always receive due consideration during the first weeks of training.

It is our belief that this "feeling" is misnamed. It is more like the experience of the tennis player when he has an "off" day. He can not account for his inability to play up to his usual standard. This is what happens to the aviator. The writer once experienced this "feeling," but recognized that it was not typical of a lack of willingness or desire to fly. He attempted to fly, but after about 15 minutes in the air, during which time nothing seemed to go right, he decided it was needlessly dangerous for him to attempt it longer. This was after he had become fairly proficient in flying. On other occasions this feeling was more readily conquered, and he could "pull himself together." This characteristic should be thoroughly understood by those in charge of flying. Of course, in case of emergency, as at the front, it is another matter.

A special condition, for which a psychological test should be devised, is the emotional stability of the aviator. The Italian psycho-physical laboratory made use of vasomotor reactions to measure the emotional disturbance caused by a pistol shot, a dash of cold water on the neck, etc. It is possible that this test, or the variations in reaction times as already noted, and claimed by the French, may be a sufficient test. However, it is believed that the experience of the sudden plunge of a plane in an unexpected direction is something no one can appreciate except those who have had the experience. The flier does not merely lose his balance at such a time. He has changed his position with reference to the earth by several hundred feet in a very few seconds. The rush of air, the abnormal pressure upon his viscera, and the loss of the direction of gravity, are capable of creating all the conditions of a violent emotion, which, if not checked quickly, become worse, and the aviator may lose all consciousness. There is no doubt that in many of the cases in which an aviator has been observed to dive or vrille a thousand feet or more to his death without an apparent attempt to right his machine, this condition has been responsible for his catastrophe. It seems, therefore, that emotional stability is one of the important problems to be investigated.

Balance in the air is undoubtedly controlled by the same factors as on the ground, viz, by the combination of impressions from the eyes, semicircular canals, skin, and muscles. As in normal activity, so in the air, a man may learn to do without one of these sense departments, particularly without vision, as in night flying, but it is extremely doubtful that he could learn to depend upon only one of them. Sensations from the skin and muscles are particularly important.

A particular factor in landing, which seemed important, was ocular muscle balance, especially the speed of convergence. The writer observed that in landing he could judge distances fairly accurately except in the last part of the glide just before the redress. In the rapid approach toward the ground the muscles of convergence did not seem to act rapidly enough when he approached nearer than 25 feet of the ground. The writer suffers from a slightly weak convergence, though it had never before been observed by him.

As to the personality of the aviator, no general rule can be laid down. Quiet, methodical men were among the best fliers. What seems most needed by the aviator is intelligence; that is, the power of quick adjustment to a new situation and good judgment. He need not be so quick in motor adjustments providing he thinks clearly or makes rapid mental adjustments. The nervous, high strung, or those bordering on the temperamental, are the least reliable; for though they often become good fliers, no great reliance can be placed upon them. They are liable to become psychotic under stress. Excessive drinking is also a characteristic of this class.

It is often claimed by aviators that a man can fly better when slightly under the influence of alcohol, and that a man who is not afraid, or too good, to drink is a better aviator. The latter observation should not be limited, perhaps, to aviators; but its truth or fallacy need not be discussed here. The former statement bears some relation directly to flying, and there is an element of truth in the observation. It is a fact, acknowledged by psychologists, that alcohol in moderate doses tends to remove inhibitions that interfere with a man's efficiency at the time, and thus increases his activity along directed lines. A sensitive, or bashful, individual is more free in his conversation, and more capable of talking to strangers or those he considers his critics in any way. In like manner, slight intoxication removes the slight fear or consciousness of himself in the case of the aviator, and he is more able to direct his entire attention to the management of his plane. He is thus less awkward and more free and skilled in his activity. There are two dangers, however. Excessive alcohol will remove inhibitions to the point that the flier becomes reckless, and wanting in good judgment. He may also lose control, both motor and mental. In the second place, alcohol has virtually the same effect as high altitude or low oxygen, as has been shown by preliminary experiments conducted by Maj. Dunlap at the Medical Research Laboratory, Mineola. The result would be to decrease at the start the altitude to which a man might safely go. The result would be sudden intoxication, or complete mental and motor collapse. There is, therefore, nothing in the special claim of aviators, distinct from any other group, for the use of alcohol.

OBSERVATION-REPORT TEST FOR AERIAL OBSERVERS.

Lieut. SCHACHNE ISAACS, Sanitary Corps.

A series of conferences was held with the instructors in the Observers' School at the Second Aviation Center, A. E. F., France. Some of these instructors had done very successful work at the front. Reports and discussions were given on the nature of aerial observation and the type of men best suited for it. Further information was obtained in informal talks with a number of observers who were returning through this center from active service at the front. The officer in charge, who was a clinician, and the psychologist of this medical research unit were already familiar with training of observers in the States, having served on the unit at the School for Aerial Observers at Post Field, Fort Sill, Okla. The members of the unit were strongly impressed with the fact that the successful observer, on account of the demands made upon him and the importance of his work, must be a man carefully selected and highly trained to even a greater degree than the pilot.

Some of the various duties of the observer have been briefly mentioned in the introduction. These duties include visual reconnaissance, missions in regard to air activity, as well as all matters of military importance taking place on the ground. These tasks are especially difficult on the days when the clouds are hanging low. What is called "Cloud reconnaissance"—a valuable type of work—gives a suggestion of the intelligence and keenness required of the observer. Very often the clouds are low and form a solid bank at probably 1,000 or 2,000 meters above the earth. The enemy takes advantage of the weather to move troops or convoys, which they would not attempt to do on clear days. To detect such movements, the observer climbs up through the clouds, then flies by compass until he arrives at the point he wishes to observe, dives down through the clouds, gets all the information that he can, climbs up through the clouds again, and goes to another point in the same manner. When the observer dives through the clouds, he must, of course, get his bearings and orient himself instantly, besides making accurate and detailed observations.

Because of these demands on the observer, it was desirable to devise a laboratory test, capable of standard application and objective measurements of results, that might reveal individual differences in the quickness, accuracy and certainty of the observation of a situation requiring definite study, especially of the nature and relation of parts, of its recall, and of its recognition when again presented. The test here described was applied to about 50 observers, and incidentally the introspection volunteered by many seemed to indicate that it involved a very similar mental performance to that in actual conditions of visual reconnaissance in aerial observation. A series of aluminum slides, 16 centimeters square, was prepared and each ruled off in 2-centimeter squares. At 6 or 7 of the 49 cross lines, holes 5 millimeters in diameter were drilled. These holes were covered with red, green, or white tissue paper or gelatin. When a slide was inserted in the window of a light box and illuminated from behind, the holes appeared as colored lighted disks of about equal brightness on a black surface defined by a white border. The window was covered by a thin open-weave black cloth, and protected from side lights by a hood 14 centimeters deep. When unlighted, the surface of the slide appeared as a uniform black area. The light box, on a swivel

FIG. III.—Observation-report test for aerial observers.

base so that it could be swung around to the experimenter for changing slides out of sight of the subject, was placed on the table at which the subject sat and about 1 meter in front of him. A slide was inserted in the window, illuminated, and the subject given instruction and practice in plotting the arrangement by noting the relation of the disks to the border and to each other, and indicating their color on a piece of coordinate paper ruled in 1-centimeter squares. When the procedure was learned, the light was cut off and the practice slide removed and replaced by another. The subject had at hand a telegraph key by which he could at will light the box and, by holding the key closed, keep it lit as long as he desired. He was instructed to turn on the light and study the arrangement of the colored disks until he felt certain he could map them accurately with pencil on the coordinate paper and to do this in the shortest necessary time. The experimenter at his side, where he could watch his work, noted on a stopwatch: (1) The time taken for study. (2) The time to report the arrangement and indicate the colors. (3) Confidence of report under headings (*a*) "Certain that it is accurate;" (*b*) "Doubtful if accurate," indicating doubtful points by question mark; (*c*) "Certain that it is not correct," the subject having been previously asked to say how certain he was of the accuracy of his report. (4) Accuracy of report and if incorrect or if confidence (*b*) or (*c*), another trial was given following the same procedure. (5) The number of trials necessary for accuracy and confidence (*a*). When this part of the test was completed, the slide was removed, and a dozen slides (among which appeared several times at random the slide which had just been studied and mapped) were inserted in succession, illuminated by the experimenter, and the subject instructed to react by closing one of two keys as quickly as he identified each as the "same" or "different" from the one he had learned. The time elapsing between the illumination of the slide by the experimenter and the discriminative recognition reaction by the subject was measured by one one-hundredths seconds by a time marker on a kymograph.

In scoring the results, the accuracy was graded on the basis of 100 for correct reproduction, debiting 8⅓ points for each misplaced disk, 8⅓ points for each wrong indication of color, and 16⅔ points for each disk added over the correct number, six, which was the number of the slide. The value of confidence was graded by assigning 100 for correct report and judgment by the subject that he was certain of his accuracy (*a*); assigning 50 for both correct and incorrect reports where the judgment made was that he was uncertain as to accuracy (*b*); assigning 100 if incorrect and judged as certain that it was inaccurate (*c*); and assigning 0 where the judgment was made as certainly correct or certainly incorrect when the accuracy was the opposite of the judgment. Where several trials were necessary before a correct report with confidence "A" was made, the total time to study, the total time to report, the average accuracy, and the average value of confidence were calculated. The results of the group of 47 observers returned from service on the Front are given in Table 1.

TABLE 1.

	M.	$P.E._M$	σ	Range.
Number of trials necessary	3.45	±0.19	1.93	1 -8
Total time to study, seconds	102.45	±6.02	61.20	27.0-319.0
Total time to report, seconds	149.04	±9.33	97.56	18.0-434.0
Average accuracy, per cent	80.96	±1.25	12.68	100.0- 50.0
Average value of confidence, per cent	65.00	±2.14	21.75	100.0- 17.0

In the discriminative recognition reaction times comparison is made of the reaction times to the sixth and seventh slides in the series, the sixth being "different" and the seventh being "same," having been preceded in the order: First, different; second, same; third, different; fourth, different, and fifth, same, the different slides in every case being different from each other as well. Forty-one observers returned from the front gave the results shown in Table 2.

TABLE 2.—*Discriminative recognition reaction time.*

1/100 seconds.

	M.	$P. E._M$	σ	*C.*	Range.
"Different"	97.92	±3.80	36.10	0.37	46.0–227.0
"Same"	92.55	±3.30	31.35	.34	34.0–159.0

The difference between the averages of the two reaction times is very slight and not significant ($D=5.37$, $PE_D=5.03$), although the variability of the "different" reactions is slightly more, and the range greater, than that of the "same."

An attempt was made to determine the relation of the performance in this test to success as an observer. Ratings 1, 2, and 3 (1 being the best) were made of these observers from the front by Capt. Cary, Medical Corps, at an interview which he held with each man, basing his estimate of the man's success on a complex of impressions gained from the man's appearance, manner, attitude, report of his experience at the front, etc. Unfortunately, no more objective measure of the man's success or failure at the front, and specifically as an observer on visual reconnaissance, could be obtained. For purposes of adequately verifying the test, such a rating would, of course, be necessary. Comparisons between two groups, Group 1 containing those rated 1, and Group 2 those rated 2 and 3, are shown in Tables 3 and 4.

TABLE 3.

	Group 1 (24 cases), containing rating 1.				Group 2 (23 cases), containing ratings 2 and 3.				Group 1–group 2.	
	M.	$P. E._M$	σ	*C.*	*M.*	$P. E._M$	σ	*C.*	*D.*	$P. E._D$
Number of trials necessary	3.75	± 0.27	1.99	0.53	3.13	± 0.26	1.84	0.59	0.62	± 0.38
Total time to study, seconds	108.75	± 7.05	51.20	.47	95.85	± 9.51	67.80	.71	12.90	±11.84
Average time to study, seconds	34.60	± 2.29	16.17	.48	37.20	± 2.89	20.60	.55	− 2.60	± 3.68
Total time to report, seconds	162.51	±14.26	103.83	.63	135.00	±12.42	88.50	.66	27.51	±19.12
Average accuracy, per cent	75.83	± 1.82	13.20	.17	86.30	± 1.33	9.46	.11	−11.30	± 2.25
Average value of confidence, per cent	59.17	± 3.39	24.42	.41	71.09	± 2.39	16.33	.23	−11.92	± 4.15

Inspection of Table 3 does not seem to differentiate the two groups in any striking way. Differences in the means are present but not significant. The difference (D) between two means, in order to be significant, should exceed 4½ times the value of the probable error of the difference (PE_D). In one case only, we find a significant difference, that in the average accuracy, in favor of group 2. As to variability (C), group 2 is somewhat more variable in the number of trials, average time to study, total time to report, and more so in total time to study, while group 1 is somewhat more variable in average accuracy and more so in average value of confidence. In the case of average accuracy, while the difference in means is in favor of group 2, the variability of group 1 is greater, and the coefficient of correlation between rating and accuracy was found to be high (0.482 ± 0.172, Pearson's cos π method). Comparison of the two groups in discriminative recognition reaction time is shown in Table 4.

TABLE 4.

	Group 1 (20 cases), containing rating 1.				Group 2 (21 cases), containing ratings 2 and 3.				Group 1-group 2.	
	M.	*P. E.*$_M$	σ	*C.*	*M.*	*P. E.*$_M$	σ	*C.*	*D.*	*P. E.*$_D$
Reaction time "different," 1/100 second	92.00	±5.84	38.78	0.42	98.32	±4.61	31.40	0.32	− 6.32	±7.42
Reaction time "same," 1/100 second	75.00	±4.04	26.84	.36	109.30	±5.19	35.30	.32	−34.30	±6.58

It is seen that group 1 is decidedly quicker than group 2 in recognizing the slide that has been studied and mapped ($D = 34.30$, $PE_D = \pm 6.58$). The coefficient of correlation was found to be very high between rating and quickness in this recognition (0.729 ± 0.173, Pearson's cos π method). This fact is interesting when it is recalled how important such recognition is in conditions of actual aerial observation. Group 1 is quicker in identifying the "same" than the "different" (18.5 per cent), while group 2 is slower (11.2 per cent), although the difference in the means can hardly be regarded as significant (group 1, $D = 17.00$, $PE_D = \pm 7.10$; group 2, $D = -10.98$, $PE_D = \pm 6.94$).

It would be desirable if this test or some similar test could be applied to a large number of cases and correlated more strictly with ability in visual reconnaissance, so that more reliable results could be obtained for developing a quick and trustworthy method of selecting the best men and eliminating the unfit for this important and highly specialized work in aerial observation.

Chapter V.

DEPARTMENT OF OTOLOGY.

Lieut. Col. Henry Horn, Medical Corps.

THE RÔLE OF THE LABYRINTH IN FLYING EFFICIENCY.—A STUDY OF 768 CASES AT THE THIRD AVIATION INSTRUCTION CENTER, A. E. F., FROM SEPTEMBER, 1918, TO JANUARY, 1919.

The history of the birth of new discoveries, or the application of old principles in a new and radical manner, is usually the same; the proponents of the new ideas see the millenium well within their grasp; the opponents endeavor savagely to tear down the pillars which support the new structure. Out of it all comes finally the truth—conservative minds, not fired with the joys of discovery or exuberated by the strife, gradually sift out the best and give to the world that which can be used.

The greater part of the otological examinations in detail in this department were made by Capt. Claude Uren, Medical Corps.

The use of the turning chair and the importance of the labyrinth to aviators have led to much research work and arguments for and against.

From the time of the first examinations, 768 aviators passed through the hands of the board, and not only were the cases studied from the standpoint of the otologist, but the most thorough examinations were made from the ophthamological, internal medical, physiological, psychiatrical, and psychological viewpoints as well.

We are concerned in this study mainly with the otological side. The details of the findings of the other departments are to be found in other chapters.

For several reasons these results are worthy of special consideration. The examinations were made by trained aviation medical men who had had large previous experience along exactly similar lines in the aviation camps in the United States; the aviators were under satisfactory conditions of military control, and an "esprit de corps" was early established by the flight surgeons and other men, in such a way that the Medical Research Board was freely consulted and the men were without fear that their flying status would be jeopardized or shortened by our studies.

It was early seen that the work, from the otological standpoint, would divide itself into two main groups: (1) Those aviators who complained of a hypersensitiveness to motion with disturbing labyrinth symptoms of various kinds which would in some way interfere with their flying; (2) those who gave no history of hypersensitiveness to motion, but during routine examinations were found to show labyrinthine findings, which characterized the first group.

Hypersensitive to Motion Type.

The hypersensitive to motion type, as we designated the men in these groups, with its characteristic symptom complex, was naturally the most interesting and it early developed that in this group a distinct history of sensitiveness to other forms of motion than that produced in the chair and the air could be brought out, even before its presence was noted in their air work.

In drawing any conclusions from the results of these studies, it must always be clearly borne in mind that, on the one hand, all the candidates had been examined previous to their admission into the service for hypersensitive labyrinths, and the marked cases disqualified. On the other hand, it would be equally fallacious to consider that the hypersensitive men who came to our notice in the A. E. F. developed this hypersensitiveness after they entered the service, on the assumption that all men with 35 seconds or above or 16 seconds or below had been automatically cut out by the original entrance examinations.

Hypersensitive Cases.

The hypersensitive cases proved to be surprisingly few and confirmed the belief that had been growing in the minds of most men experienced in this work, that, given a properly functioning, well-balanced labyrinth, low nystagmus time is a matter of very little importance.

Certainly we can not get away from the practical fact that if a candidate goes through his training with honors, continues his flying without accident, and is satisfactory to his instructors he can be regarded as a reliable type.

From this position only two conclusions are possible, if by chance we find that such men classed as satisfactory by the flying officers have abnormal labyrinthine findings: (1) Either such findings are of no value so far as efficiency goes, or (2) they have so accommodated themselves to the apparently hypersensitive labyrinth, that it bears no relation to the quality of their air work.

Equally true it is that if the candidate appears before the board and complains of symptoms of hypersensitiveness in the air and the examination discloses the fact that he possesses a hypersensitive labyrinth—the conclusion is fair that the hypersensitive labyrinth plays a causal rôle in the matter.

Another side of the question, which demands attention and which this work helped to solve, is whether in the light of our recent experience the original labyrinth examinations for admission into the service were worth while and whether we should modify or omit such examinations in the future.

A proper appreciation and a fair analysis of the factors involved in these various groups will help us add a little knowledge to the question involved in the title of this article.

The material at the Third Aviation Instruction Center was unique and the facilities for study were such that one could scarcely hope ever again to have a body of men of certain definite types under such practical observational conditions. In the first place they were men who had been culled out in the States, both physically and through the attritional grinding of the ground schools. They were all fliers of more or less experience and were eager to cooperate with the Medical Research Board. They were intelligent and took a keen interest in the results of the examinations. They were all working toward the same end, namely, to make themselves as quickly fit as possible for the great adventure of their lives. The results of a great group study of such a body of men should be dependable and should give us a very fair viewpoint of the rôle of the labyrinth in flying efficiency.

The Normal Type.

Much discussion has arisen as to what constitutes the normal or average labyrinth findings and whether our standards for the aviation candidates, more or less empirically selected in the very beginning of the aviation examinations, were too high or too low.

TABLE 1.

Nystagmus.

Totals of 842 cases (including monitors and men from front).	Nystagmus to right	24. 32
Totals of monitors, 79 cases	Nystagmus to right	24. 40
Totals of men from Front, 120 cases	Nystagmus to right	23. 61
Totals of men examined in States, over 50,000	Nystagmus to right	23. 00
Totals of 830 cases (including monitors and men from Front).	Nystagmus to left	24. 18
Totals of monitors, 78 cases	Nystagmus to left	24. 32
Totals of men from Front, 119 cases	Nystagmus to left	23. 77
Totals of men examined in States, over 50,000	Nystagmus to left	23. 10

Past Pointing.

Totals of 818 cases (including monitors and men from Front).	P. P. to right, right hand.	2. 53
Totals of monitors, 79 cases	P. P. to right, right hand.	2. 27
Totals of men from Front, 117 cases	P. P. to right, right hand.	2. 29
Totals of men examined in States, over 10,000	P. P. to right, right hand.	3. 8
Totals of 819 cases (including monitors and men from Front).	P. P. to right, left hand.	2. 31
Totals of monitors, 79 cases	P. P. to right, left hand.	2. 25
Totals of men from Front	P. P. to right, left hand.	2. 20
Totals of men examined in States, over 50,000	P. P. to right, left hand.	3. 7
Totals of 614 cases (including monitors and men from Front).	P. P. to left, right hand.	2. 30
Totals of monitors, 78 cases	P. P. to left, right hand.	2. 35
Totals of men from Front, 115 cases	P. P. to left, right hand.	2. 22
Totals of men examined in States, over 50,000	P. P. to left, right hand.	3. 8
Totals of 811 cases (including monitors and men from Front).	P. P. to left, left hand.	2. 35
Totals of monitors, 79 cases	P. P. to left, left hand.	2. 34
Totals of men from Front, 115 cases	P. P. to left, left hand.	2. 32
Totals of men examined in States, over 50,000	P. P. to left, left hand.	3. 7

Vertigo.

Totals of 55 cases (including monitors and men from Front).	Vertigo	19. 6
Totals of monitors, 79 cases	Vertigo	17. 1
Totals of men from Front, 115 cases	Vertigo	19. 50

A compilation of results of the labyrinth findings was made on more than 50,000 cases examined for admission into the Aviation Service by the Statistical Bureau at Washington. It will be recalled that these examinations were made by men specially trained in their work and all used, as far as possible, a standard technique. The results of such a large experiment must be accepted as nearly correct as lies within human capabilities. The very size of the aggregate, the fact that the results were obtained from different men in different parts of the United States, makes the average dependable.

In order to make our present study as free from criticism as possible, one examiner, who had examined thousands of candidates in the States, made over 75 per cent of all the otological examinations, and the results after final tabulation agree so closely with those given by the early examinations in America that the accuracy of both sets of statistics seems to be established.

There is a limit of accuracy in the observations of nystagmus time, as well as a possible variation in all individuals from day to day, that makes it extremely questionable whether one is ever justified in drawing conclusions from results wherein the difference does not exceed two seconds.

The idea held by many investigators that nystagmus time and past pointing are lowered by air work is not borne out by the following figures.

Table 1 is designed to give a bird's-eye view and summary of all the vestibular examinations made by the Medical Research Board in the A. E. F. and at the same time compares them with the results of the 50,000 cases examined in the United States. The right and left hand tests are grouped separately. All statistics were calculated on adding machines and the results checked. The following observations are allowable:

NYSTAGMUS.

There is no appreciable difference between the right and left side. This is in accordance with the American statistics.

The apparent lowering of the average of the men from the front is interesting but has probably no significance. It runs a little over a half a second lower as compared with the average run of men at the Third Aviation Instruction Center, but it is a little over a second higher than the general average given from the 50,000 candidates for admission into the Aviation Service at the beginning of the war. Our observations were made with extreme care and accuracy, one man examining practically all the cases, and frequent checkings would show less than a second's difference between two observers.

The fact that the monitors, who were doing from four to six hours of flying a day at the time of the examinations, show no reduction as against the students, is the best evidence that the apparent lowering in the men from the front is of no significance.

PAST POINTING.

Here there is very little difference between the various classes. The past pointing in the States is markedly higher, about 1.4 on the average. The ability to correct an exaggerated past pointing is rapidly acquired. It is a matter of fact that aviation students, all of them with previous chair or air experience, make earnest endeavors to accommodate themselves to vertigo, and for obvious reasons. This may be one reason why the general average was lower in the A. E. F., as it must be remembered that all of the men examined had had previous chair experience, while candidates in the States were having their very first sensation of vertigo, due to turning.

TABLE 2.—*Labyrinth findings, arranged by months.*

SEPTEMBER, 1918.

Nystagmus, to right, 68 cases	24.55
Nystagmus, to left, 67 cases	25.10
Past pointing to right, with right hand, 67 cases	2.47
Past pointing to right, with left hand, 67 cases	2.43
Past pointing to left, with right hand, 68 cases	2.25
Past pointing to left, with left hand, 67 cases	2.18

OCTOBER, 1918.

Nystagmus to right, 119 cases	25.24
Nystagmus to left, 111 cases	25.41
Past pointing to right, with right hand, 112 cases	2.54
Past pointing to right, with left hand, 112 cases	2.35
Past pointing to left, with right hand, 110 cases	2.32
Past pointing to left, with left hand, 109 cases	2.43
Vertigo to the right, 114 cases	23.33
Vertigo to the left, 36 cases	22.36

NOVEMBER, 1918.

Nystagmus to right, 254 cases	24.69
Nystagmus to left, 254 cases	24.32
Past pointing to right, with right hand, 245 cases	2.41
Past pointing to right with left hand, 246 cases	2.35
Past pointing to left, with right hand, 243 cases	2.32
Past pointing to left, with left hand, 244 cases	2.32
Vertigo to the right, 245 cases	18.17

DECEMBER, 1918.

Nystagmus to right, 202 cases	23.13
Nystagmus to left, 201 cases	23.25
Past pointing to right, with right hand, 198 cases	2.2
Past pointing to right, with left hand, 198 cases	2.27
Past pointing to left, with left hand, 197 cases	2.231

VERTIGO.

The average time of vertigo is given with no claim as to the value of this test. It was taken as part of the routine examination in connection with other observations and represents in a general way an average.

This test would at first seem to be subject to many inaccuracies. In fact, when used with candidates for admission or those unaccustomed to peculiar forms of motion, its accuracy is doubtful; but in the testing of men who have had air experience, the results of the vertigo examinations from day to day or from test to test were strikingly constant. Repeatedly there would be no difference at all, or perhaps a difference of less than two seconds, between two observations on the same individual in different days. The wide variations found in nonfliers are due to the confusion produced by the vertigo, to which they are unaccustomed and which militates against accurate subjective observation.

Table 2 is a separate study of the results of the same tests by months. It was thought worth while to see if, as the training progressed or if the terrific strain which the men were under in October and the early part of November, when students were being forced through the school as rapidly as possible, had any influence on the labyrinth reactions.

The differences are all in fractions of a second, or less than a complete past pointing, and evidently represent no real differences due to the period of training or the effect of strain. The vertigo was 4.19 seconds greater in October than November, and again in December raised to 19.2 seconds over 18.17 seconds, but I am loath to admit this has any real significance.

TABLE 3.—*Comparison of seasoned fliers and inexperienced men.*

MEN FROM THE FRONT.	
Nystagmus to right, 120 cases	23.62
Nystagmus to left, 119 cases	23.18
Past pointing to right, with right hand, 117 cases	2.30
Past pointing to right, with left hand, 117 cases	2.20
Past pointing to left, with right hand, 115 cases	2.22
Past pointing to left, with left hand, 115 cases	2.32
Vertigo to the right	19.51
MONITORS.	
Nystagmus to right, 79 cases	24.40
Nystagmus to left, 78 cases	24.34
Past pointing to right, with right hand, 79 cases	2.27
Past pointing to right, with left hand, 79 cases	2.25
Past pointing to left, with right hand, 78 cases	2.358
Past pointing to left, with left hand, 79 cases	2.24
Vertigo to the right	17.1
SUMMARY OF AMERICAN STATISTICS. (Over 40,000 cases.)	
Nystagmus to right	23.00
Nystagmus to left	23.1
Past pointing to right, with right hand	3.8
Past pointing to right, with left hand	3.7
Past pointing to left, with right hand	3.8
Past pointing to left, with left hand	3.7

Table 3 is a regrouping of men from the front, monitors, and the statistics from the United States arranged to show the labyrinth reactions according to the group under study. It will be noted that the differences are remarkably small between the different groups. Exceptions in the case of the past pointing have already been mentioned.

The conclusion seems obvious: That the amount of air work which these men have had, ranging in the case of students from an average of less than one hour a day or a total of 30–50 hours during their training, to the monitors who are in the air 4–6 hours daily, does not in any way materially lower their labyrinth reactions. It is equally obvious, judged from the practical standpoint of results achieved, that during the same period they accommodate themselves to new and unusual motion stimuli and are turned out finished fliers.

The mechanism of this accommodation to unusual forms of motion, of the rapid and complete compensation to the various forms of vertigo, brought about by air conditions, is a question of great complexity. A satisfactory explanation is not at hand, but it seems certain that it involves other factors than the simple accommodation of the labyrinth to new stimuli. We are certainly here dealing with a problem in which the psychological element is an important one. Our studies along these lines are replete with interest.

Every gradation of the ability of a hypersensitive labyrinth to accommodate itself to the requirements of successful flying has been met with. From a well-known American ace, who in his early acrobatic work on the field was a very hypersensitive type—even to the point of vomiting—to the extremely rare type of student, who, after his first experience in acrobatics, is willing to give up flying, we have encountered every phase. We are dealing with the unanalyzable phenomena of "nerve," and this is a factor which is difficult to subject to statistical examination.

With a large and generous quality of this typical American characteristic, many deficiencies were overcome. On the other hand, fight it out as they did, some of the grittiest of the students were unable to overcome the handicap of a hypersensitive labyrinth and were obliged to discontinue or modify their training.

The exceptions do not prove the rule. These studies convince us that more than ever the original examinations were worth while. If we erred at all, it was on the side of too great leniency as far as the labyrinth examinations were concerned. The hypersensitive type is worthy of deep consideration, and where recognized should be admitted to the service with greatest caution.

At a conservative estimate 10 per cent of the men who passed through the board, from the standpoint of the labyrinth, should never have been trained. The saving in lives and in time, in this effort to fit round pegs into square holes, would have been worth while.

THE HYPERSENSITIVE TO MOTION TYPE.

This term, although somewhat awkward, expresses exactly the condition of these men and is used throughout this article as fairly descriptive.

It is the type "par excellence," which comes within the region of labyrinth investigation, and its solution can in large part be shown by labyrinth findings.

TABLE 4.—*Table of hypersensitive to motion type, arranged according to symptoms.*

No.	Nystagmus.	Past pointing.	Vertigo.	Falling.	Nausea.	Vomiting.	Turning.	Seasick.	Merry-go-round.	Swing.	Car.	Avro.	Air.	Remarks.
122	27-26 23-24 (10/28)	2-2 2-1 2-1 1-2	... 17	Ex. N	0 0	0 0	0 0	0	0	Y	0	0	Y	Full duty.
128	23-35	5-5	...	B	0	0	Y	0	0	0	0	0	0	Hyper. laby. Class C.
130	25-30 25-30	4-3 3-4 ...	... ...	Mark. T. B.	0	0	0	Y	Y	0	0	0	Y	T. B.
131	27-26	...	30	N	0	0	Y	0	Y	Y	0		0	Eye trouble.
140	33-42 32-40 24-31 23-35	 ... (10/28)		Ex. ... Ex.	0	0	0	Y	Y	Y	0	Y	Y	Hyper. laby. Class B.
145	27-28 25-27 (10/24)	2-2 2-2 ...	38 38	Ex. Ex.	0 0	0 0	0 0	Y	Y	Y	0	0	0	Class B. Eye.
148	27-25	3-2 2-3	25	Ex.	...	...	...	Y	Y	Y	Y	0	Y	Observer.
158	23-30 22-28	...	...	Ex.	Y	Y	Y	Y	0	0	0	0	Y	Grounded.
165	26-27	4-4 4-4	45	Ex.	Y	0	0	Y	0	0	0	Y	Y	Full duty.
169	30-30	3-3 3-3	30	N	0	0	0	Y	0	0	Y	0	0	Full duty.
179	33-35	2-2 2-2	30	N	0	0	0	Y	Y	Y	0	0	0	Temp. unfit. Class C.
190	26-40 25-40	5-2 1-1	...	Sub	0	Y	0	Y	Y	0	0	0	Y	Finally overcame trouble.
191	32-34	2-2 2-2	16-15	Sub	0	0	0	0	0	0	0	Y	Y	Hyper. laby. Class B.
202	16-17 13-14 (10/25)	1-1 1-1 1-1 1-1	15 12-11	Sub ...	S1 0	0 0	0 0	Y	Y	Y	0	Y	Y	Sub normal case with nausea.
210	30-32	2-3 3-2	18	Sub	0	0	0	Y	Y	Y	Y	0	0	Routine after Fly. F. D. Class A.
227	32-30	3-3 3-3	25	Sub	0	0	0	Y	Y	Y	Y	0	0	No stereoscopic V–Class B, E. and L.
231	28-27	4-2 3-3	53	Ex.	Y	0	0	Y	Y	Y	Y	Y	Y	Poor type, but passed test.
232	34-36 11-42 40-42	4-4 4-4 ...	38 36-36	Ex.	Y	Y	Y	0	0	0	0	Y	Y	Grounded on Avro work.
234	33-34	3-4 4-2	31	Ex.	0	0	0	Y	Y	*	0	Y	Y	Grounded on lab.
237	13-15	T-1 1-T	10-9	S1	0	0	0	Y	0	0	0	Y	Y	Lack of conf. Ear.*
240	33-35	T-T 1-1	13-14	N	0	0	0	Y	0	0	0	0	Y	T. B. Class C.
247	20-20 16-16 (11/14)	3-2 2-3 ...	20 16	Ex. Ex.	Y	0	0	Y	Y	Y	0	Y	Y	Class C. Ears.
348	30-34	3-3 3-3	...	N	0	0	0	0	Y	Y	Y	0	0	Full duty.
87	23-24	4-3 3-4	23-20	Ex.	Y	0	0	0	Y	0	0	Y	0	Stopped flying at Avro field.
101	30-30	3-3 3-3	25-25	Ex.	0	0	0	Y	0	0	0	0	Y	Class A.
347	24-17	1-T	25-25	N	0	0	0	0	0	0	0	0	Y	Grounded–dipl. and deaf.
288	26-20 28-26	3-3 3-2	...	N	0	0	0	0	0	0	Y	0	Y	Trouble due to conv. insu.
521	23-24	4-3 3-3	22	N	0	Y	0	0	0	0	0	Y	Y	Class A. Overcame trouble.
168	22-22	4-5 5-4	37	N	0	0	0	Y	0	0	Y	0	0	Full duty. Ear not cause.
499	33-34	4-3 3-4	13	N	0	0	0	Y	0	Y	0	0	0	Class C. Hyper Laby.
372	20-18	2-2 1-2	23	N	Y	0	Y	0	0	Y	Y	0	Y	Class C. Temp. unfit.
268	48-43 (11/5) 35-34 (11/8)	2-2 2-2 2-2 2-2	15	N	...	...	...	Y	0	0	0	Y	Y	Hyper. due to infection.
265	30-30	5-4 4-5	35	N	0	0	0	0	0	0	0	0	0	Hyper. Ferry work.
295	24-20 26-24	3-3 2-3	...	N	Y	Y	0	0	0	0	0	0	Y	Temp. cond. due to drink.
254	35-32	4-3 3-4	22	N	Y	0	0	0	0	0	0	0	Y	Full duty.
354	30-24	6-4 2-2	24	Ex.	0	0	0	0	0	0	0	Y	Y	Stop flying at Avro.
372	20-18	2-2 1-2	23	N	Y	0	0	Y	Y	Y	Y	0	Y	Stop flying. Temp. unfit.
369	33-32	3-3 3-3	27	Ex.	Y	0	0	Y	Y	Y	Y	Y	Y	Full duty.
37	26-26	4-3 1-2	...	Mark.	0	0	Y	0	0	0	0	0	Y	Flying record poor.
350	33-32	3-3 3-3	30	N	Y	0	0	Y	Y	0	0	0	Y	Full duty.
365	26-26	2-2 2-2	22	Ex.	Y	0	0	Y	0	0	Y	0	Y	Class A.
171	28-27	3-3 3-3	23	Ex.	0	0	Y	0	Y	Y	0	0	0	Discontinue training.
252	24-25	2-2 2-2	30	Ex.	Y	Y	Y	0	0	0	0	Y	Y	Class A.
72	25-25	7-8 7-4	35-37	Ex.	Y	0	0	0	0	0	0	0	Y	Class A.
48	30-35	3-1 1-3	...	Mark.	0	0	Y	0	0	0	0	0	Y	Fly. rec.
30	14-17	2-1 1-1	16-14	N	Y	0	0	0	0	0	0	0	0	Ferry pilot.
29	40-36	3-3 1-2	...	...	Y	0	0	0	0	0	0	0	0	Flying record poor. Finlashed from Avro.
26	31-35	3-2 2-2	...	...	Y	0	Y	Y	Y	Y	Y	0	Y	Put on large machine.
4	35-36	3-3 3-2	...	Mark.	Y	0	0	0	0	0	0	0	Y	Class A.
1	21-21	2-2 2-3	...	Mark.	Y	0	Y	Y	Y	Y	Y	Y	Y	Poor in Avro. Final air work good.
102	30-28 30-30 26-27 (11/14)	6-7 7-6 ... 8-4 4-3	...	Mark.	0	0	Y	0	0	0	0	0	Y	To fly with caution.
121	22-35 23-30	3-3 3-2	...	N	0	Y	0	Y	Y	0	0	0	Y	Full duty.
143	35-34	2-2 2-2	(?)	N	0	0	Y	0	Y	.	0	0	0	Full duty.
141	25-25	2-2 2-2	20-20	...	0	0	0	0	0	0	0	0	Y	Dizziness not due to ear.

TABLE 4.—*Table of hypersensitive to motion type, arranged according to symptoms*—Continued.

No.	Nystagmus.	Past pointing.	Vertigo.	Falling.	Nausea.	Vomiting.	Turning.	Seasick.	Merry-go-round.	Swing.	Car.	Avro.	Air.	Remarks.
97	22-25........	2-3 3-2...	15-18	....	0	0	0	0	0	0	0	0	Y	Dizziness not due to ear.
438	36-36........	3-4 3-3...	30	N	0	0	0	0	Y	0	Y	Y	Y	Never passed beyond Avro.
259	30-29........	2-2 2-2...	18	S. E.	0	0	0	0	0	0	0	0	Y	Dizziness not due to ear.
289	32-32........	....	14	....	Y	0	Y	0	0	0	0	0	0	Too nauseated to finish.
416	34-33........	4-4 4-4...	30	Ex.	Y	0	Y	Y	Y	Y	Y	Y	Y	Dis. training at Avro.
262	34-33........	....	23	N	0	0	0	Y	Y	Y	Y	0	0	Full duty.
252	24-25........	2-2 2-2...	30	S. E.	0	0	0	0	0	0	0	Y	Y	Full duty.
342	26-26........	3-3 2-1...	20-20	N	0	0	0	Y	Y	Y	Y	Y	Y	Nothing in ear to acct. for hyper.
262	24-33........	3-3 3-3...	23	N	0	0	0	Y	Y	Y	Y	0	Y	Full duty A.
265	30-30........	5-4 4-5...	35	N	0	0	0	0	0	0	0	0	0	Ear has not inf. on genl. cond.
254	35-32........	4-3 3-4...	22	N	Y	0	0	0	0	0	0	0	Y	Air trouble, may be due to ear.
416	34-33........	4-4 4-4...	30	Ex.	Y	0	Y	Y	Y	Y	Y	Y	Y	Hyper to motion. Class C.
354	30-24........	6-4 2-2...	24	Ex.	0	0	0	0	0	0	0	Y	0	Ear has no inf. on genl. cond.
295	24-25........	3-3 2-3...	20-24	N	0	0	0	0	0	0	0	0	Y	Temp. cond. Class A.
456	36-34........	2-1 4-4...	29-19	....	0	0	0	0	0	0	0	0	Y	Hyper to motion. Class B.
2	28-28........	3-3 3-3...	23	N	0	0	0	0	Y	Y	0	Y	Y	Slight hyper. Air work poor.
216	38-40........	6-6 6-6...	40	S. E.	0	0	0	0	0	0	0	Y	Y	Grounded.
423	34-35........	2-4 2-4...	24	N	0	0	0	0	0	0	0	0	0	Hyper due to F. I.
369	33-32........	3-3 3-3...	27	Ex.	Y	0	0	0	0	0	0	Y	Y	Local infection caused trouble.
300	24-26........	3-3 4-4...	18	N	0	0	0	.	Y	0	0	0	0	Temp. cond. Class A.
297	25-23........	....	25	N	Y	0	0	0	0	0	0	0	0	Neuro-cir. asthenia. Class C.
294	30-26........	3-2 2-1...	22	N	0	0	0	0	0	0	0	0	Y	Yellow.

As it subsequently developed, it is unfortunate that in the original examinations for admission to the service more weight was not laid on the history of *hypersensitiveness to motion.* Candidates were originally asked if they had ever been seasick and, if so, how severely. In the light of our recent knowledge, as the following table will show, if the questions had been carried a little further much additional interesting information would have been obtained, and many of the truly hypersensitive cases could have been excluded.

The types of motion which were particularly investigated were: Seasickness, swings, merry-go-rounds, car sickness, and air sickness due to motion of the plane.

The combinations which Table 4 brings out are curious and show that a person is very seldom sensitive to one type of motion alone. There seems to be no one combination favored more than the others.

That this history of hypersensitiveness to motion, when carefully elicited, should be taken seriously in the selection of candidates, is shown by the fact that of 76 cases, 40 were obliged to discontinue or modify their air career and that 17 or 22 per cent of them were grounded from this cause alone.

In studying the way in which their air work was modified by this condition, full access was had to the official reports of the flying records of these candidates. Table 3 is given in detail in order to bring out the remarks taken from such records.

Table 4 is perhaps the most important one in this study. All cases which came before the board and which gave a history of being hypersensitive to any sort of motion, whether they realized that it had affected their air work or not, are here analyzed.

In many of these cases two examinations have been made and the second examination on a later date serves to emphasize the difference in the findings taken on different days. Thus in case 268 there is a difference of almost 10 seconds and in other cases even greater variations may be noted. It is to be remarked that case 268 was put on ferry work, which means, simply flying machines from one place to another, and in which the element of acrobatics is entirely eliminated, or in the case of 232, where the man was grounded because he was unable to do his work properly on the Avro or acrobatic machines.

It will also be noted that the vertigo runs unusually high in cases, and that this is often combined in the column of remarks with either poor flying or reasons for grounding. In the column of falling reactions, a far greater proportion than usual are marked "exaggerated" (ex.), markedly exaggerated (mark), or slightly exaggerated (S. E.).

Twenty-seven cases out of 57 are marked nauseated, which is over 47 per cent. Seven out of the group vomited during the test.

In the subsequent columns devoted to different types of hypersensitiveness motion "0" stands for negative answer and "Y" or "Yes" for positive answer. The men were quizzed very closely as to their experiences in merry-go-rounds (often designated as carousels), swings, trains, and street cars, experiences on the sea, the result of their work in the Avro, which was one of the airships used at Issoudun for trick flying and air acrobatics, and finally were questioned regarding their experience in air work in general.

Often these experiences dated from early childhood, as early as the fourth and fifth year, and the hypersensitiveness had been overcome up to the time they commenced their air work.

The questions were very carefully selected so that the ideas of hypersensitiveness would not be suggested to the candidate.

In the column of remarks we had access not only to our own very complete histories of the cases but to the official records of their flying filed at headquarters. In this way a final estimate of the true status of the student as to his air work can be fairly arrived at. And one gains the impression that in the 57 cases out of the 76 who were either grounded or discontinued their flying it would have been far better if in the original entrance examinations greater attention had been paid to the history of hypersensitiveness to motion and the candidates disqualified even if labyrinth findings fell within apparently satisfactory limits.

TABLE 5.—*Hypersensitive to motion, 76 cases.*

SUMMARY.

Sea sick, alone	0
Sea sick, combined	34
Merry-go-round, alone	0
Merry-go-round, combined	31
Swings, alone	0
Swings, combined	26
Car sick, alone	0
Car sick, combined	21
Avro, alone	0
Avro, combined	27
Avro and air, alone	8
Avro, air and sea sick	3
Air, alone	15
Air, combined	38
Number of cases to full duty, or Class A	21
Number of cases grounded or discontinuing flying or training markedly modified	40
Number of cases grounded with diagnosis hypersensitive labyrinth	17
Vomited during tests	7
Eye preponderating cause	2

Table 5 is a summary of Table 4. In this table we tried to find out if any one form of hypersensitiveness to motion was combined with any other form in an exaggerated proportion. This does not seem to be the case, and furthermore it is shown that very seldom were the fliers susceptible to any one form of motion alone, without a combination of some other form. This does not hold for the air alone, for here a positive answer was given in five cases. Almost any discomfort which they experienced in their first flight was usually credited to dizziness.

Finally it is to be remarked that 27 per cent of this series were returned to full duty, while a little over 47 per cent were either grounded or were obliged to discontinue flying on account of hypersensitiveness. And of this latter number, 17, or 29.08 per cent of the total, were disqualified with the diagnosis of hypersensitive labyrinth.

Table VI is a record of 35 cases where there was absolutely no history of being hypersensitive to motion, but where in the routine examination a nystagmus of 30 seconds or more was noted.

As a matter of convenience, 30 seconds was selected as a lower limit for hypersensitiveness, because it was found that as many cases had the characteristic symptom complex of hypersensitiveness to motion between 30 and 35 seconds as did those above.

The remarks in this chart cover a wide range of subjects and were taken from our history of the cases. As far as can be judged, 10 of the 35 cases were normal (429, 229, 285, 276, 59, 473, 302, 386, 259,

368) and show that nystagmus as high as 40 seconds (229) with a slightly exaggerated falling is not necessarily incompatible with good flying.

Case (429) with 36 seconds nystagmus, 4–5, 3–3, past pointing and 22 seconds vertigo was put in class A.

In considering these 10 exceptions, it must be borne in mind that there were 10 such cases in nearly 800 men, so that as a class, men who have high nystagmus and still make good fliers are not particularly common.

TABLE 6.—*Cases with an entirely negative hypersensitive to motion history but with nystagmus of 30 seconds or more.*

No.	NysR.	P. P.	V.	F.	N.	Flying history.	Remarks.
5	33–30	3–3	....	Ex.	Y.	Good..........	Mentally incomp., Class C.
89	32–30	3–3 2–2	22–15	Mar.	Sl.	Fair...........	Class A.
6	32–32	2–2 2–2	15–36	N.	....	.....do........	Put on DH 4.
117	35–33	3–4 4–3	....	N.	Y.	.....do........	Class B, conval. flu.
454	34–34	3–3 3–3	20–20	N.	....	No record......	
456	36–34	2–1 4–4	20–19	Ex.	....	Good..........	No flying after exam.
473	52–33	2–2 2–3	23	N.	....	Fair...........	
302	35–34	3–3 3–3	40–36	Sl.	O.	Fair to good...	
423	34–35	2–4 2–4	24	N.	....	No record.....	Increase prob. due to infect.
386	33–34	3–3 3–3	20	N.	....	Good..........	Normal type.
381	33–32	3–5 3–3	32	N.	....	Fair to good...	No flying after Nov. 21.
50	24–24	5–4 4–3	32	N.	....	....	
259	30–29	2–2 2–2	18	Ex.	....	....	Trouble not in laby.
362	33–30	3–3 3–5	20	N.	....	Fair to good...	No flying after Nov. 21.
349	35–34	3–3 3–3	22	N.	....	.....do........	To U. S. Dec. 7, '18.
368	34–33	3–3 3–4	25	N.	....	.....do........	Class A.
118	35–35	4–2 2–4	17–17	N.	....	Mediocre pilot.	Nerv. in air due to poor phys. cond. and incr. nys. an p. p. Lab.
223	30–30	3–3 3–3	35	N.	....	Good..........	Shows with these finding no results on flying.
412	35–34	3–3 3–3	30	N.	....	Fair to good...	Incr. possibly due to infec. No fly. after exam.
345	30–30	3–4 3–3	24	N.	....	Very poor to poor.	Prob. lab. cond. had nothing to do with disinclination to fly.
	[1] 25–25	2–2 2–2	35	N.	....	....	
105	30–30	2–2 2–2	12–12	S.	N.	Good..........	Call attention to 30 Nys. and low vert. and sub-nor. falling.
104	32–30	2–2 2–2	15–15	N.	....	....	Quoted to show Nys. of 30 and above, may give nothing sub-nor. Note vert. and p. p. not above.
166	36–36	3–1 1–3	22	N.	....	Fair to good...	Type where high Nys. has no bearing on history.
116	37–33	2–2 2–2	26–25	N.	Y.	Good..........	Note dec. of irritability and incr. of hearing after removal of focal infection.
	[2] 30–33	......	24–25	....	....	....	
268	48–43	2–2 2–2	20	N.	Sl.	Good..........	Focal infec. prob. had something to do with Nys.

[1] Dec. 2. [2] Nov. 22.

TABLE 6.—*Cases with an entirely negative hypersensitive to motion history but with nystagmus of 30 seconds or more*—Continued.

No.	NysR.	P.P.	V.	F.	N.	Flying history.	Remarks.
245	34-35	3-3 5-3	225	Sl.	....	No record.....	Possible that some passing cond. may have incr. the Nys. temp., but 2d ex. shown Nys. norm. Nothing in hist. to indicate Hyper. lab.
	[1]26-27	3-3 3-2	25	....	....	....	
176	30-30	3-2 2-3	27	N.	....	Good..........	Type of normal man with 30 sec.
429	36-36	4-5 3-3	22-20 18	N.	....	....	Class A.
64	30-30	3-3 3-2	18-20	Mark.	....	....	Vacation with conv. exerc. Report to eye dept. before fly.
142	30-30	4-5 5-3	30	Ex.	....	....	Type with rather high nys.
285	34-34	3-3 3-4	20	N.	....	Good..........	Nothing in hist. to show effects of high Nys.
276	30-27	......	22-20	N.	....	.....do.........	Class A.
429	36-36	4-5 3-3	22-20	N.	....	Poor to fair....	No Hyper. to motion hist.
229	38-40	3-2 2-2	25	Sl. Ex.	Y.	Good..........	Full duty.
	[2]38-38	6-6 4-4	25	Ex.	....	....	
188	32-33	3-3 3-3	20	Sl.	Ex.	....	Taken off fly.; trans. to hdqr.
154 115	35-35	......	35-35	N.	....	Fair...........	Refer to Tbc. Hosp.

[1] Nov. 7. [2] Oct. 28.

The cases under Table 6, where their flying career was markedly modified and can be charged to the hypersensitive labyrinth, are seven in number (6, 456, 381, 362, 349, 118, 188).

It is to be noted in the "Remarks" that in five cases infections or focal infections are given credit for the labyrinth irritation. It is a point which in our experience is pretty well established, that local or general infections, the focal infections of the teeth, or the more common infection of influenza, certainly do temporarily increase the nystagmus time. During such temporary increases we have forbidden the men to fly, as many deaths are directly attributable to accidents while the men are sick from partially recovered infective conditions.

Attention is called to cases 381, 345, 116, 245, where marked lowering of the nystagmus is obtained at a subsequent examination.

So important do we consider this point and so many marked cases occur throughout our studies, that we find it unwise, in studying any pathologic case, to accept labyrinth findings unless they are taken under the same observational conditions at least a week apart.

In admission examinations also, we should think it only fair, where the history of hypersensitive to motion is at all doubtful and where the nystagmus time is excessive, to disqualify the candidate, with a subsequent examination a week later. A history of a cold or active infection would also demand a second examination after the trouble had cleared up.

THE SUBNORMAL LABYRINTH.

TABLE 7.—*Cases with nystagmus of 16 seconds or below.*

No.	Nys.	P. P.	V.	F.	N.	Flying history.	Remarks.
290	16–18	T–T 1–1	10–11	N.	....	Was at front...	Held by eye dept. Not classified.
286	16–10 17–12	1–1 1–1	....	N.	....	Very good.....	Class B, chronic indigestion. Bad focal infection, teeth and tonsils.
266	13–14	2–1 T–T	19	None.	....	No record; fair.	Recom. as laby. below par that he be put on observer work.
305	15–15	1–2 1–1	10–12	N.	....	....	Class B. Needs goggles.
243	16–12	T–T 1–T	20	N.	None.	Good..........	Low Nys. did not interfere with flying.
27	16–16	1–1 1–1	....	N.	....	Fair...........	Return to active duty.
230	15–15	1–1 2–2	20	N.	....	Very good.....	Quoted to show possibility of lowering Nys. by constant turnings.
156	15–15	1–1 1–1	5	N.	....	....	Class C. Chr. rhinitis.
149	16–16	2–1 1–2	15	N.	....	None..........	Class B. Temp. unfit.
12	17–15	2–2 2–2	....	Sub. nor. and ex.		Fair..........	Trans. to Chief of Air Service.
202	16–17 [1]13–14	1–1 1–1 1–1 1–1	15 12–11	N. .... N.	Y.	Good..........	Ferrying.
237	13–15	T–1 1–T	10–9	Sl.	....	Fair...........	Class C. Shunt from vestibular to vagus.
247	20–20 [2]16–16	3–2 2–3	20 16	Ex.	Y.	.....do.........	Class C. No theory for this unless shunting theory through vagus and Hyper. verticals.
30	14–17	2–2 1–1	16–14	N.	....	Prim. very poor	Ferry pilot.

[1] Oct. 25. [2] Nov. 14.

As previously noted, these cases were extremely rare, but 14 with 16 seconds or below and but 2 with 13 seconds or below.

In the early days of the entrance examination in America the lower limit of 16 seconds was very closely adhered to, while the upper limit was more elastic.

The majority of us, I think, have deviated widely from that original conception. Very little evidence of any kind has been produced that a hypersensitive labyrinth interferes with flying ability or that it dulls the perception of special localization and movement. We must have a perfectly intact, well-balanced labyrinth and the lower limit is a matter of very little moment.

In this group of 14 cases, only 1 case was recommended for grounding on this cause alone (266). This was one of the very early cases and I have always felt it was a mistake. In the other cases, the remarks give a hint as to why they appeared before the board and the connection with the hypersensitive findings is very questionable.

MONITORS.

The monitors at the Third Aviation Instruction Center were a group of men who had been selected as flying instructors because of their superior skill and experience as fliers. They had been culled out from the thousands of students who had passed through the school because they represented in every way the ideal American aviator. No medical examination had influenced their selection as monitors. It was the cold-blooded judgment of the heads of the flying departments—the fact that they had made good without accidents, that they were dependable, morally, physically, and physiologically, that resulted in their selection for this important and dangerous work.

It is difficult to imagine where a finer group could be found for an intensive study of the American flier under conditions of intense mental and physical strain. They were all eager to cooperate with the examinations. They were all actively engaged daily with hours of air work and were in the best physical condition possible. (But 1 out of the 110 was found physically unsatisfactory; the rest were normal.)

The supervision of this group study was under the control of Maj. Edward C. Schneider, and elaborate studies were made of the rebreathing tests, the English tests for flying efficiency, and the physiological, psychological, psychiatrical sides. The eyes were studied and the ears and labyrinth examinations were made with great care. The results given in Table VIII speak for themselves.

TABLE 8.—*Summary of labyrinth statistics, taken from monitor study—Analysis of labyrinth findings on 77 monitors at Third Aviation Instruction Center.*

[Cases are given by number only.]

No.	Hours.	Nys. R.	Nys. L.	P. P. R.	P. P. L.	Fall.	Vert.
1	....	21	20	2-2	2-3	....	....
66	60	20	20	2-2	2-2	N.	....
71	30	21	23	2-2	2-2	N.	....
105	120	30-3	30	2-2	2-2	Sub.	12-12
303	200	20	22	1-3	3-1	N.	34
311	500	28	24	3-3	3-3	N.	16
315	120	16	17	2-2	2-2	N.	4-4
316	100	22	24	2-2	3-2	N.	12
317	10,200	24	23	3-3	2-3	N.	15
318	400	28-30	30	3-2	2-2	N.	15
324	70	22	20	2-2	2-2	N.	20
325	120	24	23	2-3	3-2	N.	10
328	325	15	16	1-1	1-1	N.	12
329	450	22	24	2-2	3-2	N.	16
330	80	12	11	1-1	1-1	N.	8
331	750	26	26	3-3	3-3	N.	17
332	200	18	17	2-2	2-2	N.	5-5
333	400	16	17	1-1	1-1	N.	6
334	200	22	23	2-3	3-2	N.	16
335	200	22	24	2-2	3-2	N.	12
336	150	30	28	3-3	2-3	N.	20
337	4,500	20	20	2-3	3-2	N.	20
338	550	23	22	3-3	2-2	N.	5-5
339	200	22	24	2-2	3-2	N.	20
340	180	20	20	3-3	3-3	N.	24
341	250	22	23	2-2	2-2	S. E.	22
348	500	26	25	3-3	3-3	N.	8
349	300	33	34	3-3	3-3	N.	22
350	130	33	32	3-3	3-3	N.	30
351	250	22	23	1-1	1-1	N.	16
352	250	23	24	3-2	2-3	N.	12
353	250	23	22	3-3	3-2	N.	10
41	325	25	26	3-3	3-3	N.	28
356	300	25	25	2-2	2-2	N.	25
357	200	25	25	2-2	2-2	N.	28
358	200	25	24	2-2	2-2	N.	22
359	140	20	22	2-3	3-2	N.	14
361	150	19	17	2-1	2-2	N	24-25

TABLE 8.—*Summary of labyrinth statistics, taken from monitor study—Analysis of labyrinth findings on 77 monitors at Third Aviation Instruction Center*—Continued.

No.	Hours.	Nys. R.	Nys. L.	P. P. R.	P. P. L.	Fall.	Vert.
362	60	33	30	3-3	3-3	N.	20
363	60	26	27	3-3	4-3	N.	20
366	200	22	22	2-2	2-2	N.	14
367	200	26	26	2-2	2-2	N.	27
376	150	22	21	2-2	3-2	N.	16
377	40	20	19	2-3	3-2	....	20
378	102	16	18	1-1	1-1	....	12
379	200	25	24	2-2	2-2	....	15
383	45	26	26	2-2	2-2	....	22-22
384	150	36	30	5-4	4-5	....	28
385	300	27	28	2-2	2-2	....	15
386	800	33	34	3-3	3-3	....	20
387	150	25	25	2-2	2-2	....	22
388	200	26	25	2-2	2-2	....	12
389	500	30	30	3-3	3-4	....	22
390	100	26	26	2-1	1-2	....	19
391	390	30	30	3-3	1-3	N.	29
56	1,100	25	20	2-4	3-1	....	23-22
417	200	26	26	2-2	2-2	....	20
406	350	26	26	2-2	2-2	....	15
419	....	28	27	1-1	1-1	....	20
420	400	30	30	2-2	2-2	....	19
430	250	26	26	3-3	3-3	Ex.	15
405	175	26	26	2-2	2-2	....	20
403	100	26	26	3-3	3-3	....	22
122	....	27	26	2-1	2-2	....	17
404	250	28	29	4-2	2-4	....	20
418	150	18	20	2-2	2-2	....	22
481	350	20	19	2-2	3-2	....	6
364	200	24	26	3-3	3-2	....	18
471	340	22	20	3-2	2-3	....	12
472	80	30	30	3-3	3-3	....	26
473	225	32	33	2-2	2-2	....	23
474	200	26	26	2-2	2-2	....	18
475	400	22	21	2-2	2-2	....	14
483	89	20	21	2-2	3-2	....	18
491	200	25	25	3-4	3-3	....	25
514	160	27	28	2-2	3-2	....	22

Examinations made between Sept. 16 and Nov. 27, 1918.
Lowest age 20, highest age 30. No. 420 was 20 years. No. 418 was 30 years.
All general physical examinations showed normal findings except No. 430, classified B for general physical instability.
All eye examinations normal.
All nasal examinations normal except No. 105; tonsil operation advised. No. 317 advised nasal treatment. No. 333 deviated septum. No. 351 deviated septum; operation advised when convenient. No. 122 neurological examinations all normal as to personality. No. 419 stale. No. 122 not aggressive.

Table 8 and the following charts give in detail the results of these investigations from the otological standpoint.

In passing it might be said that from the standpoint of the normal, ideal flier these statistics have never been equaled. None of these 110 men deviated physically except one man who had just returned from active duty at the Front and who had to be put on temporary monitor work.

In every single case the eye findings were normal and the men checked up normally from the physiological and psychological sides.

OTOLOGICAL STUDY.

There was no case in which the nystagmus exceeded 36 seconds. There was only one case in which the nystagmus fell below 16 seconds, on both sides (330). The lowest past pointing was 1–1 (328, 333, 378, 419). The highest 5–4 (384). The falling reaction was generally normal, in one case exaggerated, in one case subnormal. Their falling curves as shown on the self-registering joy stick were invariably normal. The vertigo was constantly low. No case of nausea or vomiting was noted. The averages are given in Table I. The only deviations from the normal for the eyes, the medical or psychiatrical examinations, are those given in the footnotes at the end of the table.

If this group study shows one thing, it is that by natural selection men have finally become to be monitors, and that the unfit temperamentally and physically have fallen by the wayside. The terrible strain of the work, the accidents and natural elimination, have dropped the weaklings and the hypersensitive to motion type by the roadside.

If this group of men represents our highest type of air men, then certainly if these physical findings correspond exactly with the original standards for admission into the service, we may conclude that these requirements as laid down in the original "609" examinations were very close to the ideal.

One suggestion which was constantly made in America, was that practice would materially lower the nystagmus and other vestibular reaction times. The analysis in Table 9, as well as statistics previously given, effectively disproves this theory. Fields 2, 5, 8, and 9 were given over almost exclusively to instruction in acrobatics.

Some of these monitors were in the air five and six hours a day, doing various forms of air stunting, such as tail spins, turnings, loops, etc. Certainly, if we are to find the influence of constant movement in cutting down the nystagmus or influencing the other tests, we would find it here.

TABLE 9.—*Comparison of reactions of monitors from various fields.*

79 cases, all fields, nystagmus to right	24.40
3 cases, field, nystagmus to right	26.6
5 cases, field 9, nystagmus to right	21
10 cases, field 5, nystagmus to right	22.5
29 cases, field 2, nystagmus to right	25.1
78 cases, all fields, nystagmus to left	24.32
9 cases, field 5, nystagmus to left	26.4
5 cases, field 9, nystagmus to left	21.6
10 cases, field 5, nystagmus to left	22.3
29 cases, field 2, nystagmus to left	24.3
79 cases, all fields, P. P. to right, with the right hand	2.27
9 cases, field 8, P. P. to right, with the right hand	2.6
5 cases, field 9, P. P. to right, with right hand	2.0
10 cases, field 5, P. P. to right, with right hand	2.2
29 cases, field 2, P. P. to right, with right hand	2.3
79 cases, all fields, P. P. to right, with left hand	2.25
9 cases, field 8, P. P. to right, with left hand	2.4
5 cases field 9, P. P. to right, with left hand	2.2
10 cases, field 5, P. P. to right, with left hand	2.3

TABLE 9.—*Comparison of reactions of monitors from various fields*—Continued.

29 cases, field 2, P. P. to right, with left hand	2.4
78 cases, all fields, P. P. to left, with right hand	2.35
9 cases, field 8, P. P. to left, with right hand	2.4
5 cases, field 9, P. P. to left, with right hand	2.4
10 cases, field 5, P. P. to left, with right hand	2.2
29 cases, field 2, P. P. to left, with right hand	2.5
79 cases, all fields, P. P. to left, with left hand	2.34
9 cases, field 8, P. P. to left, with left hand	2.6
5 cases, field 9, P. P. to left, with left hand	2.0
10 cases, field 5, P. P. to left, with left hand	1.9
29 cases, field 2, P. P. to left, with left hand	2.3
76 cases, all fields, vertigo	17.9
9 cases, field 3, vertigo	23.2
5 cases, field 9, vertigo	17.0
10 cases, field 5, vertigo	15.3
29 cases, field 2, vertigo	16.7

TABLE 10.—*Monitors, taken by fields.*

FIELD 2.

No.	Date.	Name.	Total hours.	Nys.	P. P.	Vert.	Falling.
105	Oct. 1, 1918	D. H	120	30-30	2-2	12-12	Sub. norm.
315	Oct. 13, 1918	G. E. S	120	16-17	2-2 2-2	4-4	Norm.
316	do	J. H. T	100	22-24	2-2 2-2 3-2	12	Do.
325	do	H. B. H	120	24-23	2-3 3-2	10	Do.
328	Oct. 14, 1918	R. M. B., jr	325	15-16	1-1 1-1	12	Do.
329	do	W. J. R	450	22-24	2-2 3-2	16	Do.
330	do	R. B. M	80	12-11	1-1 1-1	8	
332	do	B. M. W	200	18-17	2-2 1-2	5-5	
334	Oct. 13, 1918	T. L. D	200	22-23	2-3 3-2	16	Do.
335	do	J. P. M	200	22-24	2-2 3-2	12	Do.
336	Oct. 14, 1918	R. S. D	150	30-28	3-3 2-3	20	Do.
337	do	H. F. D	4,500	20-20	2-3 3-2	20	Do.
339	do	W. E. R	200	22-24	2-2 3-2	20	Do.
340	do	R. C. G	180	20-20	3-3 3-3	24	Do.
341	do	J. R. W	250	22-23	2-2 2-2	22	Sl. exag.
348	Oct. 15, 1918	F. W. H	500	26-25	3-3 3-3	8	Norm.
349	do	H. W. S	300	35-34	3-3 3-3	22	Do.
350	do	J. W. S	130	33-32	3-3 3-3	50	Do.
352	do	H. O. F	250	23-24	3-2 2-3	12	Do.
362	Oct. 18, 1918	W. E. C	60	33-30	3-3 3-3	20	Do.
363	do	G. V. W	60	26-27	3-3 4-3	20	Do.
364	Nov. 18, 1918	W. M. W	200	24-26	3-3 3-2	18	Do.
471	do	J. B. S	340	22-20	3-2 3-3	12	Do.
472	Nov. 26, 1918	B. F. C	80	30-30	3-3 3-3	26	Do.

TABLE 10.—*Monitors, taken by fields*—Continued.

FIELD 2—Continued.

No.	Date.	Name.	Total hours.	Nys.	P. P.	Vert.	Falling.
473	Nov. 26, 1918	J. P. M	225	32-33	2-2 2-2	23	Norm.
474	do	W. W. R	200	26-26	2-2 2-2	18	Do.
483	Nov. 18, 1918	E. A. G	90	20-21	2-2 3-2	18	Do.
491	Nov. 27, 1918	R. G	200	25-25	3-4 3-3	25	Do.
514	do	C. P. M	160	27-28	2-2 3-2	22	Do.
			FIELD 3.				
311	Oct. 11, 1918	A. M. B	500	28-24	3-3 3-3	16	Norm.
361	do	S. F. A	150	19-17	2-1 2-2	24-25	Do.
366	Oct. 18, 1918	B. H. B	200	22-22	2-2 2-2	14	Do.
367	do	R. S. O	200	26-26	2-2 2-2	27	Do.
383	Oct. 20, 1918	W. R. B	45	26-26	2-2 2-2	22-22	Do.
389	do	G. D. F	500	30-30	3-3 3-4	22	Do.
404	Nov. 20, 1918	A. J. R	250	28-29	4-2 2-4	20	Do.
440	Nov. 22, 1918	H. L	400	30-29	3-3 3-3	20	Do.
			FIELD 5.				
71	Sept. 26, 1918	R. R	30	21-23	2-2 2-2	......	Norm.
303	Oct. 11, 1918	C. S. G	200	20-22	1-3 3-1	34	Do.
317	Oct. 13, 1918	L. L. H	1,200	24-23	3-3 2-3	15	Do.
318	do	H. E. W	400	28-30	3-2 2-2	15	Do.
324	Oct. 12, 1918	H. C. M	270	22-20	2-2 2-2	20	Do.
331	Oct. 14, 1918	W. J. H	750	26-26	3-3 3-3	17	Do.
333	do	W. S	400	16-17	1-1 1-1	6	Do.
338	Oct. 13, 1918	F. W. M., jr	550	23-22	3-3 2-2	5-5	Do.
351	Oct. 15, 1918	J. E. M	250	22-23	1-1 1-1	16	Do.
353	do	L. M. D	250	23-22	3-3 3-2	10	Do.
			FIELD 8.				
66	Sept. 24, 1918	I. D. F	60	20-20	2-2 2-2	......	Norm.
41	Oct. 16, 1918	D. K	325	25-26	3-3 3-3	28	Do.
356	do	W. D. H	300	25-25	2-2 2-2	25	Do.
357	do	H. B. S	200	25-25	2-2 2-2	28	Do.
358	do	A. P. F	200	25-24	2-2 2-2	22	Do.
359	do	S. E. L	140	20-22	2-3 3-2	14	Do.
384	Oct. 20, 1918	V. D. H	150	36-30	5-4 4-5	28	Do.
385	do	G. S. V	300	27-28	2-2 2-2	15	Do.
386	do	J. H. C	800	33-34	3-3 3-3	20	Do.
391	do	L. H. S	390	30-30	3-1 1-3	29	Do.

TABLE 10.—*Monitors, taken by fields*—Continued.

FIELD 9.

No.	Date.	Name.	Total hours.	Nys.	P. P.	Vert.	Falling.
376	Oct. 19, 1918	H. W. P	150	22-21	2-2	16	Norm.
377	do	J. C. P., jr	40	20-19	3-2 2-3 3-2	20	Do.
378	do	C. P. R	102	16-18	1-1 1-1	12	Do.
379	do	S. B. M	200	25-24	2-2 2-2	22-22	Do.
403	do	R. H. Mc	100	26-26	3-3 3-3	22	Do.

FIELD 10.

No.	Date.	Name.	Total hours.	Nys.	P. P.	Vert.	Falling.
387	Oct. 19, 1918	R. B. V	150	25-25	2-2 2-2	22	Norm.
388	do	S. E. D	200	26-25	2-2 2-2	12	Do.
390	Oct. 20, 1918	J. K. N	100	26-26	2-1 1-2	19	Do.
56	Oct. 19, 1918	J. C	110	25-20	2-4 3-1	23-22	Moderate.
417	Oct. 20, 1918	P. V. A	200	26-26	2-2 2-2	20	Norm.
406	do	H. L. B	350	26-26	2-2 2-2	15	Do.
419	do	W. T. E		28-27	1-1 1-1	20	Do.
420	Oct. 19, 1918	J. W. E	400	30-30	2-2 2-2	19	Do.
430	Oct. 20, 1918	G. A. B	250	26-26	3-3 3-3	15	Exag.
405	do	T. V. L	175	26-26	2-2 2-2	20	Norm.
122	Sept. 30, 1918	I. J. H		27-26	2-1 2-2	17	Do.
418	Nov. 19, 1918	G. C. P	150	18-20	2-2 2-2	22	Do.
704	Dec. 19, 1918	A. E. G	300	30-30	1-1 1-1	15	Do.

FIELD NOT GIVEN.

No.	Date.	Name.	Total hours.	Nys.	P. P.	Vert.	Falling.
431	Nov. 23, 1918	D. M. Y	350	20-19	2-2 3-2	6	Norm.
475	Nov. 8, 1918	W. E. W	400	22-21	2-2 2-2	15	Do.
18	Nov. 9, 1918	J. Q. K., jr	38				Do.

Table 10 gives the detailed findings of the monitors by fields. A comparison of these tables shows no constant variation. We are always forced back to the same conclusion that there is no evidence that actual flying conditions lower the labyrinth reactions, but that the general averages given in Table I represent the true status, both as to the experienced and nonexperienced fliers. The difference between the two groups is simply in their ability to adapt themselves to the vertigo and not have it interfere with their air work.

THE MEN FROM THE FRONT.

Naturally, the one group which the Medical Research Board desired to make a study of was the men who had been subjected to the actual strain of fighting.

In this we were somewhat disappointed as far as any far-reaching effects in the way of staleness were concerned. Our men were not subjected to the fearful strains that the English and French had to endure during the first three years of the war, and in addition many of them, as can be seen by the following tables, had but a few short hours over the lines. Our observation of these 110 men, who had actually had experience at the front, with from 40 to 250 hours over the line, leads us to the inevitable conclusion—the general type is the same; the comparison of the labyrinth reactions shows no striking changes.

TABLE 11.—*Summary of labyrinth findings—Taken from Maj. Schneider's study of men returned from front.*

[Numbers refer to history numbers.]

No.	Hours.	Nys. R.	Nys. L.	P. P. R.	P. P. L.	F.	V.	Date arrived.	Hours.	Combats.	Huns.
487	350	20	20	2-2	....	N	21	....	243	....	0
490	300	20	20	2-2	2-2	N	17	....	250	....	0
492	300	25	25	2-2	2-2	N	31	....	180	....	0
512	230	26	26	3-2	2-3	N	18	....	150	....	[1]5
513	300	25	25	3-2	2-3	N	25	....	0	....	0
516	450	24	24	3-2	2-3	N	15	....	40	....	0
531	250	31	30	3-4	3-5	N	25	....	200	....	1
532	290	26	26	2-1	1-2	N	18	....	215	....	0
534	300	25	24	1-1	1-1	N	16	....	200	....	5½
535	300	16	16	1-1	1-1	N	12	....	200	....	0
536	500	27	27	3-3	3-3	N	28	....	200	....	1
537	80	20	20	3-4	3-3	N	9	....	0	....	0
546	325	26	28	3-3	3-3	N	26	....	185	....	4½
547	350	22	22	1-2	2-2	N	15	....	0	....	0
552	150	20	20	2-2	2-2	N	15	....	30	....	0
561	350	27	28	1-1	1-1	N	11	....	0	....	0
562	300	22	24	2-2	2-2	N	16	....	0	....	0
563	175	22	23	3-2	2-3	N	18	....	0	....	0
566	200	25	25	3-3	3-3	N	19	....	0	....	0
567	250	27	26	2-2	2-2	N	5	....	0	....	0
568	250	15	15	1-2	2-1	....	15-13	....	52	....	0
569	120	25	25	2-2	2-2	N	20	....	45	....	0
570	240	20	25	2-2	2-2	....	13	....	80	....	0
571	200	20	22	1-1	1-1	N	14	....	75	....	0
572	120	20	21	2-2	2-2	N	15	....	2	....	0
573	300	22	20	1-1	1-1	Sub. N	12	....	76	....	0
574	150	27	29	3-4	3-3	N	25	....	8	....	0
577	200	30	31	3-3	3-3	N	22	....	50	....	1
578	160	22	20	2-2	2-2	N	17	....	12	....	0
579	350	28	28	4-4	4-4	N	20	....	75	....	0
580	225	17	19	2-2	2-2	Sub. N	32	....	80	....	0
581	210	22	24	2-2	2-2	N	20	....	50	....	0
582	150	25	25	3-3	3-3	N	20	....	0	....	0
583	125	16	16	1-1	1-1	Sub. N	15	....	35	....	1
584	250	27	25	3-3	3-3	N	20	....	60	....	1
585	150	26	26	4-4	4-4	....	18	....	60	....	0
586	250	26	28	3-3	3-3	N	25	....	0	....	0
587	140	26	26	3-2	2-3	N	12	....	21	....	1
591	110	28	27	3-3	3-3	N	22	....	50	....	2
592	250	25	27	2-1	1-2	N	22	....	69	....	1
596	300	22	24	2-2	2-2	N	17	....	120	....	0
597	325	23	24	1-1	1-1	N	13	....	40	....	0
605	150	24	24	3-2	2-3	N	26	....	40	....	1
607	200	20	21	3-3	2-2	N	27	....	0	....	0
533	175	24	23	2-2	2-2	N	19	....	125	....	0
588	200	22	22	3-2	2-3	N	17	....	90	....	[2]9
613	300	28	31	2-4	3-2	N	23	....	70	....	[1]2
619	700	21	20	2-2	3-3	N	14	....	40	....	[1]4
620	125	25	26	2-1	3-2	N	12	....	0	....	0
621	450	25	27	3-3	3-3	N	21	....	40	....	[1]2
622	450	25	27	2-2	3-3	N	13	....	400	....	[1]4
623	255	18	15	2-1	1-2	N	12	....	120	....	5
625	350	26	28	2-2	3-2	N	12	....	112	....	[1]6
635	800	21	22	2-1	1-2	N	15	....	0	....	0
624	650	30	29	2-2	2-2	N	20	....	50	....	[1]2
637	250	29	33	4-5	....	....	28	....	115	....	[1]5
639	175	21	20	2-1	1-1	N	12	Sept. 7	60	8	[2]1
640	250	13	14	1-2	3-2	....	15	July 25	100	20	6

[1] Official. [2] Unofficial.

TABLE 11.—*Summary of labyrinth findings—Taken from Maj. Schneider's study of men returned from front*—Continued.

No.	Hours.	Nys. R.	Nys. L.	P. P. R.	P. P. L.	F.	V.	Date arrived.	Hours.	Combats.	Huns.
641	1,000	24	26	2-2	2-2	....	14	Aug. 18	60	12	[1]2
642	200	20	20	2-2	2-2	....	12	....	84	....	3
643	200	27	29	1-1	2-1	....	15	....	100	....	1
645	275	23	23	3-4	2-2	S	18	May 19	200	50	[1]2
646	250	21	21	1-2	2-2	....	13	....	80	....	0
647	350	32	32	2-2	2-2	....	27	....	70	....	([3])
650	250	24	26	4-4	4-5	S	131	....	180	....	2
653	250	18	20	2-2	2-2	S	10	Aug. 21	63	8	([4])
654	200	28	24	2-2	2-2	S	13	July 3	140	5	2
655	250	31	30	2-2	3-3	....	32	....	100	1	1
656	212	26	26	2-2	2-2	....	15	Aug. 15	100	6	0
657	200	26	26	2-2	2-2	S	18	Aug. 27	95	12	0
658	200	18	17	3-3	3-3	....	35	July 15	110	25	0
660	200	26	....	....	....	....	....	...do.....	120	50	([5])
661	300	22	22	2-2	2-2	S	20	July 10	40	2	0
663	200	20	20	2-2	2-2	....	15	Aug. 25	100	3	0
664	300	30	30	3-3	3-3	....	45	Aug. 26	100	5	[5]2
665	225	26	26	2-2	2-2	....	12	....	25	....	0
666	150	20	20	2-2	2-2	S	15	....	10	....	....
667	100	37	38	3-3	3-3	....	25	Dec. 1	....	....	....
668	175	26	26	2-2	2-2	S	24	Aug. 11	54	10	[1]1
669	120	27	28	3-3	3-3	S	30	Oct. 3	26	4	[1]1
670	300	18	19	1-1	1-1	S	10	July 20	150	50	([6])
671	250	20	18	2-2	2-2	S	10	Aug. 15	100	5	([7])
672	325	16	17	1-1	1-1	S	15	....	50	....	[2]3
673	250	18	18	2-1	1-2	S	14	Feb. 15	125	20	0
675	300	20	20	3-3	3-3	S. L. type.	35	July 18	105	40	([8])
676	450	28	27	3-3	3-3	Hyper.	30	June 25	250	100	[1]2
677	250	31	27	2-3	2-2	N	26	....	130	....	0
678	120	31	30	2-2	2-2	N	22	Sept. 16	33	6	2
679	110	30	29	2-2	2-2	N	15	....	....	....	....
680	375	30	27	....	....	....	29	July 1	100	0	0
681	180	18	18	1-1	1-1	N	17	May 15	75	20	[1]2
682	300	30	32	3-3	3-3	N	22	....	....	....	....
683	250	27	25	2-2	2-2	N	16	Feb. 19	135	25	[1]6
685	300	24	23	2-2	2-3	N	18	July 20	100	15	([9])
687	350	22	22	3-2	2-2	N	20	Apr. 16	154	18	3
688	250	17	18	2-2	3-2	N	22	Sept. 1	55	5	([10])
691	200	37	35	4-3	3-4	N	21	May 31	100	0	0
692	160	24	22	2-1	1-1	N	12	June 1	110	9	5
693	190	26	26	5-3	4-4	N	19	June 22	105	20	4
694	210	24	24	2-2	3-2	N	16	May 14	120	10-40	4-[2] 2
695	200	25	25	3-3	3-3	N	20	May 20	60	34	3-1
696	225	22	22	2-2	2-2	N	12	May 14	80	10	2-4
697	300	21	21	3-2	2-2	Sub. N	20	May 6	160	87	6
699	....	25	25	3-3	3-3	....	25	Jan. 19	40	....	1
701	85	28	28	4-4	4-6	N	28	....	12	....	0
707	180	26	26	2-2	2-2	N	20	July 29	25	8	[1]2
708	300	22	23	2-2	3-2	N	29	Apr. 15	....	30	[1]5
714	100	20	20	1-1	1-1	N	15	....	31	....	2-[2] 1
716	250	20	20	1-1	1-1	None.	25	Aug. 28	30	1	1-[11] 1
717	200	11	12	2-1	0-1	N	11-13	...do.....	100	8	[1]3
718	280	22	22	4-3	4-3	N	....	Aug. 11	60	8	[1]5
719	100	20	22	3-3	3-2	N	....	Sept. 29	15	2	1-[12] 2
720	150	18	18	1-1	1-1	N	....	Sept. 18	42	3	[1]1
721	200	19	18	2-2	2-2	N	14-15½	Aug. 26	70	6	[1]4
723	250	18	19	2-2	3-2	N	16	....	....	....	....
725	400	20	20	2-2	2-2	N	15	....	60	3	[2]2
Jan. 3	200	20	20	3-2	2-3	N	23	....	....	....	....

[1] Official.
[2] Unofficial.
[3] 3 official; 2 unofficial.
[4] 1 balloon; 2 unofficial.
[5] 1 balloon.
[6] 1 official; 2 unofficial.
[7] 1 official; 1 unofficial.
[8] 2 balloons; 3 unofficial.
[9] 5 balloons; 7 official; 2 planes.
[10] 3 balloons; 1 plane.
[11] Assist.
[12] Shared.

All these men were examined between Nov. 27, 1918, to Jan. 3, 1919.

The ages varied between 19 and 31.

The medical examination in all cases was normal except as follows: 512, not fit to fly B; 531, heart not fit; 561, suggest class B; 577, pus in urine; 591, needs rest; 597, class B; 533, not fit; 645, stale now; 650, stale B; 655, not fit to fly; 658, needs rest; 660, not fit, B; 661, not fit to fly; 666, cardio vascular instability; 672, class B; 673, not fit, B; 675, needs rest; 680, needs rest; 688, stale; 699, unfit, B; 701, unfit.

All eye findings were normal except 592, B class, and 721, unfit.

The ear findings were all normal except 512, not fit to fly; B, chronic rhinitis; 568, frontal sinusitis, radical operation four years ago; 581, tonsilitis, B, chronic enlarged cervical glands; 637, hypersensitive, C tests not completed on account of nausea; does not feel fit; 655, hypersensitive, nausea and vomiting, hypersensitive to motion; 658, slightly hypersensitive, slight nausea, probably stale; 660, hypersensitive, could not complete turning, has been sick at stomach for several days; 661, not fit to fly; bronchitis, infection posterior sinuses; 666, tonsils, septic; 676, hypersensitive, exaggerated falling nausea; 670, should have tonsils removed. Septic tonsils; 671, not fit, ethmoiditis acute; 676, hypersensitive to turning motion: stale. Uren; 717, slightly subnormal, in labyrinth findings, no indication that it affected flying.

Neurologically and from personality study all O. K. or of A type except 561, not fit; 578, not fit; 580, stale; 596, stale, B; 597, stale, B; 624, stale; 650, B.

Table 11 gives a detailed review of the labyrinthine findings in these men. In the column of remarks can be seen the hours over the lines and the number of air victories placed to their credit. We are impressed with the few whose nystagmus time goes over 35 seconds—only one case on both sides.

One man (637), who was hypersensitive and could not have his test completed on account of the nausea, had 29–30 seconds and 4–5 past pointing and was credited as an American ace.

The second (655), with 31–36 seconds nystagmus, was also hypersensitive and brought down two planes.

A third (660), with 26 seconds, was also nauseated.

The rest were all in the normal class. The three exceptions with no excessive nystagmus showed evidences of staleness and were temporarily indisposed.

If we refer again to the general summary given in Table 1 we note how closely these men approach the general average. More interesting, however, is the fact that when Table 11 is studied in detail we note, as in the monitor group study, an absence of the hypersensitive to motion type.

It is the striking normality of the successful type that interests us, a type which had to be picked out, as far as the labyrinth is concerned, almost empirically at the beginning of the war. These statistics speak volumes for the accuracy and soundness of the original standards.

TABLE 12.—*Study of American aces.*

No.	Date.	Name and rank.	Age.	Hours.	Nys.	Past pointing.	Vertigo.	Falling.	Remarks.
			Yrs. ms.						
512...	Nov. 29	Buckley, captain.	22 8	230	26–26	3–2 2–3	18	Normal.....	Not fit to fly (B).
625...	Dec. 9	Stevall, first lieutenant.	23 9	350	26–28	2–2 3–2	12	.....do.......	Normal.
637...	Dec. 7	Steerley, first lieutenant.	22 1	250	29–33	4–5	28	....	Do.
640...	Dec. 9	Guthrie, first lieutenant.	22 7	250	13–14	1–2 3–2	15	Normal.....	Do.
675...	Dec. 14	Luff, first lieutenant.	22 5	300	20–20	3–3 3–3	35	Slightly hypersensitive.	Needs rest.
708...	Dec. 19	Healey, first lieutenant.	24 8	300	22–23	2–2 3–2	29	Normal.....	Normal.
534...	Dec. 3	Oliver, first lieutenant.	23 8	300	25–24	1–1 1–1	16	.....do.......	Do.
567...	Dec. 2	Clark, second lieutenant.	20 8	250	27–26	2–2 2–2	5	.....do.......	Do.

It is a matter of interest purely that we tabulate eight men, Table 12, examined by the Medical Research Board, who had brought down five or more enemies, thus putting them in the class of American aces.

Had the war lasted but a few months longer many names would have been added to this list. In a large measure they had opportunities that the others did not have.

In giving their findings we are taking no credit from them when we show that they deviate in no essential particular from the other men we have examined. Their nystagmus time never reaches 30 seconds and there are no hypersensitive types among them.

CONCLUSION.

1. In conclusion, it might be said that the statistics for this paper were worked up with great care and exactness. The fact that we were dealing with the human organism had no place in the manner in which the examinations were conducted. The nystagmus was observed as carefully as possible, the past pointing and falling never guessed at.

But when the cases are totaled and compared with the statistics from America we again take into consideration the variability of the human element. The slight differences but strengthen the belief that as a result of continuous air work—acrobatic work, monitor work, or work over the lines—the labyrinth reactions are not changed in any essential particular.

2. Among the select and the successful the hypersensitive to motion types are few and far between.

3. Many typical hypersensitive to motion types can accommodate themselves to this handicap and become successful.

4. A very considerable per cent who slipped through the entrance examinations or who were on the border line of the hypersensitive to motion type are not able to overcome the handicap and are dropped by the roadside.

5. Given an intact and well-balanced labyrinth—there is nothing to indicate that the lower nystagmus limit is of consequence even as far down as 13 seconds.

6. The normal labyrinth findings, as previously determined, are substantiated by our studies.

7. Special care should be exercised in allowing candidates with a hypersensitive to motion history and nystagmus around 30–35 seconds to enter the service. Thirty-five seconds is the extreme margin of safety.

8. One can exceptionally overcome almost any handicap of hypersensitiveness to motion, but why risk it?

THE LABYRINTH AND FLYING.

Capt. CLAUDE T. UREN, Medical Corps.

The work in the Otological Department of the Medical Research Laboratory, A. E. F., afforded an excellent opportunity to draw some conclusions on the value of testing the labyrinths of fliers.

Fifty records of so-called hypersensitive labyrinths are divided into six types, as follows:

Type 1. Nystagmus, Over 30 Seconds; Vertigo, Over 22 Seconds; Exaggerated Falling

Eight pilots sent to the laboratory from field No. 3 because they were sick and dizzy in the air. All cases gave a history of seasickness, car sickness, and merry-go-round sickness. Nystagmus from 30 to 40 seconds, vertigo from 22 to 42 seconds; falling, exaggerated. Four were nauseated while in the chair and four were not.

Six pilots discontinued training at this time because of air sickness. One pilot was sent back to training, got into an unintentional tail spin on his first solo flight, and crashed. Two broken legs caused him to discontinue training. One pilot continued through the training with a fair flying record.

Type 2. Nystagmus, Under 30 Seconds; Vertigo, Over 22 Seconds; Exaggerated Falling.

Eleven pilots sent to the laboratory because they were sick or dizzy in the air. Eight of them gave a history of sea, car, and merry-go-round sickness. Nystagmus, 20 to 28 seconds; vertigo, 22 to 53 seconds; falling, exaggerated. Six were nauseated while in the chair and five were not.

Seven pilots of this type discontinued training at this time because of air sickness. Two of the four who continued had good flying records, one fair to good, and one fair.

Type 3. Nystagmus, Under 30 Seconds; Vertigo, Under 22 Seconds; Exaggerated Falling.

Five pilots sent to the laboratory because they were dizzy in the air. One pilot gave a history of sea, car, and merry-go-round sickness. Nystagmus, 20 to 30 seconds; vertigo, 15 to 22 seconds; falling, exaggerated. Three were nauseated while in the chair, two were not.

Two pilots of this type discontinued training at this time because of dizziness. Two made good flying records and one only fair.

Type 4. Nystagmus, Under 30 Seconds; Vertigo, Variable; Normal Falling.

Seven pilots sent to the laboratory because they vomited in the air. History of nausea and vomiting but no dizziness. Always feel fit after emptying the stomach. Nystagmus, 13 to 26 seconds; vertigo, 9 to 40 seconds; falling, normal. Two were nauseated while in the chair.

One pilot of this type discontinued training after the armistice was signed. He had put up with the vomiting until this time. Two made good flying records, two were ordered to duty as ferry pilots, and two made fair records.

Type 5. Nystagmus, Over 30 Seconds; Vertigo, Over 22 Seconds; Normal Falling.

Six pilots sent to the laboratory because they were dizzy in the air. Nystagmus, 30 to 36 seconds; vertigo, 23 to 36 seconds; falling, normal.

Two pilots of this type made good flying records; two fair to good; one fair; and one was ordered to duty as a ferry pilot.

Type 6. Nystagmus, Over 30 Seconds; Vertigo, Under 22 Seconds; Normal Falling.

Thirteen pilots with no symptoms of air sickness. Nystagmus, 30 to 36 seconds; vertigo, 13 to 22 seconds; falling, normal.

Nine pilots of this type made good flying records; three fair to good; and one was ordered to duty as a ferry pilot.

SUBNORMAL LABYRINTHS.

Fifteen pilots with so-called subnormal labyrinths were examined. These pilots had had from 50 to 1,000 hours in the air. Nystagmus, 10 to 17 seconds; vertigo, 5 to 20 seconds; falling, none to normal. Two pilots were sent to the laboratory because of poor air work, two because they were sick in the air, and the others found on routine examination.

Nine pilots of this type made good flying records; two made fair records; one made a poor record; one ordered to duty as a ferry pilot; one was found to be temperamentally unfit, and one discontinued training because of hypermetropia.

CONCLUSIONS.

It will be seen in the classification that 24 of the 50 pilots with hypersensitive labyrinths fall in the first three types and that 16 of these 24 pilots were forced to discontinue training because of air-sickness. In all of these cases there was an exaggerated falling or hypersensitive vertical canals. It would seem then that the vertical canals play a very important part, especially so in stunt flying, and a more accurate measure of the stimulation from these canals should be sought. This we did by timing the falling, and by the addition to the chair of a self-recording control stick.

Timing the Falling.

The pilot is turned five times in 10 seconds, with his head forward on his knees. At the end of the fifth turn, he is instructed to sit up, with his eyes closed and to regain the upright position as soon as possible, keeping the eyes closed throughout the test. The time between the end of turning and the pilot's recovery from the falling is taken with a stop watch. This time varied between 0 and 70 seconds. Pilots with an exaggerated falling did not recover under 20 seconds and were often nauseated.

"Joy Stick."

A stick freely movable in any direction was inserted into the foot board of the chair. Into the top of the stick was placed a small brass rod resting on a steel spring. A table was fastened to the foot board of the chair so that any movement of the stick would make a

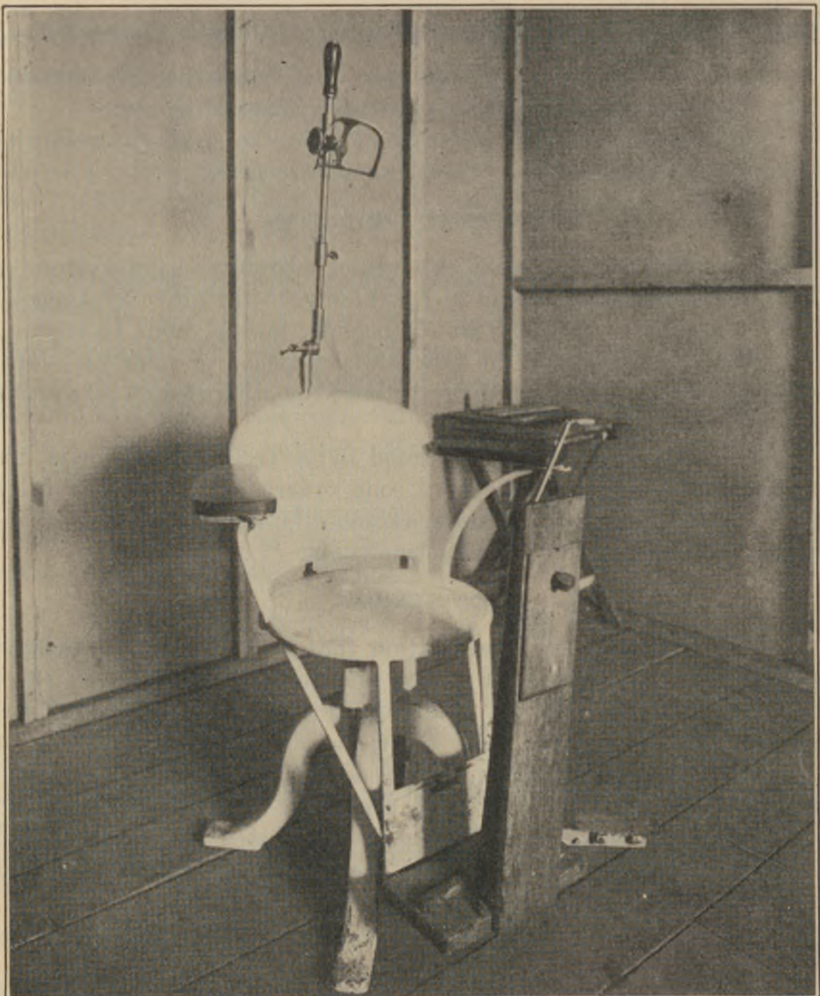


FIG. I.—Rotating chair with self-registering "joy stick" attached.

tracing on paper fastened to the under side of the table. (See Fig. I.) Carbon paper between two sheets of writing paper takes the record. The pilot sits in the chair with his head forward resting on the table and grasps the stick with his right hand, holding it back and to the right. The position of pilot and stick during a vrille to the right. (See Fig. II.)

The chair is turned to the right five turns in 10 seconds. Just before the last turn is completed, the pilot is instructed to push the stick into neutral, which is the perpendicular. As the chair stops turning, he is instructed to sit up, keeping his eyes closed. This is repeated to the left. The record is then removed and examined. (See Figs. III, IV, V, VI.) These records show the amount of stimulation both from the turning and upon changing the position of the head after turning.

A vrille can not be exactly duplicated in the chair. In the ship there are two distinct revolving motions together with a rapid descent. Furthermore, the rudder is the more important control used in coming out of a vrille.

FIG. II.—Subject in position for being rotated, with right hand grasping the self-registering "joy stick."

A series of tracings taken in actual flight, to compare with the records on the chair, was planned.

Type 4 represents the vomiting type in which the chair shows us very little. This type can possibly be accounted for by supposing a hypersensitive vagus. They are not confused by the vertigo of the first three types, and in most cases this vomiting is overcome.

Type 5 shows that hypersensitiveness of the horizontal canals is not a dangerous type except perhaps for the confusion that may come from the vertigo. This is overcome by frequent flying.

Type 6 shows that a prolonged nystagmus time in itself means nothing.

None of the subnormal type discontinued training because of their labyrinths. Some of these were said to have had normal labyrinth responses at the time of their acceptance into the service, but these responses became gradually shorter at each examination as the pilots

171364—20——11

C. S. C., first lieutenant; 4½ months at the front; flight commander; 3 Huns official. No history of dizziness.

Nys.	Vert.	P. P.	Falling.
20 20	12	2-2 2-2	Normal.

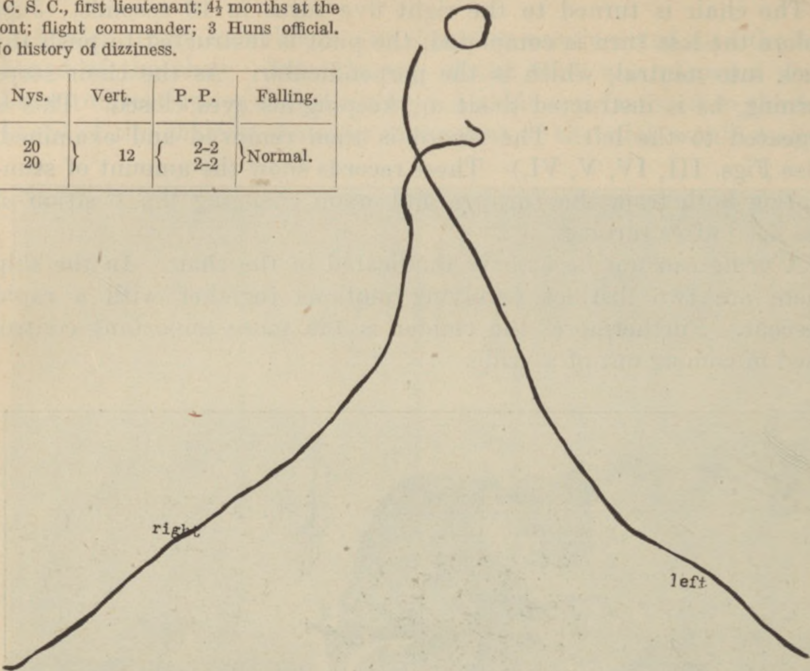


FIG. III.—Normal curve made by pilot with four and a half months' flying at the front.

G. D. F.; monitor field 3; 500 hours flying 22,000 feet.

Nys.	Vert.	P. P.
30 30	22	3-2 3-4

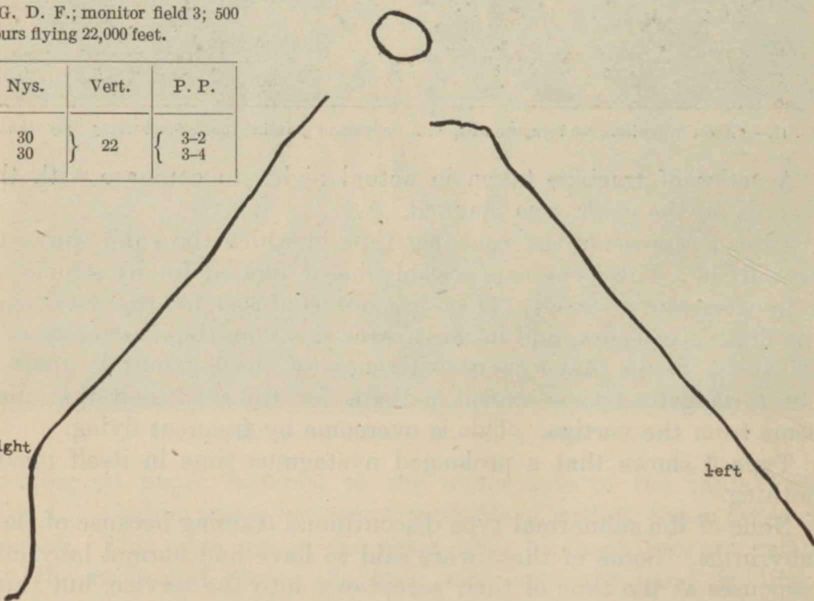


FIG. IV.—Normal curve made by a monitor from field 3, where much acrobatic flying is done.

B. P.; hypersensitive to motion; could not pass avro work; sick in air, seasick; car sick; merry-go-round sick. 9,000 feet. 45 hours.

Nys.	Vert.	P. P.	Exag. falling.
34 33 }	30	{ 4–4 4–4	}Nausea.

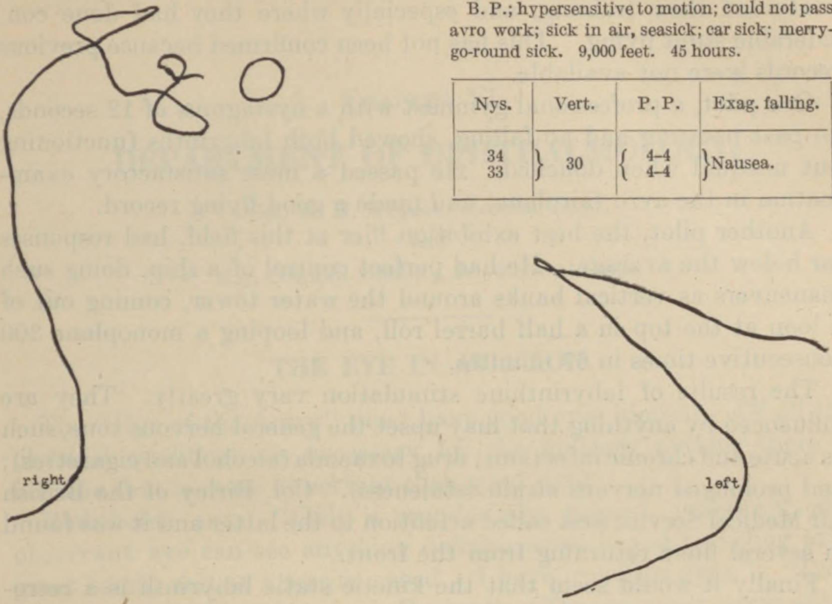


FIG V.—Curve of hypersensitive labyrinth. Shows marked stimulation and confusion. Made by pilot who is hypersensitive to motion and could not pass strict acrobatic tests.

H. E. T.; hypersensitive; could not pass avro work. Comes out of vrilles cock-eyed. Loses head.

	Nys.	Vert.	Exag. falling.
Oct. 8.........	33 32	42 40	Exag. falling.
Oct. 18, after 5 turns in avro.	23 24	33 37	Exag. falling.
Oct. 28	24 23	31 35	

Made good on one occasion, which was a day after drinking wine. Later failed to make good. Class B. Hypersensitive labyrinth.

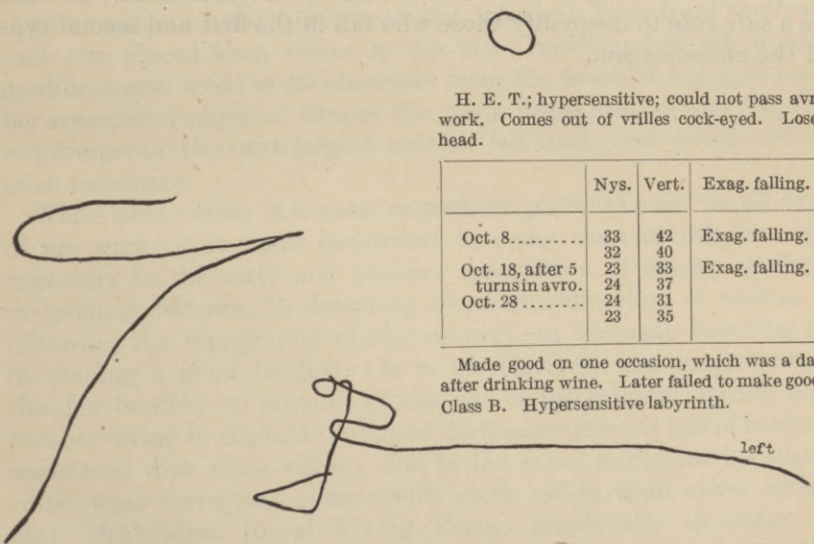


FIG. VI.—Curve of a hypersensitive labyrinth shows marked stimulation and compression.

continued their training, and especially where they had done con siderable stunt flying. This has not been confirmed because previous records were not available.

One pilot, a professional gymnast with a nystagmus of 12 seconds, no past pointing and no falling, showed both labyrinths functioning but unequal when douched. He passed a most satisfactory examination in the avro (airplane) and made a good flying record.

Another pilot, the best exhibition flier at this field, had responses far below the average. He had perfect control of a ship, doing such maneuvers as vertical banks around the water tower, coming out of a loop at the top in a half barrel roll, and looping a monoplane 300 consecutive times in 67 minutes.

The results of labyrinthine stimulation vary greatly. They are influenced by anything that may upset the general nervous tone, such as acute and chronic infections; drug toxaemia (alcohol and cigarettes); and prolonged nervous strain (staleness). Col. Birley of the British Air Medical Service first called attention to the latter and it was found in several fliers returning from the front.

Finally it would seem that the kinetic static labyrinth is a retrograde organ in man, being highly developed in birds, less so in fish and least in man. It undoubtedly undergoes training with the pilot. By force of will, many hypersensitive labyrinths are overcome during training. A functionating labyrinth should be required of a pilot, but there should be no set limits on nystagmus. It would be a safe rule to disqualify those who fall in the first and second types of the classification.

Chapter VI.

DEPARTMENT OF OPHTHALMOLOGY.

Col. W. H. Wilmer, Medical Corps,
and
Maj. Conrad Berens, Jr., Medical Corps.

THE EYE IN AVIATION.

The "Eye of the Army" must have good eyes himself. Of all the physical qualifications necessary for the military aviator there is not one that is more important than good sight.

Richthofen says: "Only a wonderfully trained, practiced, and observant eye can see anything definite when one is traveling at a great height and at a terrific speed. I have excellent eyes." "Contact" writes in his "Air-man's Outing": "The eye must cover every direction and cooperate with the brain in perfect judgments of time and distance." A submarine many feet under the surface of the water may be invisible to a ship but it does not escape the keen-sighted airman.

At a conference with 100 successful American fliers from the front, each one placed keen vision as the most important of all physical qualifications; while of 89 observers from the front, the largest number considered physical fitness the most important of the physical requirements, the next largest number felt that good vision was the most necessary.

While keen vision is a most important physical asset in all types of air work, it is more important in some than in others. It is necessary in the early and positive recognition of enemy airplanes, in judging distance, in detecting speed and direction of motion, in following the topography of the country, in accurate shooting and in making a good landing. It is of relatively less importance to the day bomber on account of the size of his targets; to the night bomber owing to the fact that good dark adaptation is not of necessity associated with acute vision; and to the aerial navigator because he could wear correcting glasses with more safety than other airmen. Maj. McCudden, Royal Flying Corps, graphically describes the tragedy of the unseeing pilot: "I shall never forget how that Fokker looked on the 2–C's tail, whilst the British pilot was calmly flying straight, not looking behind him at all, and no doubt thinking of

Blighty, home, and Beauty." One of our pilots very tersely puts it: "Men with poor vision did not come back."

Should, however, some ocular error become manifest in a flier who is good otherwise, the error should be carefully corrected, preferably by having the correction ground in his goggles. He should, however, be carefully advised of the fact that goggles may be blown off or be broken, or become fogged or soiled with water or oil.

Of the Allies, Guynemer, Bishop, and Rickenbacker (with scores of others) had very acute vision. Among the enemy, the elder von Richthofen and Boelke were the possessors of good sight. Even the keenest sight becomes better by practice over the lines.

The problem of the one-eyed man should not exist in civil or in military flying, save during the exigencies of war. All men experienced in the requirements of aviation agree that only the man with two eyes should be admitted to a flying status. However, where a successful combat pilot with trained "air vision" loses an eye it is quite another question—one of the utmost military and economic importance. The British, with their usual efficiency, have it now under consideration. The objections to returning him to duty are based upon the facts of a diminished field of vision and the impairment of the ability to judge speed and distance, with consequent difficulty in landing. The restricted field of vision is of lesser importance owing to the nature of seeing in the air which is achieved by the constant twisting of the head in all directions—it may be described as a "rubber neck" type. Many fliers have spoken of the enlargement of the neck muscles by this constant motion. The difficulty in landing is more serious. But the gradual return, or failure to return, of the ability to take off and to land, could be tested with a fast ship at the aerodrome. Great stress has been laid upon the economic value of the training, judgment, and experience of the combat pilot. Another consideration is that the number of men who get to the front is very small in proportion to the number entering training—one-fourth to one-half. In our service, approximately a little less than one-half of the observers and one-third of our pilots, who started training, got to the front. The first few trips over the lines are the critical ones. Further considerations are the length of time it requires to make an aviator, and that not all good fliers are good in combat. Therefore, it might seem wise, in certain exceptional cases of this type, to consider the possibility of returning such a flier to his combat status if he is keen to return. Under such circumstances, a few British combat pilots did return, and they continued to be successful.

The proper recognition of colors plays an important part in the success of all types of fliers. On the maps generally used by observers the woods are green, rivers blue, roads yellow, railroads black, and towns brown. Sky-rockets with a parachute are white, red, or green; and cartridges, with and without parachutes, are of similar colors. Bengal flares, which are used in woods and heavy underbrush, are red and white. The aerodromes use red and green, or white lights for homecoming planes, while the planes themselves carry a red light on the port and a green light on the starboard side. In a "dog fight," fliers of great experience state that it is necessary to recognize colors on a machine to avoid the possibility of shooting down a friend. In artillery work the sense of color is necessary to detect false woods, trenches, and guns which have been camouflaged by colored screens, trees, etc. Infantry contact is one of the most trying pieces of work that an aviator is called upon to do. Rapid recognition of color is most helpful in this branch of work. In addition to everything else, the Infantry airman must recognize the various uniforms. All types of fliers (over land) are liable to have to select quickly a place for a forced landing. In this connection, Capt. S. J. Allen, Royal Air Force, states that good color vision is necessary to detect differences of color on the ground. "A light field indicated stubble; a dark green field, grass or wet and marshy ground; dark green stripes running across fields, water or ditches; yellow, sand; and rough brown spots, bumps." If a flier who has been successful in training is found later to be color blind, he can be used as an instructor, ferry pilot, or night bomber, provided only white lights are used at his aerodrome. In great emergencies, he could be used as a day bomber owing to the height at which he usually flies.

Good muscle balance has been considered of great importance by all of those experienced in aviation. In 1914 Halben, who was so liberal in his views in regard to vision, laid emphasis upon the danger of the laming of an eye muscle, thus producing a false projection and a disturbance of orientation. Our British colleagues have recognized the importance of good muscle balance and have established a school of heterophoria under Maj. Clements. Many pilots have been salvaged for their country by his painstaking work. In addition to well-balanced muscles, strong convergence, and accommodation, we realize the necessity for muscles resistant to the strain of air work. We also feel that a rapid change of accommodation for different distances, with this strength well balanced in each eye, is of great importance.

The value of stereoscopic vision has been questioned owing to the recognized fact of the predominant eye, and for the reason that a few men with only one eye, and some with poor stereoscopic vision, have, nevertheless, been successful in flying. However, it is of great value in judging distance in landing and in studying stereoscopic plates. The British have found good correlation between stereopsis and good flying. In our personal experience, it is possessed by all the very successful fliers whom we have examined.

A good dark adaptation is essential to the night flier. It is also of value to all types of fliers. For, during the exigencies of war, pilots, either of necessity, or by the lure of the contest, were deluded by the light of the higher altitudes, and, in consequence, they were surprised to find darkness upon their return to their aerodromes. Landing then became a different matter. McCudden, writing of a pilot flying at night, says: "He left the ground in the dark to fly 20 miles across France to an aerodrome, and as soon as he was off the ground

FIG. I.—Ophthalmological room, Medical Research Laboratory Third A. I. C., A. E. F.

he flew through the side of a house. The only thing undamaged was himself."

Quick visual reaction time, which is so important to the acrobatic flier, is also of advantage to the combat pilot, if it is associated with cool decision and accurate muscular coordination. Richthofen says: "It followed that the victory would accrue to him who was calmest, who shot best and who had the clearest brain in a moment of danger. We have lost many good fighting pilots through their getting excited and dashing headlong into an unequal combat." The most successful combat pilots did not press the trigger until they had taken deliberate aim and the enemy was within the proper range. They frequently brought down their opponents with the first burst, and occasionally by the first bullet.

In general, affections of only passing inconvenience on the ground may be serious in the air, such as scintillating scotoma, muscae volitantes, photophobia, heterophoria, and, for the night flier, poor dark adaptation. Eric Wood very aptly brings out the similarity of distant planes to "muscae." He writes: "There presently appeared a little bunch of black spots, which to any but a man whose eyes had been trained to see, might have been taken, perhaps, for the dancing, mocking dots, which are to many the signs of indigestion."

ROUTINE WORK.

The exigencies of war prevented the carrying on of much research in France, so that the work there consisted mainly in the practical application of the information that had been gained in the Medical Research Laboratory at Mineola, and at the flying fields in the United States.

In addition to 168 entrance examinations and the cases that were daily referred to the laboratory, examinations were made of testers, monitors, American fliers from the front, and French fliers. The fliers from the front were often tired and nervous. The strain of flying, altitude, loss of friends, and personal danger had left a deep impress. This was demonstrated by the records of the near point of convergence, near point of accommodation, the duction tests, and particularly the fatigue of accommodation and convergence, as tested with the ergograph. These showed relaxation of muscle tone and tendency to easily fatigue. As a rule it was found that a rest of a week or 10 days did more to help the ocular conditions than keeping the men at the post and giving them muscle exercises. Examinations were made of student fliers who were having difficulty in landing, or who had crashed, or who were not sure of themselves in judging distance in the air. Examination of the men who were habitually poor landers, often showed some derangement of the ocular muscles although in some cases, we were unable to discover any ocular cause. The most common trouble was a marked weakness in the converging power as shown by the usual tests, even more graphically by the fatigue test. The accommodation was also affected. In those cases that were not helped by rest and muscle exercises, a focus of infection was frequently found, and many of them improved rapidly after removal of diseased tonsils, the extraction of teeth with abscessed roots, or the drainage of infected nasal sinuses. In some cases, derangement of binocular vision was the whole cause of the difficulty in judging distance. When one is accustomed to using both eyes there is often great difficulty in effecting a landing when only one eye can be relied upon—which may be the case in the rapid descent with a dead motor from a great altitude. We had several examples of the different types of cases (1) where there was constant difficulty in maintaining binocular vision and (2) where this disturbance was temporary—due to a sudden change of altitude.

Two crashes occurred at our field about the same time. The first accident was caused by a paralysis of the superior oblique muscle of one eye of the flier, who not only experienced trouble in judging distance in landing but had difficulty in walking about, although his diplopia field was small. The second crash was due to a temporary disturbance of binocular vision—the result of a rapid descent from a great altitude. The flier in this case was a monitor who had never made a bad landing previous to this experience. Under usual conditions his eyes were normal. He was flying one day at a high altitude when his motor stopped. He glided down rapidly to his own field. When he thought he was within 50 feet of the tops of some trees at the edge of the field he leveled off to pick out a landing place, but upon looking over the side he realized that he was probably 200 feet above the trees instead of 50 feet. He nosed over again, and this time came within about 50 feet of the tops of the trees. The field was full of machines, but he quickly located a spot for a landing, glided down, and leveled off, as he thought, a foot or so from the ground. As soon as he had lost flying speed he let the machine down and crashed. He was examined in the hospital at the Third Aviation Instruction Center within an hour and a half, but no physical defect could be found to account for his crash. He had misjudged his distance the second time, and, instead of being 2 feet from the ground when he leveled off, he was at least 15 feet above it. He had been at an altitude of 15,000 feet for about an hour, and had come down so rapidly that his ocular muscles could hardly have had time to have adjusted themselves. This accounted for his difficulty in judging distances. To prevent such occurrences as this every student flier is supposed to make a "tour de piste" before attempting to land.

We have always felt—and practical experience in the field has demonstrated the fact—that men with weak converging power frequently have trouble in landing. In one man who was sent to us from the British because of inability to judge direction in the air (supposedly due to a low degree of myopia) there was convergence weakness combined with divergence excess, which was evidently the cause of his trouble in judging distance and direction. He stated that after having flown at an altitude of 16,000 feet or over for a period of an hour he had upon three occasions cut across the flight, and that before this occurred he had difficulty in judging distance and direction. As his vision was 20/20 under homatropine and 20/20 − 2 without homatropine, we felt justified in eliminating myopia as the cause of the difficulty. Our entrance requirements excluded men with more than 1° of hyperphoria or with more than 2° of exophoria at 6 meters. As a general rule we found that men with hyperphoria and exophoria had difficulty under flying conditions in France. In rare instances, however, men with normal vision in each eye but with so much hyperphoria and exophoria that they were unable to use both eyes together, had made good fliers and apparently had had no difficulty in judging distance or in landing fast machines. In only one instance was it necessary to transfer a man because of inability to fuse distant objects. This pilot had never been able to use his eyes together in spite of an early muscle operation and fusion training, and he had had considerable trouble in judging distance in tennis. After repeated tests he was forced to give up trying to land a fast plane, although he was usually able to land a slow one. After two months' work with this pilot, in the attempt to fit him for his duties, he was finally transferred to a school for observers, where he was to be given work in which the rapid and accurate judgments of distance and direction were not so necessary.

In the A. E. F. the work of classification (from an ocular standpoint) of the flier as to his fitness for flying and his ability to withstand the lack of oxygen was determined by the careful routine eye examination. After a very thorough examination, it did not seem necessary to examine the eyes during the rebreathing test—which was done in all cases in the United States. From our experience in examining over 600 pilots at Mineola, we were convinced that we could usually foretell the type of case that would fail ocularly to withstand the lack of oxygen. If the eyes were normal under this very rigid examination the break in them would be secondary to other physical or psychological causes, and the flier would therefore be classified accordingly by the other departments. A complete history of the pilot was taken, which included family and personal history, previous eye and medical history, flying record, and present condition. An estimation of his general physical make-up and the notes taken from the physical examinations in the other departments were recorded on the eye blanks. The vision, with and without correction, was then recorded, and the correction also, if glasses were worn. If his vision were not 20/20 or better, or if he showed a high degree of manifest hypermetropia as recorded, routinely, by the fogging method, a complete refraction was usually made under homatropine. The interpupillary distance, near point of accommodation for the right and left eye as recorded in millimeters from the anterior surface of the cornea, and the near point of convergence in millimeters from the same point, were then taken. The muscle balance, the converging power, the diverging power, and sursumverging power (all at 6 meters and at 25 centimeters) were then recorded. The tension, fields, lids, lachrymal apparatus, ocular movements, conjunctiva, cornea, iris, lens, media, and fundus were then examined.

Color vision was tested by the Jennings color test and the findings checked with Stilling's plates and Williams lantern. For central color defects the Abney-Oliver color test and the small aperture in the Williams lantern were used. Stereoscopic vision was tested by means of the usual stereoscopic pictures and checked by asking the candidate to make judgments in regard to distant objects in the landscape. A modification of Herring's test was installed for use at 25 feet. Unfortunately, the apparatus for determining reaction time in the judgment of distance was not completed in time to be put to the practical test. The retinal sensitivity was tested roughly with Reeve's wedge and Reeve's contrast squares. The Hare perimeter and the tangent screen were used for testing the visual fields, muscle anomalies, mapping out scotomata, and outlining the blind spots. The Howe's modified ophthalmic ergograph was used, routinely, in the

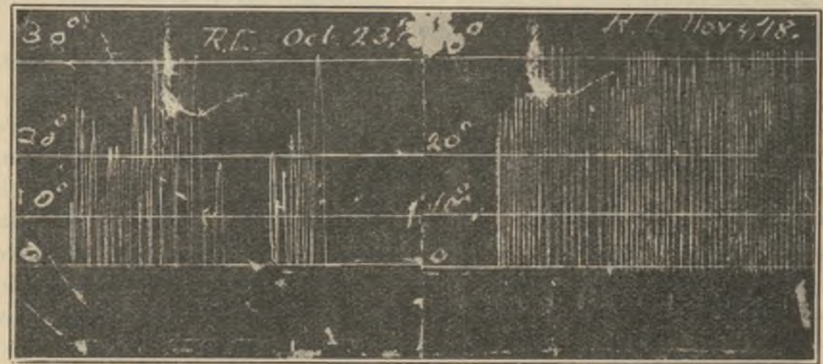


FIG. II.—Two records of the fatigue of convergence of Lieut. R. C. are recorded by the modified Howe's ophthalmic ergograph. The time is recorded in half minutes. The horizontal lines correspond to 10, 20, and 30 prism degrees and are so marked. Note the increase in strength of the converging power between Oct. 23, 1918, and Nov. 4, 1918.

making of diagnoses, in giving converging exercises, and in recording the accommodation fatigue. We believe that the Ferrée apparatus will prove valuable in the eye problems of aviation as well as in clinical problems, and we regret that we were able to make only a few estimations with it.

After an examination in the eye department, a summary of the findings, the diagnosis, and recommendations were typewritten on the history, signed by the officer who had made the examination, passed by the officer in charge of the department, and then sent to the board.

All fliers were examined when they were discharged from the hospital, and they were not permitted to resume flying until they had been cleared by the various departments. This probably saved many accidents.

It was realized that a monthly examination of the pilot's eyes was advisable whenever practicable. The careful prescribing of the proper lenses to be worn in the goggles was an important part of this work.

The dazzling of the retina by artificial lights and by the sun is a most important subject. Zade examined 150 men from his service for the after effects of dazzling, but he did not discover a single case of scotoma. Among 162 men examined in the Antiaircraft Service, he found that 31 members of gun crews showed scotomata following retinal dazzling. The scotomata in these cases were always peripheral and usually in the lower part of the visual field, in the neighborhood of the 40° and 50° meridians. That the aviator is occasionally blinded by glaring light is well known, and two accidents from this cause have been reported—one from blinding in daylight and the other from the dazzling effect of a searchlight.

The treatment of the ordinary ocular troubles fell naturally under our supervision.

TABLE 1.—*Summary of eye examinations.*

Examinations and treatments:	
A. Number of individual cases	794
B. Total examinations and treatment	1,074
Special examinations:	
A. Monitors	70
B. Testers	8
C. Fliers from American front	112
D. French fliers	12
Diagnoses:	
A. Congenital anomalies—	
1. Arterial loop on right disk	1
B. Color blindness	3
C. Lids—	
1. Marginal blepharitis	14
2. Burn of lids	1
D. Lachrymal apparatus—	
1. Stenosis of right lachrymal duct	1
E. Conjunctiva—	
1. Chronic conjunctivitis	5
2. Follicular conjunctivitis	1
3. Acute conjunctivitis	1
4. Muco-purulent conjunctivitis	1
F. Cornea—	
1. Macula of cornea	1
2. Nebula of cornea (traumatic)	1
G. Iris—	
1. Foreign body in right iris	1
H. Choroid—	
1. Chorio-retinitis	7
2. Rupture of choroid with secondary partial atrophy	1
I. Retina—	
1. Neuro-retinitis	1

TABLE 1.—*Summary of eye examinations*—Continued.

Diagnoses—Continued.	
J. Optic nerve—	
1. Optic neuritis	8
2. Optic atrophy	2
3. Traumatic neurosis (hysterical amblyopia)	1
K. Arteries—	
1. Arterio-sclerosis	1
L. Muscles—	
1. Convergence insufficiency	74
2. Convergence excess	2
3. Divergence excess	11
4. Divergent strabismus	2
5. Muscle imbalance	1
6. Fusion sense defect	1
7. Paralysis of left inferior rectus	1
8. Paralysis of left levator palpebrae superioris	1
9. Paralysis of right superior rectus	2
10. Paralysis of right superior oblique	1
M. Refraction—	
1. Emmetropia	431
2. Hypermetropia	213
3. Compound hypermetropic astigmatism	10
4. Hypermetropic astigmatism	13
5. Compound myopic astigmatism	5
6. Myopic astigmatism	7
7. Myopia	12
8. Mixed astigmatism	4

The ocular difficulties that arose from nose and throat infections formed another part of the work of the Ophthalmological Department. In a number of these cases there was an enlargement of the blind spot—a condition most important to detect in the aviator. In mapping out the blind spots the Hare perimeter was used, the head of the subject being kept accurately fixed by using a wooden tongue depressor as a mouth bite. A 1-millimeter black dot was made upon the back of the pilot's own history card (5 by 8), which was fixed upon the arc of the perimeter at 27 centimeters distance from the front of the cornea. This dot corresponds to the center of rotation of the arc of the perimeter. A 3-millimeter black circle upon a light rod was used as a test object. This method had the advantage of saving time, detecting very small enlargements of the blind spot, and preserving upon the permanent history record the graphic, diagrammatic changes in the size and contour of the spot, as shown in Fig. III.

EFFECT OF ALTITUDE.

During the war the effect of altitude upon the ocular functions was of increasing importance owing to the great altitudes at which air combats took place. Many physiological studies upon the effects of altitude have been made in balloons, in decompression chambers, and on mountains. But with the exception of an occasional reference to the fact that vision was disturbed, or that things became black before the eyes, very little study of the effect of altitude upon ocular functions has been found in the literature at our disposal—apart from the records of our own work at Mineola.

The effects of a lowered oxygen tension upon vision, visual fields, color vision, the motor and accommodative apparatus, stereopsis, and the perception of the direction of motion, have already been touched upon in the Manual of the Medical Research Laboratory, Air Service. But it will be necessary from time to time to refer briefly to our former work. While this research work was hasty by reason of the spur of war, and not always conclusive, it is hoped that it may prove an incentive to further and more exhaustive study of these subjects.

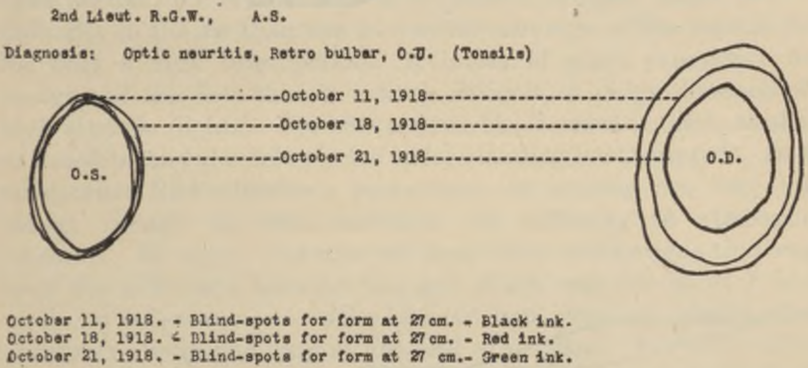


FIG. III.—Rapid clinical method of recording the size of the blind spots.

Visual Acuity.

In the American Expeditionary Forces, as in the United States, visual acuity was tested chiefly by the Ives apparatus. From our experiences at Mineola, we feel that the effect of altitude upon the ocular functions is simulated in the laboratory best by holding the subject at an artificial altitude from about 18,000 to 20,000 feet, for from 30 minutes to an hour. Pilots have often spoken of blurred vision, both at the training stations and during flights at the front. Schroeder, in the account of his altitude flight record, thus described the effect of lowered oxygen tension on his sight: "When I reached 25,000 feet I noticed the sun growing very dim * * * the trend of my thought was that it must be getting late, that evening must be coming on, and that was the reason for the sun's getting so dim * * * as soon as I started to inhale the oxygen the sun grew bright again * * * and the day seemed to be a most beautiful one."

In the manual published in 1918 we spoke of the test of visual acuity under the influence of nitrite of amyl to ascertain if there were any improvement of the vision by an artificial stimulation of the cerebral centers. Of the 12 very accurate subjects examined for this purpose, only one (a myope) experienced improvement at any stage of the tests. In this case the vision grew better owing to the relaxation of the accommodation. Practical experience gained later has served to increase our belief that the sight of the slightly myopic pilot is less affected by altitude than one with hyperopia.

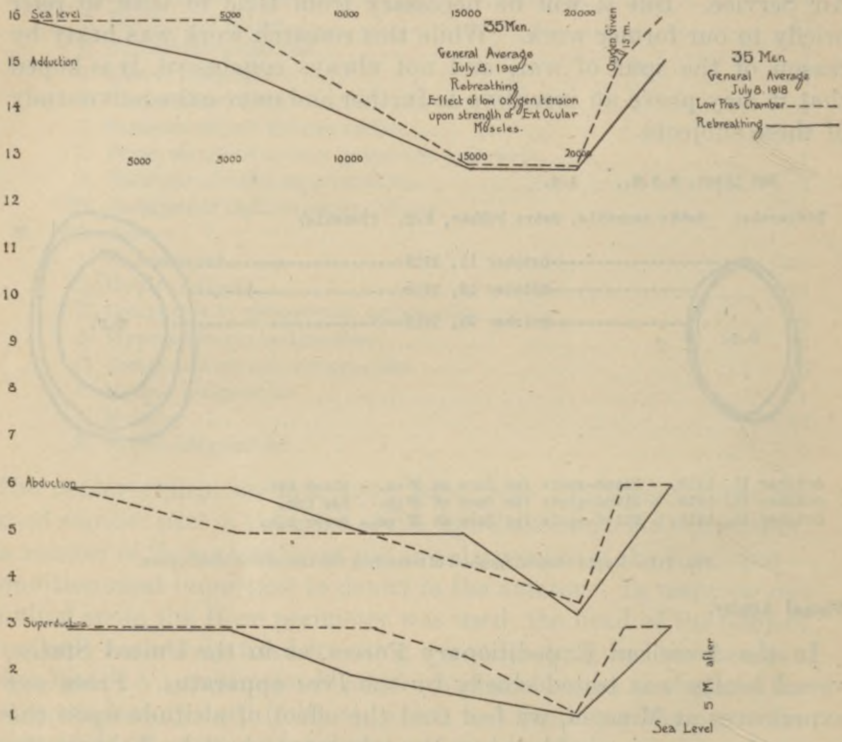


FIG. IV.—Weakening of the duction power of the ocular muscles from artificial altitude.

Color Vision.

From our experience before going to France we feel that there is diminution in the power of the retina to recognize colors as the altitude increases. We were mindful of this fact, but the cases examined were too few and the tests not sufficiently sensitive to permit the drawing of any definite conclusions.

Muscles.

To avoid repetition, it will be sufficient to say that our practical experience in France convinces us that our previous reports were, in the main, correct—showing as they do that at 20,000 feet and over there occurs a loss of duction, accommodation, and convergence power with a restriction of the fields of binocular fixation. While this change takes place in a large percentage of cases, it varies with the general resistance of the flier to oxygen want, and specifically in accordance with his refraction and muscular balance and strength at the beginning. Figure IV shows the average decrease (in 35 men) in the strength of the ocular muscles due to artificial altitude, and also the recovery of the muscle strength after the administration of oxygen. The ordinates represent prism degrees. In ascertaining the fatigue of accommodation, our tests on the rebreathing apparatus and in the low-pressure chamber usually showed a rapid onset of fatigue at 20,000 feet, as compared with the control records. It is possible that the pilot whose near point of convergence is greater than normal, but who is able to withstand fatigue, might have less difficulty in the air than one who could converge at the normal point for only a very brief period. Aviators of great experience have recognized the fact that it is very difficult to judge distance after high altitude flights. For this reason, the descent is made as slowly as possible, and the field circled before landing is attempted. In this connection Rickenbacker's precautions in landing are very interesting, though he does attribute the difficulty to atmospheric pressure. He says: "Another of those little precautions that might spell the difference between life and death was the habit I forced upon myself always to make one or two complete circles of the aerodrome before landing at the end of a patrol * * *. Diving swiftly and suddenly from 15,000 feet altitude, where the air is thin and very cold, to the ground level where the change in the pressure upon the temples is often very severe, may easily make the airman dizzy. He may misjudge the distance above the earth and crash violently when trying only to skim the ground. A circuit or two just above the surface of the landing field will give him time to adjust his vision and to accustom himself to the change in air pressure."

Stereoscopic Vision.

The importance of this qualification seems to grow greater as our experience increases. We feel that this function which so largely depends upon the dynamic conditions of the intrinsic and extrinsic eye muscles is of necessity affected by altitude changes. However, in our previous work upon the subject in the low-pressure chamber only the ordinary stereoscopic charts were available and therefore changes that were slight could not be recognized. In actual flying the return to normal is too rapid to be detected after the landing is made. But with the apparatus of Prof. Spearman, Maj. Berens, and Capt. Howard we feel that the changes in the power of stereopsis under altitude conditions will be easily demonstrated in the laboratory. This function can also be tested in the roomy new planes.

Visual Fields.

We have so far not been able to detect any marked restriction of the visual fields that is due to diminished oxygen. This restriction has been small indeed compared to the limitations of the ordinary goggles.

Retinal Sensitivity.

The contrast sensitivity was tested quickly with the Reeve's wedge and contrast squares. The threshold sensitivity test was made with the wedge and a minute point of light of fixed photometric value, the retina having been previously dark adapted. Other methods of making more accurate tests were being worked out, but the lack of time was a very real handicap. We are not familiar with any test of this type that can be completed within an hour. However, the test is of such importance that the expenditure of time in making it is well worth the while in the case of one who has to fly at night.

Perception of Motion and Its Direction.

From our tests of the peripheral retina at Mineola, there is seemingly an average difference of approximately 10° between the point where the test object is first noted and the point where the direction of motion can be accurately perceived. It was hoped that a test of this sort might be of value in selecting aviators. But the fields for perception of motion and direction of motion have seemed to bear such a close relation to the visual fields as usually taken that the latter test has been sufficient for practical purposes. However, the subject requires a more thorough investigation. The determination of direction of motion by central vision is most important, particularly in maneuvering for position and in using a machine gun. It is sometimes difficult to rapidly determine direction. In the words of Capt. Allen, Royal Air Force: "To a young pilot there are certain positions a near-by plane may assume in which it is rather hard to judge the exact direction of motion. For example, when the enemy plane is above, in front of, and to the starboard side." Bearing this in mind, we have devised an apparatus which will record reaction time in the judgment of direction of a moving plane. We believe that the time element with the influence of altitude upon it, is most important and we hope that practical experience in the future will demonstrate the value of some such test.

The following are the results of tests made before and after flight without oxygen and with its artificial use:

Altitude test (16,000 feet for one hour).

[J. C., second lieutenant, Aviation Section.]

	Without oxygen, Nov. 23, 1918.		With oxygen, Nov. 24, 1918.	
	Before flight.	After flight.	Before flight.	After flight.
	Mm.	*Mm.*	*Mm.*	*Mm.*
Accommodation OD (average)	80	96.6	90.6	99.6
Accommodation OS (average)	76	102	89	99.6
Convergence (average)	31.6	50	47.3	46.3

Fatigue of accommodation, slight (Fig. V).
Fatigue of convergence, slight (Fig. V).

[H. A. C., second lieutenant, Aviation Section.]

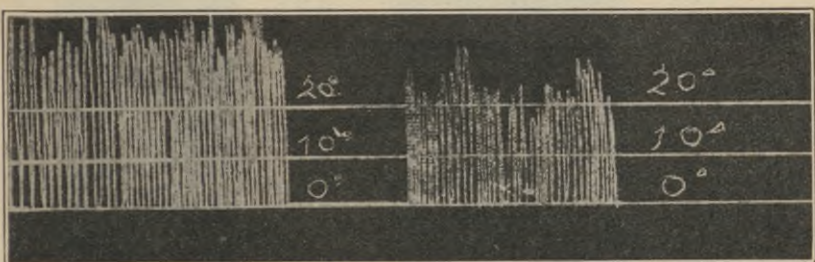
	Mm.	*Mm.*	*Mm.*	*Mm.*
Accommodation OD (average)	109.3	126.6	103.3	105.6
Accommodation OS (average)	105	121.6	104	96.3
Convergence (average)	51.6	47	37.3	36.6

Fatigue of accommodation, marked.
Fatigue of convergence, slight (had been using convergence exercises for several weeks previous to this test).

ALTITUDE TEST WITHOUT OXYGEN.

J. Canfield, Second Lieut., A. S., Nov. 22, 1918. 1.45 p. m. At 16,000 feet, 1 hour. Convergence for 25 cm., N. P. C., before test 35–30–30. After test 47–50–53. Convergence at 25 cm., 10 minutes after landing.

H. A. Colver, Second Lieut., A. S., Nov. 22, 1918, 1.45 p. m. At 16,000 feet, 1 hour. Descent at 3.25 p. m., N. P. C., before test 55–45–45. After landing 47–47–47. Exercise case. Convergence fatigue at 25 cm. 20 minutes after landing.



Accommodation fatigue, Jaeger type, 110 mm. from cornea one-half hour after landing.

Accommodation fatigue, Jaeger test type No. 1 at 115 mm. from cornea 40 minutes after landing.

FIG. V.—Record of fatigue of accommodation and convergence after a flight without use of oxygen.

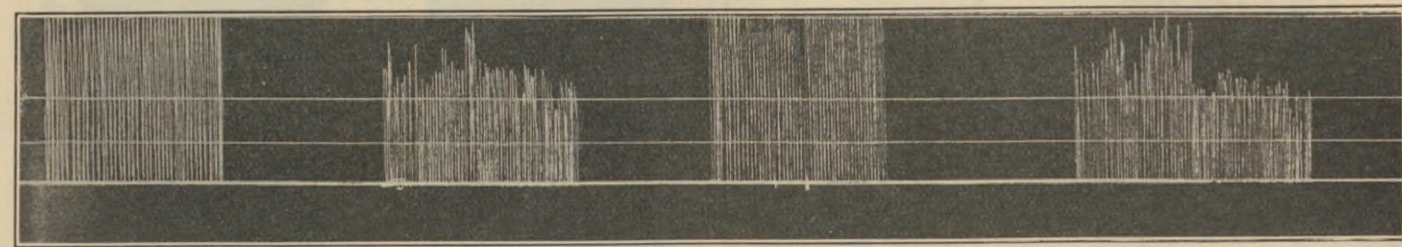
ALTITUDE TEST WITH OXYGEN.

J. Canfield, second lieut., A. S., Nov. 25, 1918, 11.40 a. m. At normal convergence for 25 cm., N. P. C. 52–45–45; convergence at 25 cm. 10 minutes before flight.

H. A. Covert, second lieut., A. S., Nov. 23, 1918, 11.40 a. m. Normal convergence for 25 cm., N. P. C. 40–37–35; convergence at 25 cm. 10 minutes before flight.

J. Canfield, second lieut., A. S., Nov. 23, 1918, 1.40 p. m. At 16,000 feet, 1 hour. Descent at 1.40 p. m. Convergence for 25 cm., N. P. C 47–45–47; convergence at 25 cm. 10 minutes after landing.

H. A. Covert, second lieut., A. S., Nov. 23, 1918. At 16,000 feet, 1 hour. Descent at 1.40 p. m. N. P. C. 40–35–35; convergence at 25 cm. 10 minutes after landing.



Accommodation fatigue, Jaeger test type, 110 mm. from cornea 20 minutes before flying.

Accommodation fatigue, Jaeger test type, 110 mm. from cornea 20 minutes before flying.

Accommodation fatigue, Jaeger test type, 110 mm. from cornea 20 minutes after landing.

Accommodation fatigue, Jaeger test type, 110 mm. from cornea 20 minutes after landing.

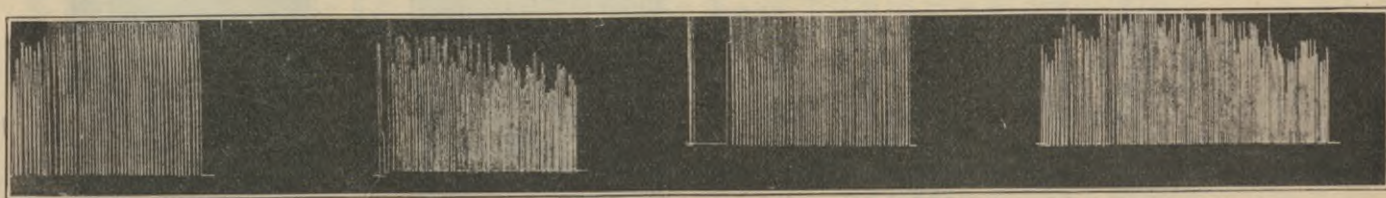


FIG. VI.—Record of fatigue of accommodation and convergence, of two pilots, after a flight with use of oxygen.

In both cases where oxygen was used during the flight there was less change in the near points of accommodation and convergence than when the flight was made without it. In the fatigue tests when oxygen was used there was practically no change. (Fig. VI.)

The ideal method of making these tests would be to have the observer and apparatus in the plane with the pilot so that the examinations could be made in the machine itself, before and after flight, as well as several times during flight. With the construction of the comfortable new planes, these examinations could easily be carried out.

We know, from decompression chamber and rebreathing experiments, that the ocular functions often return to normal rapidly after an altitude test, and this accounts for the slight difference found upon examination after a flight. It can be well understood that flying an aeroplane at the front adds a strain which is not experienced in ordinary flying.

As a rule one does not realize that the observer's duty is very fatiguing. But working a machine gun at high speed in the terrific blast of the propeller, while attempting to observe things all about him, requires great strength and endurance, and, above all, normal eyes which are able to withstand the effect of altitude.

In addition to much routine and classification work, by Capt. H. R. Skeel, Medical Corps, in the eye department of the Second Aviation Instruction Center, at Tours (training school for observers), careful examinations were made of the eyes of 92 observers from the front when the men were undergoing the rebreathing test. Color blindness was found in only one case. But in a large proportion of the men who had seen very trying work at the front, there was a disturbance of the motor apparatus of the eye. This was shown by a weakened power of accommodation and convergence.

CONCLUSIONS.

1. In altitude experimentally produced the chief effect is a disturbance of the muscular apparatus of the eye, though it is possible that sensitivity is lessened at extreme altitudes.

2. Up to 10,000 feet ocular changes noted are not constant. Occasionally apparent improvement is noted; but in averaging the examinations of a number of men, there is usually little change. Beginning weakness of the ocular functions is usually noted between 10,000 and 15,000 feet, and changes are nearly always more marked at 20,000 feet and over.

3. From our findings we believe that at lower altitudes the ocular functions may possibly be stimulated for a brief time, but at higher altitudes weakness results. The apparent improvement occasionally noted at low altitudes may be due partly to the difficulty in obtaining the maximum effort in the preliminary examinations. The factor of

excitement, in the first few minutes of a new experience, may bring forth greater muscular effort. But we doubt that the early changes are due to oxygen want. At increasing altitudes, depending upon the individual, the eye ceases to function. This is secondary to cerebral or circulatory breakdown.

4. The administration of oxygen prevents the onset of changes due to altitude, and quickly restores ocular functions to normal even when there is lowered atmospheric pressure.

5. The results obtained on the rebreathing apparatus and in the low-pressure chamber are for practical purposes identical. The experiments that were made after actual flights were small in number but they agree with the results obtained at an altitude produced artificially.

THE EFFECT OF TOBACCO, ALCOHOL, AND DRUGS.

Tobacco.

It is a well-known fact that men living under the strain of war conditions use more tobacco than ordinarily. This was particularly true of the aviator at the front, for he frequently had long hours of waiting with little to do except smoke. The cigarette was smoked almost universally in the Air Service, and many of the men we met inhaled the smoke from 30 or 40 cigarettes a day. Knowing conditions in regard to the use of tobacco, Capt. Underwood tested in 1918, in the ophthalmological department of the Medical Research Laboratory, Mineola, the effect of smoking on ocular functions. He has since revised and enlarged his work, which will later be published.

Later on in France there was some research work carried on concerning the effect of tobacco smoking upon the eyes. The subjects examined were relatively too few to determine so large a question or to enable very specific conclusions to be drawn. However, it may be said in general that the inhaling of several cigarettes, or the smoking of one cigar, seemed to impair some of the ocular functions for a time, even in habitués. Among the aviators examined at the laboratory in France, the effect was transient, passing off, as a rule, within an hour.

Drugs.

There was also some investigation of the effects of alcohol and such drugs as quinine, aspirin, and phenacetin upon the eye functions. Here, too, the cases were too few for definite conclusions to be drawn. But the importance of having some accurate knowledge of the effect of these substances upon the eye is very great. In our experience a number of aeroplane accidents occurred after the fliers had been using such drugs as aspirin, phenacetin, bromides, and an advertised remedy for seasickness.

TABLE II.

Type of aviator.	Number examined.	Age.	Type of work.	Diagnosis.	Wore correction in goggles.	Manifest hypermetropia.	Interpupillary distance.
Ace, American	21	Average.... 23.10 High....... 31.9 Low....... 21.6	All chasse........	Emmetropia...... 12 Hypermetropia... 5 Myopia........... 1 Comp. myopic astigmatism..... 1 Convergence insufficiency...... 1 Undiagnosed refractive error.... 1 *P. ct.* Emmetropia..... 57 Hypermetropia... 23.4 Myopia........ 4.8 Comp. myopic astigmatism .... 4.8 Convergence insufficiency........ 4.8 Undiagnosed refractive error.... 4.8	2 or 9.5 per cent.	Average.. 0.44S High..... 1.25S Low...... .25S	Average...... 63 High......... 68 Low......... 56
French fliers..	12	Average...... 26 High........ 35 Low......... 21	Night bombing, per cent....... 58.4 Chasse, per cent...... 41.6 Night bombing....... 7 Chasse 5	Emmetropia...... 7 Hypermetropia.... 3 Myopic astigmatism........ 1 Chorio retinitis (central)....... 1 *P. ct.* Emmetropia...... 58.4 Hypermetropia... 25 Myopic astigmatism......... 8.3 Chorio retinitis (central)........ 8.3	None..........	Right. Average.. 0.53S High..... 1.00S Low...... .25S Left. Average.. .55S High..... 1.8 Low...... .25S	Average..... 62 High........ 65 Low......... 60
Testers.......	8	Average..... 24.8 High....... 29.1 Low....... 22.2	All testers........	Emmetropia...... 3 Hypermetropia... 5 *P. ct.* Emmetropia...... 37.5 Hypermetropia... 62.5	None..........	Average.. 0.53S High..... 1.8 Low...... .25S	Average..... 61 High........ 70 Low........ 58
Monitors......	70	Average..... 24.8 High....... 33.3 Low....... 20.7	Bombing...... 12 Nieuport...... 12 Observer...... 1 Acrobatics.... 7 Rouleur....... 19 Cross country 5 Combat........ 4 Not given..... 11 Others....... 6 80 Instruction in 3 types..... 3-6 Instruction in 2 types..... 4-4 10 Total.. 70	Emmetropia....... 56 Hypermetropia..... 9 Myopia........... 1 Comp. hyper. astigmatism........ 1 Convergence insufficiency......... 3 *P. ct.* Emmetropia........80 Hyperopia.........13 Myopia........... 1.5 Comp. hyper. astigmatism....... 1.5 Convergence insufficiency......... 4	None..........	Average.. 0.63S High..... 1.12S Low...... 0.0S	Average..... 64 High........ 68 Low......... 55
Men from front (including aces).	112	Average..... 24.1 High........ 31.9 Low........ 19.7	All chasse (1 in charge of training also).	Emmetropia....... 66 Hypermetropia.... 34 Comp. myopic astigmatism.......... 2 Conv. weakness.... 2 Myopia............ 3 Myopic astigmatism 1 Mixed astigmatism. 2 Diverg. excess...... 1 Muco purulent conjunctivitis....... 1 Hyper. astigmatism 1 *P. ct.* Emmetropia...... 59 Hypermetropia... 30 Comp. myopic astigmatism..... 1.7 Conv. weakness... 1.8 Myopia........... 2.4 Myopic astigmatism............ .9 Mixed astigmatism............ 1.6 Hyper. astigmatism............ .9 Diverg. excess..... .9 Muco purulent conjunctivitis....... .9	4 or 3.58 per cent.	Right. Average.. 0.566 High..... 1.70 Low...... .12 Left. Average.. 0.605 High..... 1.50 Low...... .12	*Mm.* Average... 63.6 High...... 78 Low...... 56
Total.........	223	Average..... 24.5 High........ 35.3 Low........ 19.7	Monitors..... 70 Chasse....... 138 Testers....... 8 Bombing..... 7	*P. ct.* Emmetropia..... 64.57 Hypermetropia.. 25.15 Myopia.......... 2.24 Comp. myopic astigmatism.... 1.34 Convergence insufficiency..... 2.24 Myopic astigmatism.......... .9 All other......... 3.56	6 or 2.7 per cent.	Average 0.5715S High... 1.50S Low.... .12S	*Mm.* Average.. 63.49 High..... 78 Low..... 55

Visual acuity (uncorrected).

Type of aviator.		Right. Men.	Right. Per cent.	Left. Men.	Left. Per cent.
Ace, American	Below 20/20...	5	23.8	4	19
	20/20........	7	33.3	5	23.8
	20/15........	9	42.9	12	57.2
	20/10........	0	0	0	0
French fliers	Below 20/20...	1	8.33	3	25
	20/20........	4	33.34	2	16.67
	20/15........	7	58.33	6	50
	20/10........	0	0	1	8.33
Testers	Below 20/20...	1	12.5	0	0
	20/20........	3	37.5	2	25
	20/15........	4	50	6	75
	20/10........	0	0	0	0
Monitors	Below 20/20...	6	8.57	6	8.57
	20/20........	17	24.28	22	31.43
	20/15........	45	64.29	39	55.7
	20/10........	2	2.86	3	4.3
Men from front	Below 20/20...	17	15.31	17	15.32
	20/20........	41	36.94	36	32.43
	20/15........	53	47.75	57	51.39
	20/10........	......	....	1	.9
	(1 man no record.)				
Total	Below 20/20...	30	13.52	30	13.52
	20/20........	72	32.43	67	30.18
	20/15........	118	53.15	120	54.05
	20/10........	2	.9	5	2.25

Type of aviator.	Near point convergence.	Near point accommodation.	Muscles. 6-meter.	Muscles. 25-centimeter.
Ace, American	Average......... 51 High............ 85 Low............ 20	Right / Left Average...... 106 / 106 High......... 130 / 130 Low.......... 80 / 60	Divergence (power of). ° Average........ 5 High........... 8 Low........... 3 Convergence. Average........ 14 High........... 25 Low........... 8 Rt. sursumvergence. Average........ 2½ High........... 2½ Low........... 2½	Divergence (power of). ° Average........ 18 High........... 25 Low........... 11 Convergence. Average........ 36 High........... 55 Low........... 16 Rt. sursumvergence. Average........ 2½ High........... 2½ Low........... 2½
French fliers	Average......... 41 High............ 80 Low............ 27	Right / Left Average...... 89 / 88 High......... 115 / 115 Low.......... 60 / 55	Divergence (power of). ° Average........ 8 High........... 11 Low........... 6 Convergence. Average........ 14 High........... 25 Low........... 25 Exophoria (5 men). Average........ 3 High........... 5 Low........... 1 Esophoria. Average........ 1.3 High........... 2 Low........... 1 Rt. sursumvergence. Average........ 3 High........... 4 Low........... 2	Divergence (power of). ° Average........ 19 High........... 50 Low........... 10 Convergence. Average........ 45 High........... 60 Low........... 18 Exophoria. Average........ 4 High........... 18 Low........... 2 Esophoria. None. None. None. Rt. sursumvergence. Average........ 3.½ High........... 4 Low........... 3
Testers	Average......... 56.6 High............ 80 Low............ 40	Right / Left Average...... 111.9 / 113.1 High......... 150 / 150 Low.......... 90 / 90	Average for 2 men. ° Exophoria........ 1 Esophoria........ 1 Hyperphoria...... ½	Exophoria....... 4.5 Hyperphoria...... .25 High........... .5 Low........... 0 Exophoria: High........... 5 Low........... 4
Monitors	Average......... 53 High............ 115 Low............ 30	Right / Left Average...... 103 / 105 High......... 140 / 140 Low.......... 65 / 65	Divergence (power of). ° Average........ 5.8 High........... 15 Low........... 2 Convergence. Average........ 16.5 High........... 25 Low........... 6 Rt. sursumvergence. .... Exophoria. Average........ 1.07 High........... 2 Low........... 1 Esophoria. Average........ 1.4 High........... 3 Low........... .5 Hyperphoria. Average........ .5	Divergence (power of). ° Average........ 14 High........... 20 Low........... 7 Convergence. Average........ 22 High........... 31 Low........... 6 Rt. sursumvergence. .... Exophoria. Average........ 4.7 High........... 12 Low........... 2 Esophoria. Average........ — High........... — Low........... —
Men from front (including aces).	Average......... 43.06 High............ 85 Low............ 25	Right / Left Average...... 102.1 / 100.9 High......... 130 / 130 Low.......... 65 / 60	Divergence (power of). ° Average........ 5.9 High........... 10 Low........... 3 Convergence. Average........ 13.7 High........... 35 Low........... 1 Rt. sursumvergence. Average........ 2 High........... 2.5 Low........... 1 Exophoria (26 men or 23.2 per cent). Average........ 1.6 High........... 13 Low........... .5 Esophoria (26 men or 23.2 per cent). Average........ 1.54 High........... 3 Low........... .5 L. hyperphoria (3 men or 2.7 per cent). Average........ 1.17 High........... 3 Low........... .5	Divergence (power of). ° Average........ 15.2 High........... 25 Low........... 9 Convergence. Average........ 38.1 High........... 90 Low........... 8 Rt. sursumvergence. Average........ 2 High........... 2.5 Low........... 1 Exophoria (56 men or 50 per cent). Average........ 5.11 High........... 18 Low........... 1 Esophoria (6 men or 5.35 per cent). Average........ 2.5 High........... 4 Low........... 2 L. hyperphoria (2 men or 1.5 per cent). Average........ 1.5 High........... 2 Low........... 1
Total	*Mm.* Average......... 47.3 High............ 115 Low............ 20	Right / Left (*P. ct.*) Average...... 102.4 / 102.41 High......... 150 / 150 Low.......... 60 / 55	Divergence (power of). ° Average........ 5.82 High........... 11 Low........... 2 Convergence. Average........ 14.1 High........... 35 Low........... 3 Rt. sursumvergence. Average........ 2.54 High........... 4 Low........... 1 Exophoria. Average........ 1.5 High........... 13 Low........... .5 Esophoria. Average........ 1.43 High........... 3 Low........... .5 L. hyperphoria. Average........ .75 High........... 3 Low........... .5	Divergence (power of). ° Average........ 16.47 High........... 50 Low........... 7 Convergence. Average........ 38.02 High........... 90 Low........... 1 Rt. sursumvergence. Average........ 2.57 High........... 4 Low........... 1 Exophoria. Average........ 5.32 High........... 18 Low........... 1 Esophoria. Average........ 2.5 High........... 4 Low........... 2 L. hyperphoria. Average........ 1.17 High........... 2 Low........... .5

In the muscular measurements the degree sign is used to express the prism diopter.

Near-point convergence. / *Near-point accommodation.* (Total)

Age.	Men.	Average.	High.	Low.	Right eye. Average.	Right eye. High.	Right eye. Low.	Left eye. Average.	Left eye. High.	Left eye. Low.
20	3	36.67	45	30	81.67	90	65	80	90	65
21	8	45.875	80	27	96.875	110	80	95.625	110	75
22	44	45.25	70	20	104.55	130	80	102.95	130	75
23	44	47.4	100	25	102.57	130	85	103.4	130	85
24	29	48.86	110	30	102.1	130	60	101.9	130	85
25	31	49.645	115	30	104.68	140	80	103.74	140	80
26	21	46.24	65	25	93.24	120	65	90.7	110	60
27	9	48.33	65	30	105.22	140	85	108	145	90
28	10	50.3	80	30	107.5	150	80	106.5	150	80
29	5	46	80	30	110	120	100	110	120	100
30	5	41	55	30	108	120	100	107	120	95
31	3	66.67	80	60	106.67	130	80	106.67	130	75
32	4	38.75	45	30	112.5	130	85	112.5	130	85
35	2	37.5	40	35	102.5	110	95	102.5	110	95
	5[1]									
	223									
SUMMARY.					SUMMARY.					
26.64	218	47.17	115	20	102.68	150	60	102.1	150	55

Type of aviator.	Flying history.	Hours of flying at front.	Enemies.	Chief complaint.	Ocular examination.	Color vision.	Stereoscopic vision.	Recommendations.
Ace, American	Hours. Total.... 6,255 Average.. 298 High..... 1,000 Low..... 160 Landing. All OK. No. of crashes. 6 Shot down 3	(For 15 men.) Total.... 2,051 Average.. 137 High..... 400 Low..... 100	Total ... 137 Average.. 6.5 High..... 12 Low..... 5	*P. ct.* No complaint... 53 Nervous......... 18 Restless......... 14 Tired out....... 10 Poor condition . 5	All normal......	All normal..	All normal..	Convergence insufficiency and rest, 1. Held by ophthalmological department, 1 (correction in goggle).
French fliers	Hours. Total.... 6,308 Average.. 525 High..... 1,163 Low..... 220 Landing. No. of crashes. 2	Total.... 3,030 Average.. 275 High..... 500 Low..... 110	(Chasse only.) Total.... 19 Average.. 3.80 High..... 11 Low..... 3 Balloons. 2	*P. ct.* No complaint. 91.7 Complaint.... 8.3	*P. ct.* Not normal 33.3 Normal.... 66.7	All normal..	All normal..	All fit.
Testers	Hours. Total.... 3,450 Average.. 431 High..... 1,500 Low..... 60 Landing. Crashes.	None...........	None...........	*P. ct.* Nervousness.. 12.5 No complaint. 87.5	*P. ct.* Not normal 12.5 Normal.... 87.5	All normal..	All normal..	Al fit.
Monitors	Hours. Total... 16,149 Average. 245 High.... 1,200 Low.... 12 Landing. No. of crashes 3	None...........	None...........	*P. ct.* Complaint... 4.3 No complaint 95.77	*P. ct.* Not normal 5.7 Normal.... 94.3	All normal..	All normal..	Unfit temporarily, 1.
Men from front (including aces).	Hours. Total... 29,850 Average. 269 High.... 1,200 Low.... 100 Landings 100 per cent OK. No. of crashes (20 men or 18.3 per cent) 20 Shot down (6 men or 5.7 per cent).... 6	Total.... 9,606 Average.. 101 High..... 400 Low..... 2	Total...... 286 Average, per cent...... 3.2 High....... 12 Low....... 0	Lack of exercise, 1 or 0.9 per cent. Staleness, 2 or 1.85 per cent. Poor eyesight, 1 or 0.9 per cent. Complaints, 4 or 3.65 per cent. No complaints, 96.35 per cent.	All normal......	All normal..	All normal..	Unfit temporarily 3 or 2.75 per cent. Convergence excess, 1 or 0.9 per cent. Long rest, 1 or 0.9 cent. Not to fly until released by ophthalmological department, 1 or 0.9 per cent. Normal, 97.25 per cent.
Total	Hours. Total... 62,012 Average. 279 High.... 1,500 Low.... 100 Men crashed, 34 or 15.25 per cent. Men shot down, 9 or 6.2 per cent. (No monitors or testers included in this number.)	(For 139 men.) Average. 105.40 High.... 500 Low.... 2	Total...... 442 Average (per chasse pilot) per cent.....3.29 High....... 12 Low....... 0	*P. ct.* No complaint 84.85 Complaints .. 15.15	*P. ct.* Normal... 96 Not normal. 4	All normal..	All normal..	Temporarily unfit, 6 or 2.68 per cent.

[1]No record.

ANALYSIS OF SPECIAL EYE EXAMINATIONS OF AVIATORS.

Eye examinations were made of 11[illegible] pilots from the American front (21 of whom were American [illegible] 70 monitors, 8 testers, and 12 French fliers. The results of these examinations are outlined in the following table in which the 21 American aces appear twice—in a group by themselves and again in the group of fliers from the American front. Although 58 per cent of the French fliers examined were night bombers, the results show that their eyes were well above the average. The table shows that the American ace was not ocularly supernormal compared with the French pilots or with the other American fliers. But it does show, however, that his ocular standard was in line with his other high attributes, for the American ace was a remarkably fine specimen of manhood.

Vision.

These men, with 442 enemy planes to their credit, had excellent uncorrected vision. In 118 cases (53.15 per cent) the vision in the right eye was 20/15 or better. In 120 cases (54.05 per cent) the vision in the left eye was 20/15 or better. Only 2.7 per cent of the number wore correction in their goggles, and those who needed correcting lenses were myopic and corrected to 20/15 or better.

Color Vision.

Every one of the men examined had normal color vision. One hundred and twenty-four had flown at the front and the other 78 had been selected as instructors or testers. Ninety-one and seven tenths per cent of the men, questioned about normal color vision, declared that it was most necessary; 8.3 per cent considered the matter unimportant, but they themselves passed Jenning's test without an error.

Accommodation.

According to the present requirements for entrance into our Air Service, a near point of accommodation greater than 110 mm. at 20 years of age; greater than 130 mm. at 25 years; or greater than 150 mm. at 30 years, disqualifies. Of the men examined, the average near point of accommodation at 20 years of age, in this table is 81.67 mm., high 90 mm., low 65 mm.; at 25 years, average 104.68 mm., high 140 mm., low 80 mm.; at 30 years, average 108 mm., high 120 mm., low 100 mm. These figures show that the present requirements give sufficient latitude in selection. Although no allowance is made for the hypermetropia (which averaged +0.57 D in the total number of examinations), these measurements correspond closely with Donder's figures as amended by Duane.

Extrinsic Ocular Muscles.

The duction power of the ocular muscles at 6 meters and at 25 cm. should be part of the record. For practical reasons, the adduction should be tested last. In this table, at 6 meters the average prism divergence is 5.82°, prism convergence 14.1°, and prism sursumvergence 2.54°. At 25 cm. the same tests give correspondingly 16.47°, 38°, and 2.67°. Therefore, it seems that the converging power should never be less than double the diverging power at all distances.

Near Point of Convergence.

The average near point of convergence of those men whose ages averaged 26.64 years is 47.17 mm. The highest average figure of 66.67 mm. happens to correspond to the average of 31 years of age, though four of the men were 32 and two were 35 years old. It would seem wise, therefore, to consider a near point of convergence of over 95 mm. a cause for disqualification.

The Master Eye.

To determine whether the master eye gives an indication as to which side the pilot looks in landing, 12 aviators were examined. All the pilots were right-handed, the right eye was the master eye in 72.72 per cent, and yet 58.1 per cent looked to the left on landing and only 24.9 per cent looked to the right. Eight and five tenths per cent looked ahead and 8.5 per cent either side indiscriminately. The fact that the pilot was right or left handed or that the right or left eye was the master did not give any indication of the side to which he would look in landing.

Stereoscopic Vision.

All the men examined had normal stereoscopic vision and most of them made their judgments quickly and accurately. This fact is strongly suggestive of the value of normal stereoscopic vision for the successful pilot.

OPHTHALMOLOGICAL PROBLEMS THAT NEED FURTHER CONSIDERATION.

One of the most important of the problems that should have further investigation is the question of the effect of altitude upon the visual acuity for near and distant vision. The findings for the distance would be of particular value if the accommodation were paralyzed and the full correction worn during the test. In determining the effect of altitude upon near vision, the Johnson apparatus will give useful information. The tests made at Mineola to ascertain the ocular changes at altitude should be repeated under the added effect of cold.

The problem of the effect of altitude upon the extra and intraocular muscles is a large one and it is most important where it touches the study of stereopsis and the more complicated problems of judging distance and direction in flying and in shooting. In this last problem some apparatus similar to Spearman's stereoscopic test with the latest improvements for recording findings on a smoked drum would probably furnish one of the best methods for studying the effect of altitude upon stereopsis. In this test the subject endeavors to keep two pieces of milk glass (viewed through a slit) edge to edge. The fact that one piece of glass is kept in constant motion by means of a small motor necessitates careful attention upon the part of the subject. The addition of a timing clock gives some indication of his speed in making judgments. The effect of altitude and lowered temperature upon accommodation, muscle balance, and muscle fatigue are among the problems most worthy of further research.

The work on color vision requires much investigation, for we consider that it is most important for the aviator to be able to recognize colors rapidly in a reduced light and in a fog. These conditions can be approximated in the laboratory.

The question of dark adaptation is being studied by the Italians, the British, and by Capt. Cobb in the Medical Research Laboratory at Mineola. When the results of this research work are applied to solving the problems of night flying, the photometric value of stars, moonlight, white and colored flares, searchlights, etc., will require special investigation. Capt. Jones, working in the Psychological Department, University of London, with his modification of the Spearman apparatus will soon have some results for publication. Prof. Spearman's apparatus is a small box containing a half-watt standardized lamp connected with Becker's three-dial resistance coil. After the subject had been "light adapted" by looking at a white screen illuminated by a 1,000-candle-power lamp for five minutes, he is placed in complete darkness for five minutes. Small windows may be opened in the front of the box, permitting the projection of light squares upon a concave screen 20, 40, and 50 degrees from the central point of fixation, which is a small circle of luminous paint. Snellen's 10 and 30 foot type are used opposite the central window, and the intensity of illumination is increased until the letters or squares are just visible. Examinations are made every few minutes during the entire period of adaptation.

More careful recording of pupillary diameters and the reactions of the irides to light and accommodation at high altitudes would give valuable information as to the general muscle tone and reactions. The few tests made at Mineola have been spoken of in the manual.

Blind angles of the aeroplane were the subject of early study, mainly by means of the stereoscopic camera held in the position of the observer's or pilot's head. Examination of these pictures shows how easy it is for accidents to occur in planes of the usual construction. These pictures also demonstrate how much of the ground is visible to the pilot, laterally, in making a landing, but how little he can see directly ahead. Pilots often state that they do not look at the ground in landing, but we doubt if they realize how much of the ground is seen with the peripheral retina. The large blind angle straight ahead accounts in part for accidents caused by the landing of one plane upon another. Maj. Clements, R. A. M. C., believes that most of the head-on collisions occur in angle 17, corresponding to the blind spot of the normal eye. The cause of these accidents, in his judgment, is the fact that many of the fliers suppress the image of

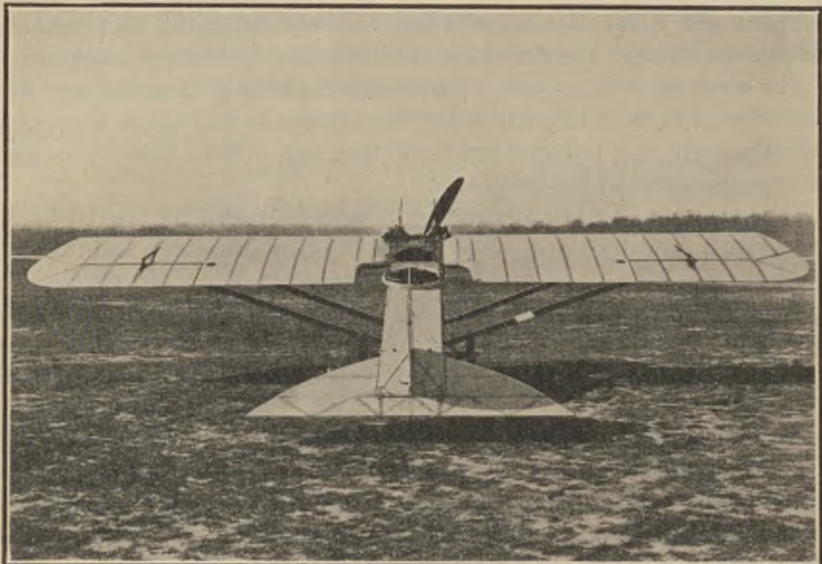


FIG. VII.—Loening monoplane demonstrates how improved aeroplane construction is eliminating dangerous blind angles.

one eye and the plane is lost in the blind spot of the other. This does not seem likely. Probably blind angles of the plane and lack of attention upon the part of the pilot would be a better explanation. That improved construction will soon do away to a great extent with blind angles due to the plane, may confidently be predicted, and the Loening monoplane (Fig. VII) shown is a big step forward in this direction. In the future, mirrors and periscopic apparatus will undoubtedly decrease the danger from blind angles. Maj. Clements' findings, demonstrating the frequency of partial or complete suppression of one image by the aviator, are very interesting. The number of cases of this kind among our pilots, and the part that the blind spot plays in aeroplane accidents, should be studied in this country. Actual tests in planes would yield interesting and valuable information in regard to those men who are known to suppress one image.

Little work has been done upon the effect of altitude and low temperature in relation to reaction time. The work upon discriminating tests under these conditions would be of special value.

It would be very valuable to determine the reaction time in the judgment of distance, direction of motion, form discrimination, color discrimination, and orientation in map reading. Such tests would aid in the efficacy of classification standards.

The effects of tobacco, alcohol, phenacetin, aspirin, quinine, etc., upon the ocular functions—particularly upon visual reaction time—should be thoroughly investigated. It would be valuable, also, to make ocular examinations before and shortly after the typhoid inoculations.

GOGGLES.

While a number of good goggles have been manufactured, there is still much room for improvement. Unfortunately, some goggles that are distinctly dangerous have been put in circulation; they lessen visual acuity; create an irregular astigmatism; limit the field of vision; finally certain tints used in the lenses seriously alter the color values of objects necessary for following the topography of the ground or recognizing certain changing meteorological conditions. A very successful British pilot early in the war said in regard to an issued goggle: "They would be certain death overseas." McCudden, the famous British flier, writes: "I am a 'stickler' for details * * *. It may sound absurd, but such a thing as having dirty goggles makes all the difference between getting or not getting the Hun."

Among the 100 American pilots from the front selected for conference, 86 were dependent upon goggles in flying, 6 used them only occasionally and 8 did not wear them at all. It is reported that several of the most famous British aces did not use any protection for the eyes in flying. The flier was not always inclined toward the wearing of goggles, chiefly because the average goggle did limit materially the extent of the visual fields, and a feeling of diminished visual acuity was the result. The British triplex and the goggles provided for our fliers early in the war did limit the visual fields to a marked extent. In taking the perimetric readings with and without the average goggles with the eyes in the primary position, it was usually found that the goggles restricted the field of vision about 20° in all meridians. Although the head is capable of much twisting in order to see in all directions, no goggle should be permitted if it restricts vision in any way. One type of goggle used by many of the allied fliers gave an almost perfect field of vision, but the projecting metal edges were dangerous because they were not rolled or padded.

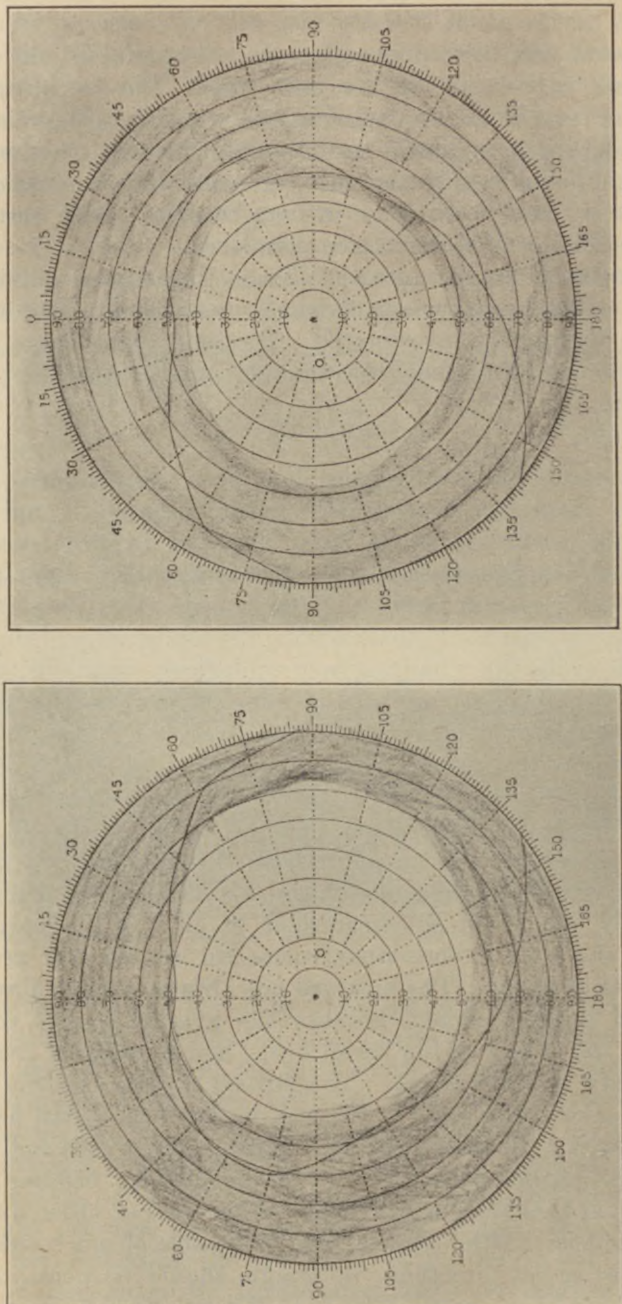


FIG. VIII.—Visual fields, measured with service goggles, Oct. 5, 1917, by daylight, noon, clear, northern exposure. Visual fields markedly diminished.

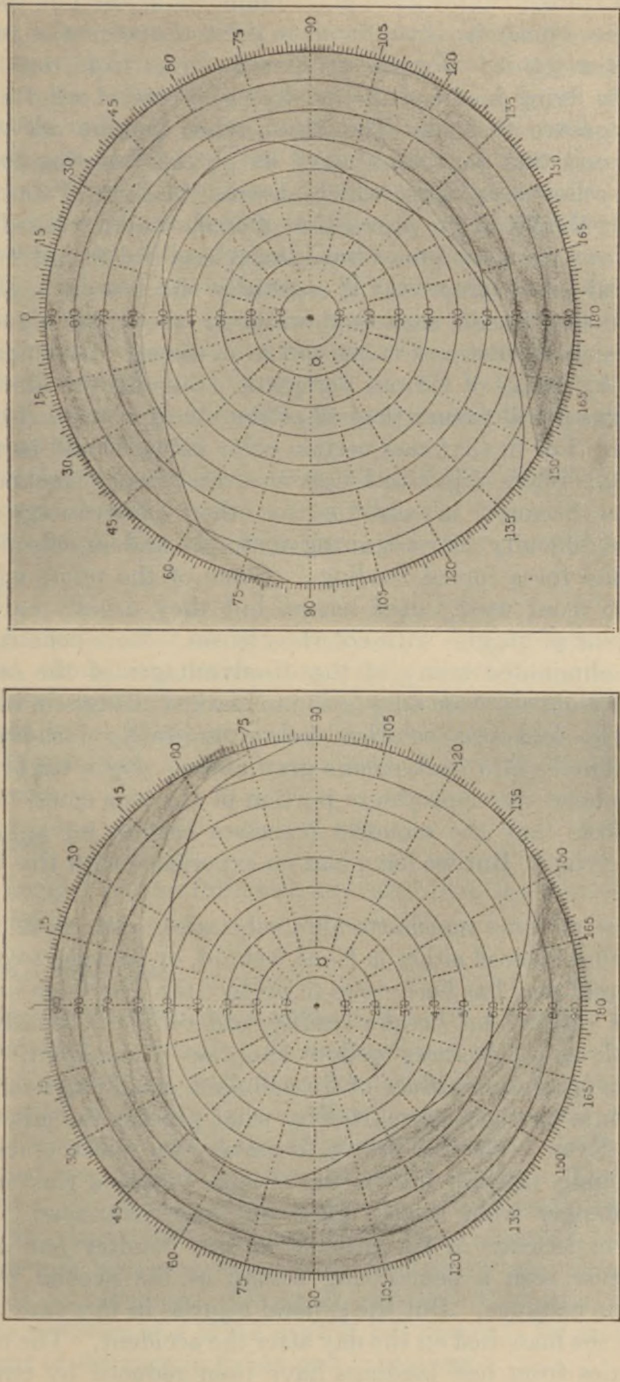


FIG. VIII.—Visual fields measured without goggles, Oct. 5, 1917, by daylight, noon, clear, northern exposure.

Other types of eye protectors devised by different manufacturing firms in the United States gave good temporal fields, but the large size of the lenses made it very difficult to grind the correction required by a refraction error. Goggles protect the eyes from dust, water and oil, from flying insects and the drying effects of wind and the injurious exposure to cold. The vision when goggles are worn is better than any that can be obtained by partially closing the eyes. Lenses of a yellow-green tint (which absorbs the light of short wave lengths) are valuable in the prevention of ocular and nervous fatigue. This tint allows the maximum visual acuity and it does not seriously disturb useful color values. It is especially effective in bright sunshine and in flying over snow and water or above the clouds. It improves vision in mist and haze, and in detecting camouflage that is produced by means of various pigments. But this tint should not be of such an optical nature that all of the blue spectral light would be absorbed. For in that case certain color values would be altered too radically. Fliers object to lenses that are deeply smoked or of certain tints because, in addition to other disadvantages, they increase the difficulty in recognizing uniforms and in selecting the proper ground for a forced landing. Some of the pilots who had flown at the front used tinted lenses, but they usually carried in addition a pair of goggles with colorless lenses. Zade constructed a lens which eliminated many of the disadvantages of the ordinary colored glass and permitted adaptation to marked changes in intensity of light. The lens was colorless below, gradually blending into yellow and finally into dark smoke gray above. By a slight movement of the head the appropriate portion of the lens could be used.

Halben feels that the monocle possesses certain advantages in all types of flying. But we have had no experience with this type of glass.

By the use of some nonshatterable substance, such as mica or a piece of celluloid placed either in front, behind, or between two pieces of glass, a great deal has been done to protect the eyes from breaking glass. Mica cracks and breaks readily and celluloid usually deteriorates with age, becoming yellow and less transparent. If the glass is on the posterior surface of the celluloid, small chips can break off and fly into the eye, no matter by what process the adhesion is produced. Even with this defect, however, the piece of celluloid may occasionally prevent the driving of large pieces of glass into the eye. The danger from broken glass has been overrated. For in two years' experience in flying fields, in this country and abroad, we have never seen a penetrating wound of the eyeball by glass except in one instance. But the general injuries in this case were so serious that the man died on the day after the accident. The number of eye injuries from bad landings have been reduced by cutting a portion of the rim of the cockpit, by proper pneumatic padding of rigid places, by changing the dangerous metal rim of the wind shield, and by using goggles with well-rounded, protected edges that lie flat against the face. As the danger from breaking glass is relatively so slight, the safety afforded by a protective layer of some non-shatterable material seems hardly necessary even when applied to the posterior surface of the lens, a method sometimes used. In regard to industrial accidents, good optical glass is in itself a protection rather than a danger to the eye; for in 30,000 of these accidents where protecting lenses have been shattered, the eyeball was penetrated in only one instance. However, the force with which the goggles are struck in aeroplane accidents would make penetrating wounds more common in aviation. We agree with most of the pilots with whom we have spoken on this subject, that in case of trouble or in landing on rough ground, the goggles should be pushed well up on the forehead.

Although our manual has already mentioned the qualities that the ideal goggle should possess, a brief outline at this point seems wise in order to emphasize the importance of their future development.

Material.

The material must be noninflammable. So far, glass is the best material, though the future may produce something more suitable. The glass should be a good optical glass, not hardened under tension. It should be carefully ground and not less than 2 mm. in thickness. White glass should have a light transmission of more than 90 per cent.

Visual Fields.

The goggles of the future should not limit the monocular or binocular fields.

The Central Blind Angle.

In the construction of goggles, it is very important to eliminate the blind angle. This may be accomplished by using a very narrow central hinge or by connecting the lenses by a horizontal strip of metal curved in such a manner that it arches upward well over the bridge of the nose. It is therefore entirely out of the line of vision. These features appear in a new model of goggles. This model has been cut down so as to give an almost perfect visual field, and the dangerous edges rolled and protected. Even a small central bar may interfere with binocular vision when the pilot's head is turned to the side as it is in landing. We agree with Maj. Clements, R. A. M. C., that the presence of a broad central bar accounts for many errors in judgment of distance in flying and in landing.

Lightness, Strength, and Comfort.

Goggles should be simply yet strongly constructed. They should be light in order to be comfortable. They should not press upon the bridge of the nose and the frame should be easily and quickly adjustable to the face. They should be arranged so as to permit easy removal with one hand.

Protection of Eye and Surrounding Structures From Injury.

All parts of the goggle coming in contact with the brow, nose, and cheeks should be flat against the face. All edges should be rounded and protected by some pliable material.

Adjustable Interpupillary Distance.

Adjustable interpupillary distance is most important in goggles, especially when a refraction error has to be corrected. In spite of the very strict visual requirements for entrance into our service, it was necessary to prescribe correcting lenses in seven cases during our first month at Issoudun.

Lenses Quickly and Easily Changed.

Some method should be devised whereby lenses could be quickly and easily removed for cleaning, or for replacement when new lenses are needed. The box which carries the goggles should have small compartments for holding extra sets of lenses. Everything about the goggles should be vermin proof.

Protection of Sinuses.

Sufficient covering should be connected with the goggles, or supplied in such a way that it might be quickly fitted to the goggles in order to protect the sinuses from the cold. The cold of high altitudes causes great pain in the frontal regions.

Ventilation.

Some indirect method of ventilating is most important to prevent steaming on the ground and frosting at high altitudes. The heat and moisture from the face will cause fogging rapidly unless there is a properly constructed ventilating system to carry the outside air to the posterior surface of the lenses. In this connection, Maj. Schroeder's account of his altitude record flight is very interesting: "While still climbing in large circles, my goggles became frosted. The temperature at this altitude (he was then more than 16,000 feet) was 2° below zero C. * * *. I believe that if my goggles had been better ventilated, they would not have frosted * * *. When I was about 27,000 feet I had to remove my goggles. The cold, raw air made my eyes water, and I was compelled to fly with my head well down inside the cockpit."

Frosting.

Some chemical substance should be more perfectly developed for applying to the lenses before flight in order to prevent frosting. The following words of Maj. Schroeder are very suggestive: "I gazed about through the small portion of my goggles which had no frost—due to a drop of oil which had splashed on them from the motor."

Tint.

When a tint is required, it should allow the maximum vision, be restful to the eye, and not alter color values seriously.

Future Construction.

The question of supplying the aviator with a well-constructed goggle and with properly ground lenses (where necessary) for constant wear in flying is an important one and our experience in France demonstrated how inadequate the facilities were for providing proper goggles and lenses.

In order that the best goggle may be obtained, the whole matter should be placed in the hands of a committee composed of an experienced flier, an ophthalmologist, a physicist, and a skillful goggle maker. This committee should draw up the specifications, pass upon the samples presented, and they should have power to accept, or to reject if necessary, the finished product.

During the rush of war this plan was not feasible. But the great future of military and commercial aviation calls for a thoroughly efficient goggle which, so far, has not been produced. Now is the time for carrying out this plan—while the shortcomings of the present goggles are still vividly in mind.

NEW APPARATUS.

The following apparatus was devised or modified in France by Maj. Berens:

A stand with tongue depressor bite for fixing head, to be used in connection with the tangent screen and with the perimeter in taking fields and mapping out blind spots. (Figure IX.)

Method and apparatus for testing fatigue of accommodation and convergence.

Howe's ophthalmic ergograph modification.—It is found that a tongue-depresser mouth bite for fixing the head in taking accommodation is valuable to prevent the drawing away of the head from the headrest when the accommodation becomes fatigued. A string is passed from the accommodation test object, through the rod under the chin of the subject, and at the end of this string a grip is attached. This permits the subject to make his own record without arm fatigue. The accommodation apparatus is placed in connection with the convergence apparatus and the two are screwed down to a perimeter

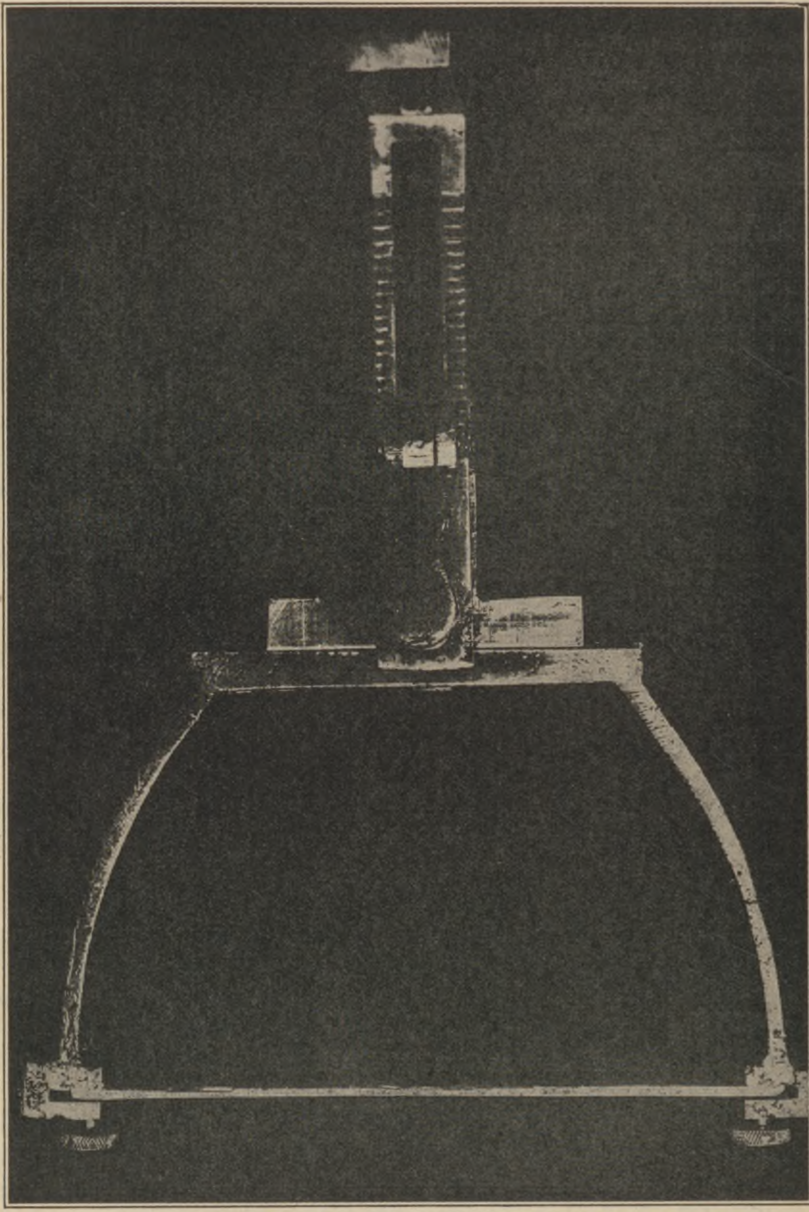


FIG. IX.—Tongue depressor fixation to be used in connection with perimeter.

table. The drum is walled off from the view of the subject and the same point is used to record the findings for accommodation and convergence. Maj. Pierce gave valuable assistance in suggesting and supervising changes in this apparatus. (Figure X.)

Shutters for Recording Visual Reaction Time.

A. Simple shutter worked by hand.—This shutter is a 20 by 30 centimeter piece of 2-millimeter sheet brass, with a 4 by 13 centimeter

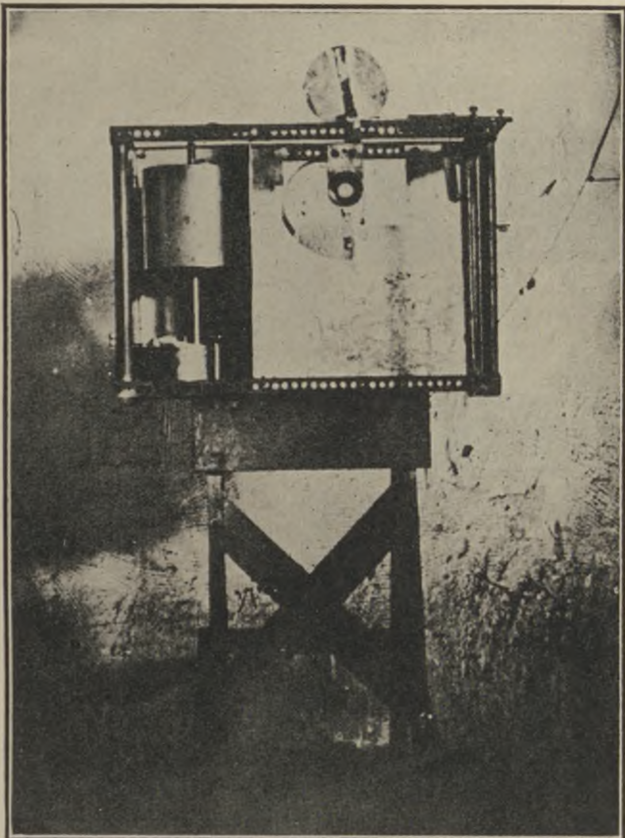


FIG. X.—Howe's modified endograph.

rectangular opening, centrally cut 4 centimeters below the upper edge of the screen. A shutter, 4½ by 14 centimeters, sliding in a slot and suspended by rubber bands, is manipulated in front of this opening by means of a thumb hold. Electrical contacts are so arranged that the "break" occurs as the upper edge of the covering screen passes the upper edge of the pupil and the "make" occurs again as the upper edge of the screen covers the upper edge of the pupil. The contacts are connected with the D'Arsonval apparatus which records time in one-hundredths of seconds.

B. Complex screen working on the lever principle.—This screen is much the same as the simple one, except that a lever and weight govern the rapidity of movement of the shutter, and that the width of the shutter can be changed. (Figures XI and XII.)

Apparatus for determining the reaction time for the determination of motion, rapidity of motion, and direction of motion by the eye.—The

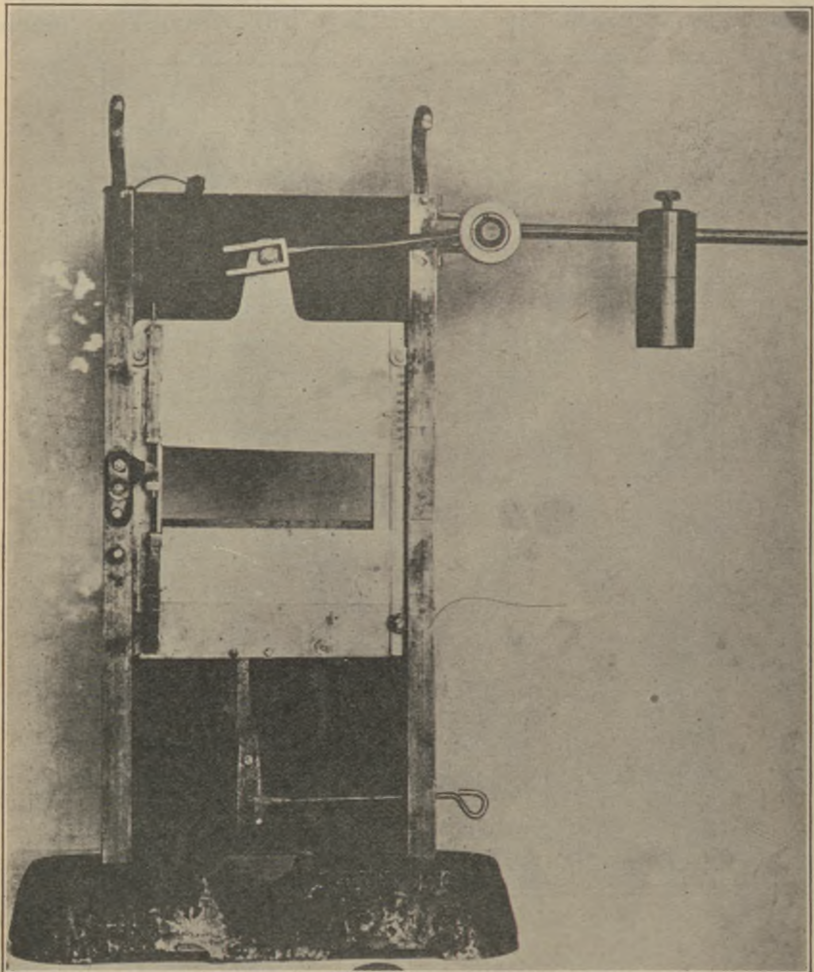


FIG. XI.—Visual reaction time screen shutter open.

complex shutter is used, and a test object (for aviation purposes, an aeroplane) is moved in any direction at any desired rate of speed, within two large steel rings which may be moved in any position, the inside ring sliding on the outside ring. This apparatus can be used in connection with a camera machine gun, arranged with aeroplane sights to determine rapidity and accuracy in shooting a machine gun.

Reaction time in the judgment of distance, where the direction of motion and the monocular parallax are considered.—Either the simple or the complex shutter may be used, and the test may be employed at any required distance. A 20 by 60 centimeter plate of sheet steel is grooved out to receive a large carriage which will carry 10 upright rods

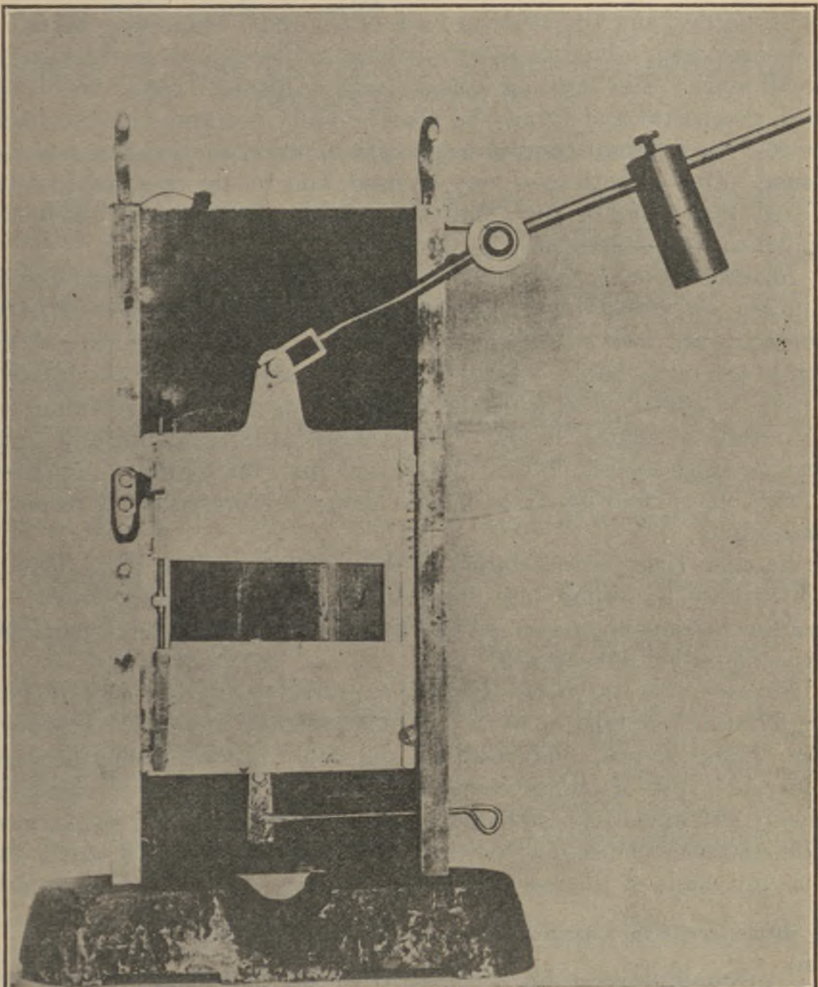


FIG. XII.—Screen and shutter for recording visual reaction time, shutter closed.

as test objects, and which will move in the anterio-posterior direction. Other tracks are grooved out diagonally to receive a smaller carriage carrying three upright rods. The rods are painted a neutral gray and may be of any desired size. Five and ten millimeters are the sizes in use in this laboratory. The best method of making the rods is to mill them out of steel. The carriage is milled out to receive these rods which are held in place by a spring and cap. The carriage is marked off in millimeters in the milling machine, and the rods may be placed from 1 centimeter to 20 centimeters apart at will. Motion is imparted to the carriage by means of a small phonograph motor, and a string working around guides. Screens are placed, one in front of the rods (corresponding to the fuselage of the aeroplane) and painted neutral gray, and the other in back of the rods, which may be either a neutral gray, a landscape with houses and trees, or a background of small rods. The lighting comes from a filament lamp connected with a rheostat and it may be placed in any position, front or back, to test the different conditions of lighting upon the judgment of distance. One or both eyes may be used, and by this method it is believed that some of the conditions which an aviator faces in the judgment of distance may be simulated.

Reaction time for color discrimination.—Aeroplane lights, four in number, are placed on a board, 20 feet from the observer. Three of the lights are on at a time and the reaction time for determining which lights are on is taken. The colors are obtained by the use of color filters. Conditions which must be met with in flying are simulated by means of neutral filters. Cloths used in different uniforms may also be used as test objects. Reaction time for telling which three of the four colored lights, or colored cloths, are presented, is recorded each time.

Reaction time for orientation in map reading.—Two maps (one of which may be swung) are exposed through the timing screen. A point is marked on one screen and the rapidity with which orientation is accomplished is recorded.

Reaction time for discrimination for form.—Different test objects for aviation (aeroplanes, or models of aeroplanes) are exposed through the timing screen, and reaction time for discriminating between different types of planes recorded. Practice in rapidly recognizing enemy and allied planes should be given to every man in the service. Silhouettes of planes may be thrown on a moving picture screen and a record made of the reaction time when type of plane is recognized.

A Simple Device for Changing Colors on the Hare Perimeter.

Two small pieces of brass are fitted to the upper and lower part of the color carrier, and two steel rods are bent and held in position on the back of the arc. This permits the changing of colors rapidly and easily and it does away with the long cords, which soon get out of order.

Test for Inertia of Adjustment of Accommodation.

The Ferrée apparatus seems to be a valuable help in testing this most important function; and if a more simple way of recording findings could be devised, it should prove to be of great value in testing aviators who are having difficulty in landing or in making visual adjustments in the air, inasmuch as the flier, whose accommodation is sluggish, is probably at a disadvantage in landing a fast machine and in making the accommodative changes required in observing and fighting. But we were not able to test practically the few changes that were made in this apparatus.

EFFECT OF NOSE AND THROAT INFECTIONS UPON THE OCULAR FUNCTIONS.

Maj. Conrad Berens, jr., Medical Corps, and Capt. Claude T. Uren, Medical Corps.

In studying the results of operative interference in nose and throat infections of 38 pilots in the A. E. F., it was found that many of the men who required operation by the Otological Department were diagnosed temporarily unfit to fly by the Ophthalmological Department. Therefore the eye records were examined in regard to the following questions:

1. How many pilots requiring operation by the Otological Department were under observation in the Ophthalmological Department, and what were the diagnoses in the latter department?

2. What relation existed between the nose and throat infections and the blind spots, and what were the results of treatment?

3. In a similar way the effect on vision.

4. What was the effect of the infections upon the ocular muscles? What results were obtained by treatment?

1. In answer to the first question the following data were found:

Records of 38 pilots treated by the Otological Department were found in the Ophthalmological Department. Nineteen, or 50 per cent, showed some ocular trouble which possibly had infection of the nose and throat as the underlying cause. Search was made by means of X-ray and laboratory examination, in addition to physical examination, for other foci of infection. The ophthalmological diagnoses were as follows:

	Number.	Per cent.
Retro-bulbar neuritis or congestion	6	15.80
Convergence weakness	9	23.63
Divergence excess with convergence insufficiency	1	2.63
Acute catarrhal conjunctivitis	1	2.63
Marginal blepharitis	1	2.63
Photophobia and lachrymation (blind spots not examined in last case)	1	2.63

2. The second question is given the following answer:

Six (15.80 per cent) of the 38 pilots showed definite enlargement of one or both blind spots. The blind spots were examined by a rapid clinical method and compared with findings on the Bjerrum screen.

Résumé of the history of six pilots diagnosed retro-bulbar neuritis:

1. *R. C.* Referred from Nose and Throat Department, October 12, 1919. Nose and throat diagnosis. Deviated septum. Infection of sphenoidal and posterior ethmoidal sinuses bilateral.

Eye examination: V. O. D. 20/15-4. O. S. 20/15-2. 6 meters. Esophoria ½°. Divergence 5°. Convergence 8°. 25 centimeters exophoria 11. Divergence, 21°. Convergence, 15°. Chief complaint, photophobia. Eye examination, including central color vision, showed fields and fundi normal except that the right pupil was 1 mm. larger than the left. Physical examination was negative except for a subacute bronchitis.

October 18, 1918, submucous resection of nasal septum.

October 22, 1918, enlarged blind spots.

Eye diagnosis, retro-bulbar neuritis or congestion (bilateral). Convergence weakness.

October 23, 1918, convergence weakness shown by ergograph. To have converging exercises three times a week.

October 26, 1918, blind spots normal and convergence fatigue less marked.

November 4, 1918, convergence fatigue normal.

November 8, 1918, near point of convergence, 60 mm. 6 meters. Divergence, 4°. Convergence, 30°.

Results: Nasal, physical and ocular conditions improved.

Continued training as a pilot.

2. *L. W. B.* Second Lieutenant Air Service Aviation. 24. Single. October 8, 1918.

Chief complaints: Photophobia, dull pain back of eyes. Right eye vision blurs periodically. Smokes cigarettes. Does not drink. Denies venereal infection. Has had no trouble in flying. Photophobia. Pain back of eyes and blurred vision for one month. Dilated right pupil noted one month ago.

Eye examination: V. O. D. 20/40-1. O. S. 20.15-1. O. D.+.75 cyl. ax. 90/20/20-4. O. S.+25 cyl. ax 90=20/15.

N. P. C. 65 mm. N. P. A. both 105 mm. 6 meters Ortho. 25 cm. Ex., 29. O. D.: Globe is tender and there is tenderness upon pressure back of globe. Right pupil, 4½ mm. Left pupil, 3½ mm. Right reacts slightly to eserine. Right nerve slightly congested. Central color vision normal. Right blind spot greatly enlarged. O. S.: Blind spot slightly enlarged.

Diagnosis: Retro-bulbar neuritis (bilateral).

Ear: Negative.

Nose: Chronic hyperplastic rhinitis. Worse on right side. Bilateral infection of the posterior ethmoid sinuses. Deviation of nasal septum.

Throat: Chronic follicular tonsilitis.

Teeth: Medical: Neurological and Laboratory: Negative.

Course and Treatment: October 12, 1918, submucous resection of the nasal septum followed by local treatment. October 21, 1918, blind spots smaller. November 17, 1918, vision with correction: O. D. 20/20-1 right pupil still dilated. O. S. 20/15 photophobia. Right blind spot still enlarged.

Nose shows marked improvement.

Results.—Ocular improvement seemed to be in conjunction with nasal improvement.

3. *T. O. D.* First Lieutenant, Aviation Service. 25 years. Single. October 25, 1918.

Chief complaint: Referred because of many bad landings,

Previous history and habits: 15 cigarettes a day. Wine, no other spirituous liquors. Never to excess. Denies venereal infection. Pneumonia eight years ago, no complications. Wears reading glasses occasionally. Otherwise normal. Has made many poor landings. Had one crash from altitude 1,200 meters. Slight injury to back but able to keep on flying.

Present history: Feels well at present. Is nervous about landings. Eyes tire easily and ache at times.

Physical examination:

Eye: V. ou. 20/20-1. N. P. C. 40 mm. =N. P. A. both 120 mm. Muscles 6 meters. Ex. 1°. Divergence, 5°. Convergence, 8° 25 cm. Ex. 3°. Divergence, 15°. Convergence, 16°. Both blind spots somewhat enlarged. Left more than right. Ocular examination including central color vision negative.

Diagnosis: Retro-bulbar neuritis (bilateral) convergence weakness.

Ear: Negative.

Nose: Negative.

Throat: Large mass of adenoids. Septic tonsillitis. Other examinations negative.

Treatment and course: November 9, 1918, no improvement. Refused operation.

Results: Removed from flying and given ground position.

4. *J. C. K.* Second Lieutenant, Aviation Service. 23. Single. October 4, 1918.

Chief complaint: Constipation, nervousness, sleeps poorly, appetite poor, feels constantly fatigued, blurred vision and photophobia.

Past history: Three cups of coffee a day. No alcohol, no tobacco, never has had trouble with eyes.

Eye examination: V. O. D. 20/15+3 homatropine. O. S. 20/30-2 refraction. Accepted plus 0.25 cylinder axis, 90°, but this did not improve vision. Near point convergence, 275 mm. Near point accommodation, O. D., 114 mm. O. S., 260 mm. 6 meters divergence, 4°. Convergence, 6°. Fundi normal. Central color vision normal. Fields contracted, more on the left.

Ear: Nerve deafness, left ear.

Nose: Normal.

Throat: Considerable amount of pus expressed from both tonsils. Moderate mass of adenoids.

Dental: Negative.

Medical: Fatigued and nervous.

Neurological: Negative.

Psychological: Negative.

Laboratory: X rays of head (two examinations) negative.

Wasserman blood test negative. Spinal fluid negative.

Diagnosis: Retro-bulbar neuritis. (Infectious.)

Treatment: Adenoids and tonsils removed October 10, 1918. Complained of severe pain in eyes when tonsils were removed. Both blind spots greatly enlarged after operation. Septic clot in tonsillar fossa. Converging exercises and blind spots taken at regular intervals, showing no improvement. Blind spots greatly enlarged and out of proportion. No change in central color vision. December 31, 1918. V. O. D. 20/50-2. O. S. 20/50-2. N. P. C. 440 mm. N. P. A. O. D., 380 mm. O. S., 410 mm. 6 meters. Divergence, 2°. Convergence, 3°. Fields contracted, left more than right. Blind spots greatly enlarged, left more than right. Retro-bulbar tenderness, slight pallor of left optic disk; central color vision normal. Ordered to the United States, after this examination.

Result: Ocular condition worse. General health improved. Ordered to United States, so the final result was not ascertained.

5. *C. H. S.* Second Lieutenant, Aviation Service. 24. Single. October 30, 1918.

Wore glasses for a time for close work.

Smokes seven cigarettes a day.

Does not feel well. Headaches. Sleeps poorly.

Eye examination: O. D. 20/10-2. O. S. 20/10-1. N. P. C. 35 mm. N. P. A. O. D., 100 mm. O. S., 105 mm.

Right blind spot slightly enlarged.

Diagnosis: Retro-bulbar neuritis O. D.

Ear: Negative.

Nose: Acute empyema right antrum.

Throat: Pus in both tonsils.

Dental: Negative.

Medical: Recovering from influenza.

Neurology: Negative.

Psychology: Negative.

Laboratory: X ray shows cloudiness of right antrum.

Treatment: Tonsillectomy, November 5, 1918. November 15, 1918, throat healed, feels better, headaches gone. Blind spots normal.

Results: 1. Ocular condition improved. 2. Physical condition improved.

6. *R. G. W.* Second Lieutenant, Air Service. 21, single. October 3, 1918.

History: Smokes 10 cigarettes a day. Wore glasses five years ago for study. Feels sick most of the time. Fatigued constantly.

Eye examination: V. both 20/15–1. Pd 65 N. P. A. O. D. 115 mm. N. P. C. 55 mm. O. S. 115 mm. 6 meters Ex. 2°. Divergence, 6°. Convergence, 18°. 25 Cm. Ex. 14°. Divergence, 20°. Convergence, 40°. October 11, 1918: Right blind spot enlarged. Fig. No. 6.

Diagnosis: Retro-bulbar neuritis or congestion O. D.

Ear: Negative.

Nose: Negative.

Throat: Chronic septic tonsilitis.

Dental: Dental X-rays negative. Lower right wisdom tooth not fully erupted but not causing trouble.

Medical: Fainting spells.

Neurological: Anxiety neurosis.

Laboratory: Negative.

Treatment: October 12, 1918: Tonsillectomy. Considerable edema in soft palate following operation. October 18, 1918: Right blind spot larger. October 21, 1918: Throat healed. Blind spot normal. Headaches improved.

Result: 1. Ocular condition improved. 2. Headaches and general physical condition improved. 3. Class B. Anxiety neurosis.

CONCLUSIONS.

1. The blind spots are, seemingly, frequently enlarged in nose and throat infections before vision or other ocular functions are affected.

2. Repeated examinations of the blind spots in nose and throat infections give information as to the efficacy of treatment and often show the need for more radical measures.

3. Fliers who are receiving treatment for focal infection should have their blind spots examined routinely.

In answer to the third question concerning visual acuity, our records revealed that 2 of the 38 pilots with nose and throat infections had diminished visual acuity which could only be partially corrected by lenses. The case histories of these two officers appear in detail above. Case 2, *L. W. B.*, and case 4, *J. C. K.* Both complained of periodic blurring of vision, photophobia, and pain back of eyes. The vision of one, *L. W. B.*, was slightly improved and the size of the blind spots reduced by resection of the nasal septum followed by local nasal treatment. The vision of *J. C. K.* became worse and the blind spots larger, following tonsillectomy and adenectomy. The blurring of vision was very troublesome and at times made it difficult for them to judge distance in landing.

Conclusion 1.—The periodic blurring of vision in nose and throat infections is sufficiently common to be the cause of an occasional crash.

Conclusion 2.—Pilots suffering from nose and throat infections should not be permitted to fly, particularly when there is any enlargement of the blind spots.

In answer to the fourth question it was found that 10 of the 38 pilots with nose and throat infections had affections of extra or intraocular muscles, divided as follows:

Extraocular Muscles.

Convergence weakness. Nine pilots had this defect.

TYPICAL HISTORY.

1. *R. C.* October 12, 1918.

History given under Case 1, *R. C.* in retro-bulbar neuritis group.

Nose and throat diagnosis: Infection of posterior ethmoids and sphenoid sinus.

Eye diagnosis: Convergence weakness. (See fig. No. 2.)

Result: Converging power improved after resection of septum and converging exercises. Continued training as pilot.

Divergence excess with beginning convergence insufficiency, one pilot.

INTRAOCULAR MUSCLES.

Only 3 of the 38 pilots showed any affection of the intraocular muscles.

R. C. (Case 1, retro-bulbar neuritis). Right pupil dilated. Accommodation unaffected.

L. W. B. (Case 2, retro-bulbar neuritis). Right iris dilated (recent). Accommodation unaffected.

J. C. K. (Case 4, retro-bulbar neuritis). Marked weakness of accommodation, but irides unaffected. Accommodation weaker after tonsillectomy.

CONCLUSIONS.

1. Many of the pilots who showed little weakness of converging power as measured by the near point of convergence and prism converging power showed rapid onset of fatigue when tested on the ergograph. The same was true of accommodation, only fewer men were examined for fatigue of accommodation.

2. Our experience leads us to believe that weakness and rapid onset of fatigue of the extra and intraocular muscles are frequently

associated with nose and throat infections and that this subject is worthy of further study.

3. Weakness in the converging power was often associated with bad landings. Whether this was due to derangement of binocular vision or to the general disturbance associated with the convergence weakness is treated more fully elsewhere.

THE EQUIPMENT OF THE OPHTHALMOLOGICAL DEPARTMENT, THIRD A. I. C.

1 acuity test, Ives.
1 apparatus, Ferree.
4 brackets, extension, W. P. shades.
1 cabinet, medicine, with usual drugs.
1 cabinet, Valk, with instruments.
1 card for stereoscope, 4 sets.
2 cards, test, Black's sets.
4 cards, test, Snellen's and E's.
1 case, trial, with mult. maddox rod.
1 clock, Seth Thomas.
2 clusters, Benjamin.
3 color tests, Jennings.
1 diaphragm, Iris, with stand, DeZeng.
1 diaphragm, test, Harmon.
1 ergograph, Howe's.
2 frames, trial, Rodgers.
1 headrest, photographer's.
3 illiterate cards, E.
1 instrument, drafting set.
1 kymograph.
1 lamp, alcohol, metal.
1 lamp, operating, on stand.
1 lantern, Williams.
1 lens, condensing, 16 D. H. R. rim.
1 lens measure, Geneva.
1 Loupe corneal.
1 meter stick.
1 ophthalmoscope, electric, Hare.
1 ophthalmoscope, Hare.
1 ophthalmoscope, May.
1 perimeter, Hare.
2 perimeters, Schweiger, modified.
1 photometer, Williams, simplex.
1 prisms, $\frac{1}{2}$–50, set.
1 prisms, square, box.
1 pupillometer.
1 rack, Marple, set Skiascopy.
1 retinoscope.
3 retinoscopes, folding.
2 rheostats, 1 De Zeng and 1 Meyrowitz.
3 rules, Prince, fitted for nose.
1 rule, 5-foot tangent.
2 rules, small, 15-cm.
1 scissors, bandage.
1 screen, tangent on roller, Bjerrum.
1 stand, DeZeng, with lamp and iris diaphragm.
1 stereoscope.
1 sterilizer, w. c., 13-inch.
3 stools, adjustable.
1 table, glass top.
2 tables, perimeter.
1 test, color, Oliver-Abney.
1 transilluminator, Wurdemann.
2 trays, instrument, 10 by 12.
12 type, test, Jaeger, with 1 case.
1 verascope.
1 wand, Wilmer.
1 watch, stop.
6 wedges, Reeves.

CHAPTER VII.

AVIATION ACCIDENTS.

Lieut. Col. L. G. ROWNTREE, Medical Reserve Corps.

Nature's laws are inexorable. They operate continuously and can never be annulled. Her forces may be overcome temporarily through the operation of superior forces but their effectiveness becomes apparent immediately upon the withdrawal of such forces.

Aviation is a new art, made possible through science. The heavier than air machine is subject to Newton's laws just as is the apple. Langley discovered, appreciated, and partially succeeded in applying the forces capable of keeping afloat the heavier-than-air machine. Science has finally succeeded in applying them through utilizing a powerful motor, great speed and a skilled pilot.

The weight factor is constant; the laws governing it, merely circumvented. Speed is attained through mechanical ingenuity, involves increasing the weight and is of no avail except as controlled by skilled pilots. These are created only through mastery of the art of flying. The training involved is a hazardous one; art is long but war needs urgent. Flying is beset with danger, and skill has been bought at the expense of safety.

For the British in the Boer war and for the American in the Spanish war typhoid fever accounted for more deaths than combat. Accidents have proven the greatest source of fatalities in the American Air Service in the present war, for every flier killed in combat three succumbed to accidents. War has its by-problems. Typhoid fever has been brought under control but the accident problem remains unsolved.

NUMBER AND DISTRIBUTION OF ACCIDENTS IN THE TRAINING SCHOOLS OF THE A. E. F.

At the signing of the armistice 169 American fliers had been listed as killed in combat, while 203 had succumbed to accidents in the training schools in France, and 42 to accidents at the front. Statistical studies define the problem more definitely and also serve to emphasize its importance.

Prior to November 13, 1918, there had been in all 5,646 pilots and observers, of whom 2,141 were still under training; 1,940 turned over to the zone of advance; 94 with allied squadrons; 821 instructors, test, transfer, and staff pilots; 349 discontinued from training; 98

killed with allied squadrons and 203 killed in training. Chart I presents weekly data covering the distribution and fate of the flying personnel (pilots and observers) of the A. E. F. from May 1, 1918, until the time of the signing of the armistice.

Thirty-four and three-tenths per cent of the men entering the training school were turned over to the zone of advance while

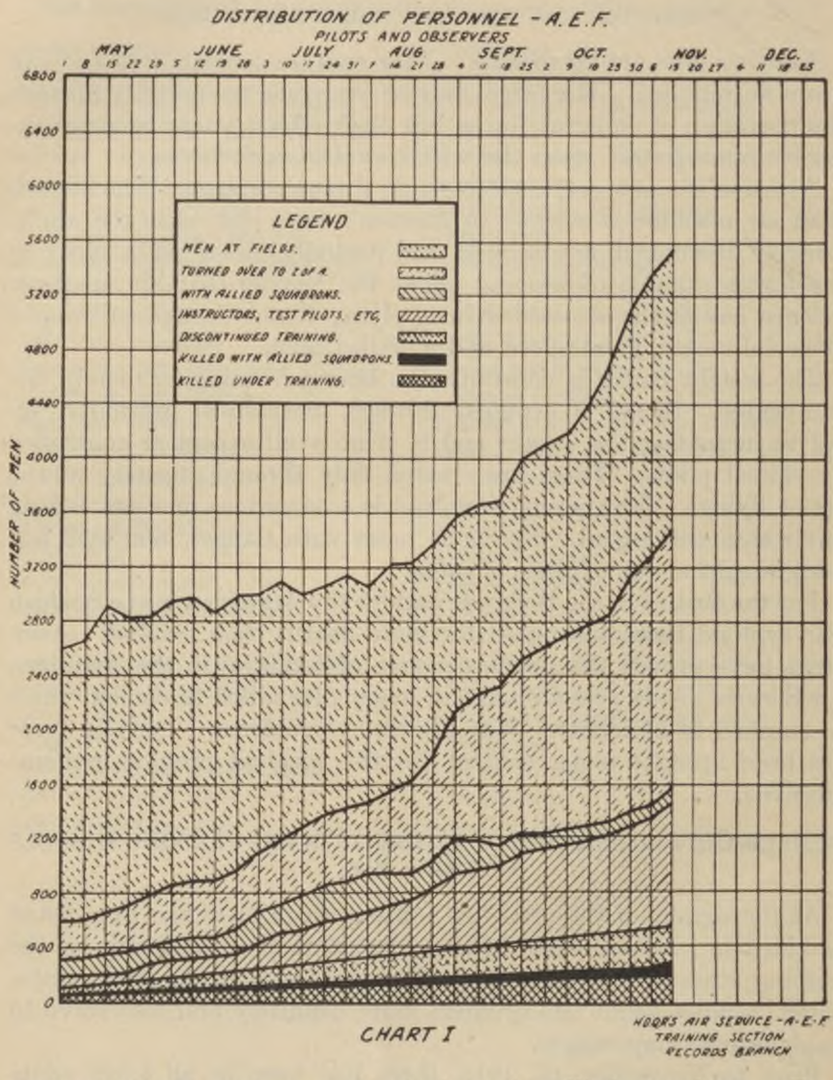


CHART I

another 1.6 per cent were attached to the allied squadrons. Two thousand and thirty-four fliers or approximately 36 per cent of those entering the training schools in France actually arrived at the front. Ten per cent as many men were killed in training in France as reported for service in the zone of advance.

Of the 5,646 men, 3,905 were pilots and 1,741 observers, or approximately 70 and 30 per cent respectively. Inasmuch as the work of the pilot and observer differs fundamentally, these two groups should be considered separately.

Chart II gives the weekly distribution of the piloting personnel, A. E. F., until November 13, 1918. In total there were 3,905 pilots

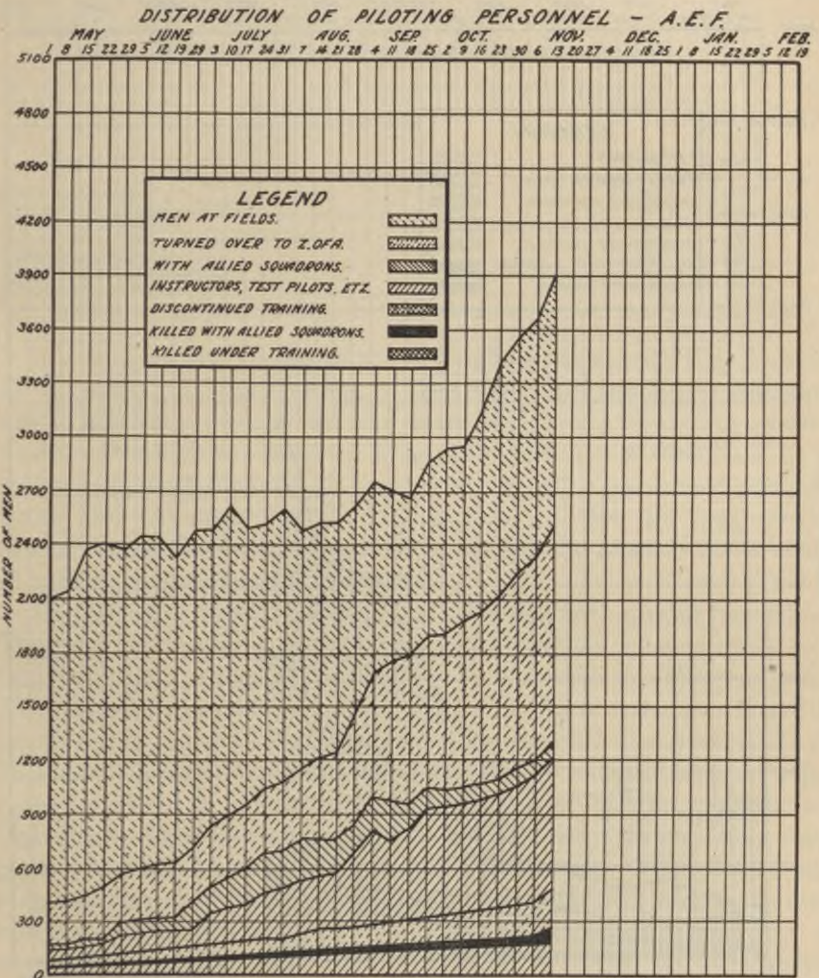


CHART II

H.Q. Q.R.S. AIR SERVICE A.E.F.
TRAINING SECTION.
RECORDS BRANCH.

in the A. E. F., distributed as follows: 1,411 still with the fields; 1,195 turned over to the zone of advance; 86 with the allied squadrons; 735 instructors, transfer, test and staff pilots; 196 discontinued from training; 86 killed with allied squadrons and 196 killed under training.

One thousand two hundred and eighty-one pilots or 32.8 per cent of those entering the schools of France reached the front either in the zone of advance or with the allied squadrons. For every 100 men who arrived at the front more than 15 were killed through accidents in the training schools of France.

Data relative to weekly distribution of the observing personnel for the A. E. F., for the same period, are given in Chart III.

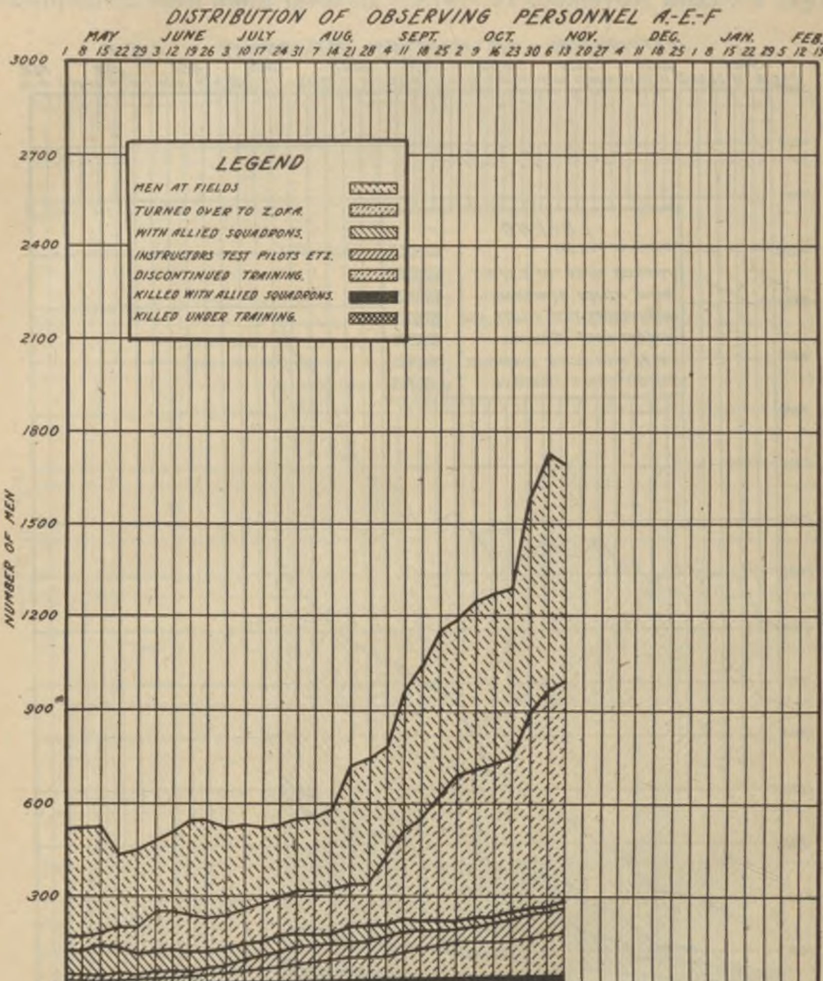


CHART III

In total there were 1,741, of whom 730 were still in the fields; 745 turned over to the zone of advance; 8 with the allied squadrons; 86 instructors, transfer, staff and test pilots; 153 discontinued from training; 12 killed with the allied squadrons and 7 killed under training.

More than 43 per cent of the observing personnel reached the zone of advance or allied squadrons. For every 100 trained observers arriving at the front only one man was killed in training. This is in striking contrast to the data just presented relating to pilots, and indicates that in France the hazards of training were 15 times greater for the flier than for the observer.

In order to facilitate a comparison of the data relating to the fate of the total flying personnel, of pilots and of observers, these figures have been tabulated. (See Table I.)

TABLE I.—*Flying personnel, total, pilots and observers.*

Distribution.	Total.	Pilots.	Observers.
Total	5,646	3,905	1,741
Still under training	2,141	1,141	730
Turned over to zone of advance	1,940	1,195	745
With allied squadrons	94	86	8
Instructors, transfer, test, and staff pilots	821	735	86
Discontinued training	349	196	153
Killed with allied squadrons	98	86	12
Killed under training	203	196	7

It is evident that the incidence of fatalities varies with the character of the work. In the training of observers only the larger and more stable machines are utilized and these are always piloted by trained fliers. Although the observer directs the activity of the plane, he is, so far as its actual control is concerned, merely a passenger, the pilot being the chauffeur. This combination, of the the large stable machine and the trained pilot, accounts for the relative infrequency of accidents to observers in France.

All phases of the training of the pilot are not equally hazardous. The greatest danger is encountered in training on the small unstable, fast machines. Chart IV reveals the fact that in the Third Aviation Instruction Center 90 per cent or more of the accidents occurred in pursuit or advanced training. In connection with the chart it should be stated, however, that observation and bombardment were but recently added to the curriculum of the Third Aviation Instruction Center, and that at the time of the armistice they played but a small part of the total instruction given in that center. Nevertheless, the fact remains that the greatest danger encountered was in pursuit and advanced training. Of the 2,221 taking pursuit training, 49 were killed; of the 2,486 taking advanced training, 26 were killed; and of the approximately 600 taking observation and bombardment, 6 were killed. The data showing the weekly distribution of the training personnel in relation to pursuit and advanced training, observation, and bombardment are shown in Charts V, VI, and VII, respectively.

The education of the flier involves danger not only to himself but to his instructor. Of the 203 fatalities due to accidents in the train-

171364—20——14


ISSOUDUN
COMPARATIVE CHART OF FATALITIES
FEB. 27TH
85.7%
14.3%
MAR. 13TH
75%
25%
MAR. 20TH
66.7%
33.3%
APRIL 10TH
60%
40%
APRIL 24TH
54.6%
45.4%
MAY 1ST
64.3%
35.7%
MAY 15TH
70.6%
29.4%
MAY 22ND
60%
40%
MAY 29TH
57.2%
42.8%
JUNE 5TH
60.8%
39.2%
JUNE 12TH
56%
44%
JUNE 26TH
53.9%
46.1%
JULY 3RD
51.9%
48.1%
JULY 17TH
51.7%
48.3%
JULY 24TH
51.6%
45.2%
32%
JULY 31ST
5.3%
43.8%
32%
AUG. 7TH
54.5%
42.4%
31%
AUG. 14TH
53.8%
41.1%
51%
AUG. 21ST
56.6%
39.1%
4.3%
AUG. 28TH
36.2%
37.5%
4.2%
2.1%
SEPT. 4TH
57.2%
36.7%
41%
2%
SEPT. 11TH
56.7%
35.3%
4%
4%
LEGEND
PURSUIT TRAINING
ADVANCED TRAINING
TEST PILOTS
OBSERVATION & BOMBARDMENT
H. D.Q.RS' AIR SERVICE A.E.F.
TRAINING SECTION
RECORDS BRANCH

CHART IV

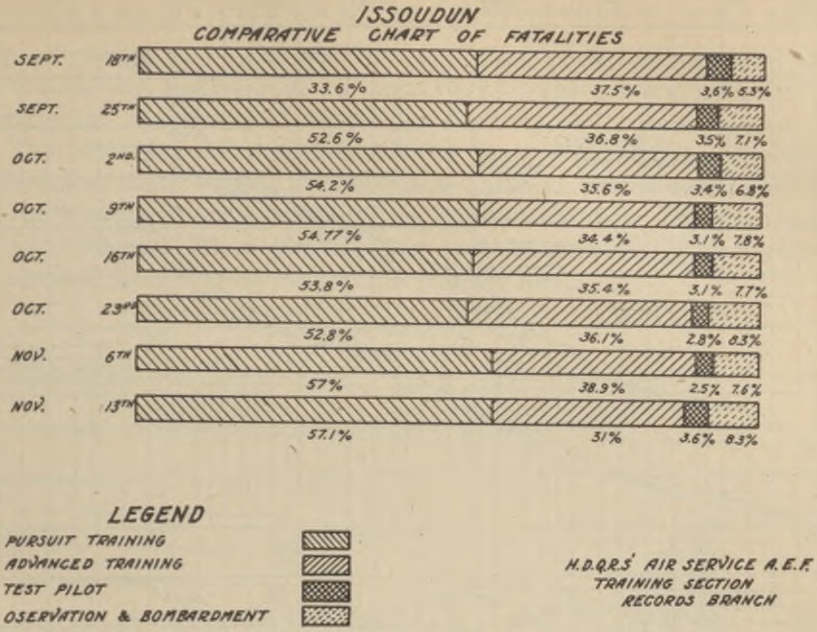


CHART IV (CONT'D.)

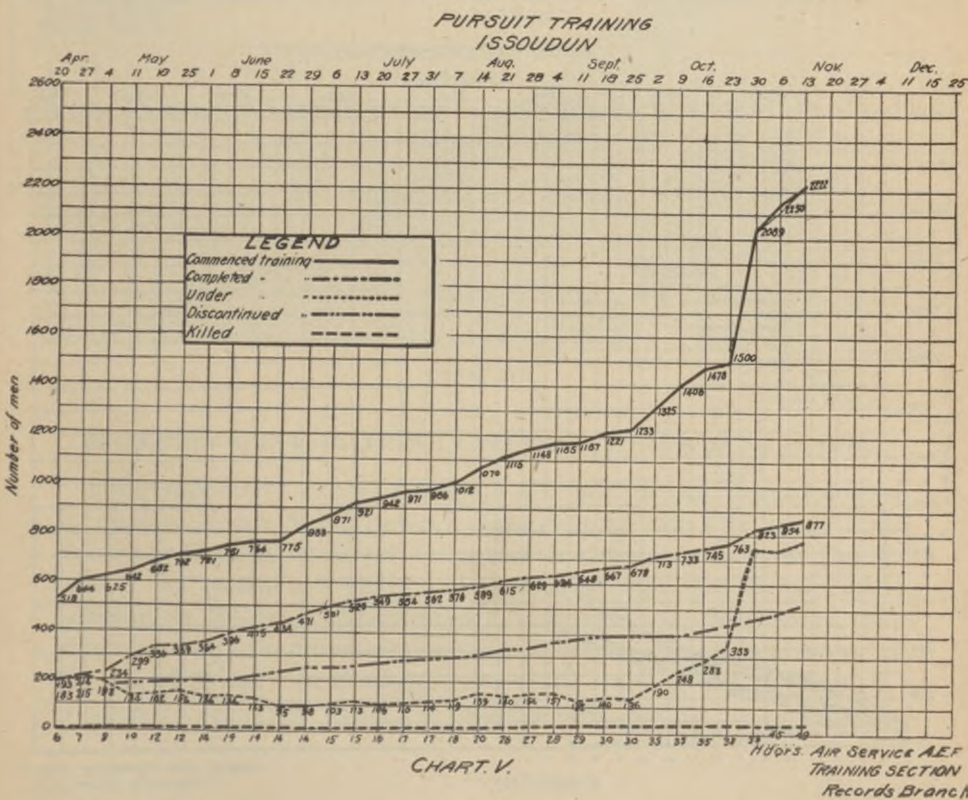


CHART V.

ADVANCED TRAINING
ISSOUDUN

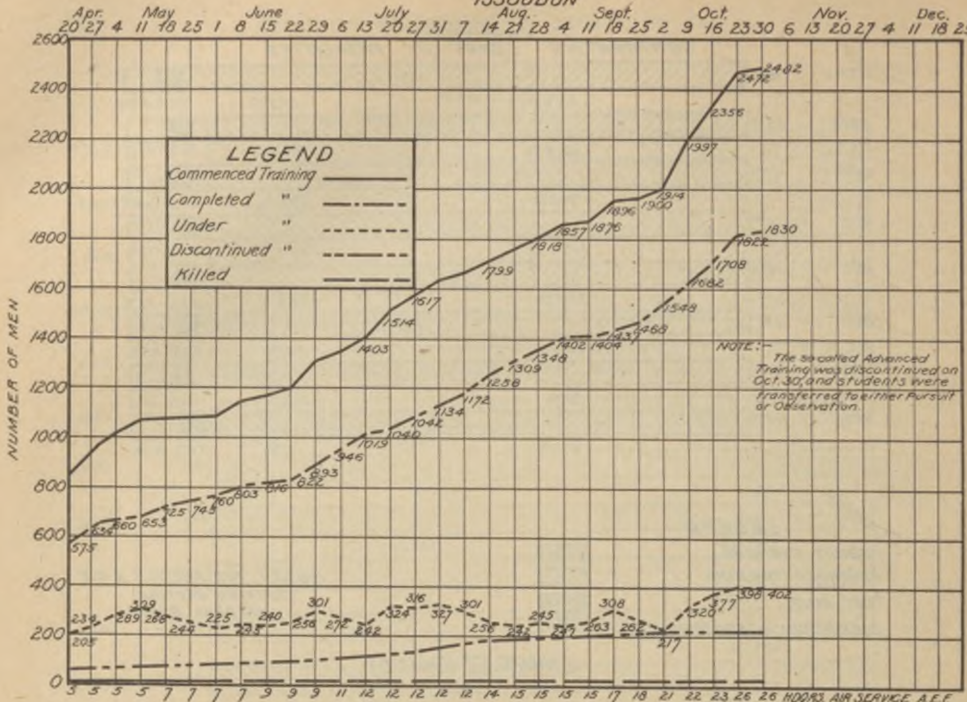


CHART VI

HDQRS. AIR SERVICE A.E.F.
TRAINING SECTION
RECORDS BRANCH

OBSERVATION & BOMBARDMENT
ISSOUDUN

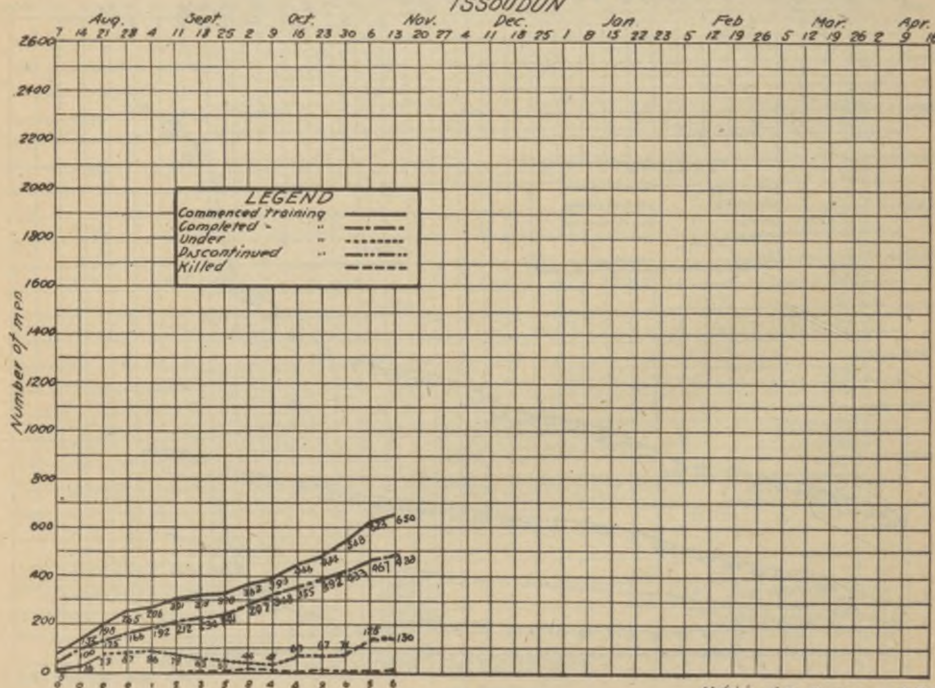


CHART VII.

Hdqrs. AIR SERVICE A.E.F.
TRAINING SECTION
Records Branch

ing schools of the A. E. F., 161 were killed under training and 42 administering instruction. (Chart VIII.) There were in all 821 instructors, transfer, and test pilots.

The percentage of fatalities, 5.6 per cent, is large when one considers that these were all trained pilots. When, however, the nature of the work of the instructor and test pilot is understood this figure is not surprising. Many of these lives were sacrificed in the effort to determine factors of safety for the student flier.

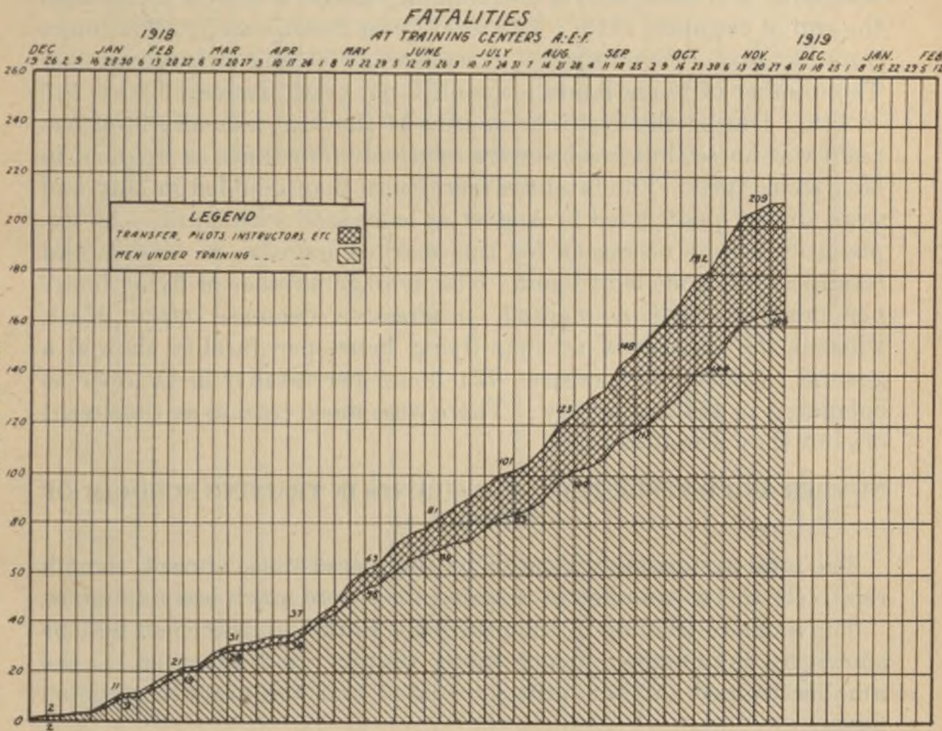


CHART VIII

HDQR AIR SERVICE - A.E.F.
TRAINING SECTION
RECORDS BRANCH.

ACCIDENTS AND FATALITIES IN RELATION TO HOURS OF FLYING.

For comparative studies accidents and fatalities are best expressed in relation to the flying hours. Data dealing with number of accidents per training center or per period of time have no great significance. In instruction centers the work accomplished is calculated entirely on the basis of hours flown, it being taken for granted that this represents the hours devoted by the students to the mastery of the art of flying. In the beginning of his training and in his introduction to acrobatic flying the student pilot has an instructor with him in his flight, while the advanced student flies alone and pilots his own ship. The "hours flown" represent the total hours that the total number of machines are actually in the air, irrespective of the number of occupants of the machine.

The number of passengers, however, plays a definite rôle in statistics dealing with fatalities, since frequently both pilot and passenger are killed simultaneously.

Chart IX presents graphically the comparisons of the flying hours, accidents, and fatalities for the training centers of the A. E. F. until the end of October, 1918. The total hours flown were 132,586 (more than 15 years); the number of crashes was 550, and of fatalities 184. The number of flying hours per month per crash decreased from 525 to 318. During the first four months of the year a steady improvement was noted, but crashes were relatively four times as frequent in May as in April. The fatalities were more than doubled in May and were almost quadrupled in August as compared with April. An explanation seems necessary for this marked increase in crashes and fatalities, but none is at hand. The average number of flying hours per crash showed a marked, progressive decrease after April; whereas the number of average flying hours per fatality showed a general tendency to increase—721 hours per fatality in October as compared to 464 in January. There were more crashes as time went on, but they were less fatal.

NUMBER AND DISTRIBUTION OF ACCIDENTS IN TRAINING SCHOOLS OF THE U. S. A.

The fatal accidents in America outnumbered those abroad, though relatively to the number in training they were much less numerous.

The scope of training in America prior to the armistice can best be shown by the number of men under training on November 11, the number trained to that date, graduated, and the number of hours flown.

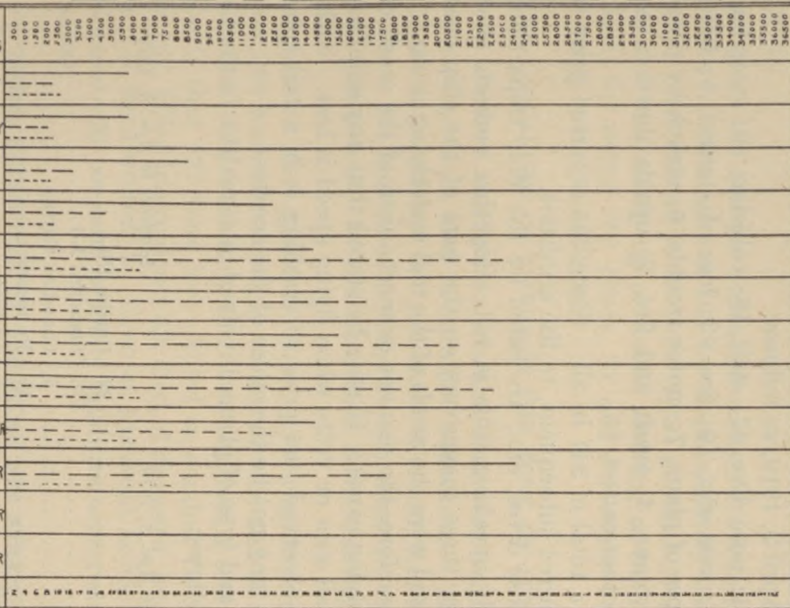
TABLE II.

[Figures in parentheses indicate pilots.]

	Under training Nov. 11.	Total number to Nov. 11.	Graduated.	Number hours flown.	Number of fatalities.
Primary fields	2,764	12,231	[1] 8,688	653,009	204
Instructors' school	82	835	742	56,425	13
Bombarding	430 (630)	853 (1,084)	414 (329)	32,312	8
Observers	325 (226)	1,399 (1,435)	907 (1,192)	35,801	22
Pursuit	414	1,003	479	43,712	16
				821,259	263

[1] R. M. A.

COMPARISON OF FLYING HOURS, ACCIDENTS (CRASHES) AND DEATHS OF PILOTS AND PASSENGERS AT TRAINING CENTERS LISTED BELOW



FLYING HOURS	NUMBER STUDENTS PER MONTH UNDER TRAINING	AVERAGE MONTHLY FATALITIES	TOTALS TO DATE: FLYING HOURS	TOTALS TO DATE: CRASHES	TOTALS TO DATE: FATALITIES	NUMBER OF FLYING HOURS PER MONTH: PER CRASH	NUMBER OF FLYING HOURS PER MONTH: PER FATALITY	AVERAGE NUMBER FLYING HOURS TO DATE: PER CRASH	AVERAGE NUMBER FLYING HOURS TO DATE: PER FATALITY
JANUARY	611	.0116	5563	10	12	525	464	525	464
FEBRUARY	603	.0180	11409	19	23	650	531	640	486
MARCH	678	.0148	19828	32	33	647	842	635	607
APRIL	1365	.0073	32112	51	43	648	1288	629	749
MAY	1465	.0170	46491	148	68	159	575	314	684
JUNE	1242	.0161	61257	244	88	154	737	251	698
JULY	1143	.0151	76450	332	103	173	1013	230	742
AUGUST	1022	.0244	94673	426	128	194	330	222	739
SEPTEMBER	1188	.0210	108761	475	155	288	564	228	711
OCTOBER	1729	.0179	132586	550	184	318	769	241	721
NOVEMBER									
DECEMBER									
ACCIDENTS AND FATALITIES									

LEGEND
—— FLYING HOURS
– – – ACCIDENTS (CRASHES)
········ FATALITIES

AVORD
CHATEAUROUX
CLERMONT-FERRAND
CAZAUX
COETQUIDAN
ENGLAND
FOGGIA ITALY
FURBARA ITALY
ISSOUDUN
LE CROTOY
SAUMUR
SOUGE
ST JEAN DE MONTS
TOURS
VOVES
MUECON
CHATILLON

Hq. Air Service A.E.F.
TRAINING SECTION
Records Branch

CHART · IX

Above are tabulated under the various forms of training, primary fields, instructors' school, bombarding, observing, and pursuit training, with the number of fatalities.

Prior to the armistice approximately six times as much training was done in America as in France—821,259 hours, or more than 93 years. There resulted 263 fatal accidents or one fatality for every 3,122 hours flown.

The "hours flown" per fatality to date (Apr. 21, 1919) was stated by the Air Service to be 2,801.39. Accidents were relatively much less frequent in the United States. On the other hand, larger and more stable machines were used as a rule—ships which, although useful for training purposes, are totally unsuitable for fighting at the front.

The causes of the fatal accidents have been classified by the Air Service up to April 2, 1919, as follows:

Tail spin, 111; nose dive, 47; stall, 15; collision, 56; steep bank in strong wind, 1; side slip, 19; fire, 13; loss of control, 5; fall from plane, 3; collapse of plane, 7; motor trouble, 6; struck by propeller, 13; struck by plane, 4; crash and fire, 2; upside down in air, 1; unknown, 23; other causes, 15.

These make a total of 341 in all. Since 263 occurred prior to, 78 must have occurred subsequent, to the armistice.

Tail spins, nose dives, etc., are listed by the War Department as causes. Strictly speaking, this is not altogether correct, since, in many instances, these maneuvers on the part of the ship occurred subsequent to and were the result of the real underlying cause. They represented, therefore, the manner or mechanism of the crash rather than the underlying cause. It may be stated that any ship is liable to fall into a tail spin or vrille when flying speed is lost. Although the ship when observed just prior to crashing is in a tail spin, the tail spin per se may not be the cause of the accident.

The number and type of planes involved in casualties in the United States are as follows:

Fatalities to Apr. 3, 1919.

Standard J-1	23
Curtiss JN-4	176
Curtiss R-4	5
Canadian Curtiss	55
Thomas-Morse Scout	11
DH-4	5
Caproni	1
No record (No Standard J-1s)	31
Le Pere	1
Total	308

Accidents to Apr. 3, 1919.

Curtiss JN-4	156
Standard J-1	10
Canadian Curtiss	27
No record	26
Le Pere	1
Total	220

These figures, though interesting, have no great significance since they convey no real indication of the relative stability of the various types concerned. This can be ascertained through a consideration of the number of hours flown per type per crash—data which were not available to the writer.

In comparing the data for the same period relating to the training schools at home with those of the A. E. F., certain facts become apparent:

1. The bulk of the training was given in the United States.
2. Fatal accidents at home outnumbered those of the A. E. F.
3. The number of fatalities (263 as compared with 203) for hours flown was relatively much smaller at home than abroad—the hours flown per fatality being 2,801 in the United States and 721 abroad. Accidents were, therefore, relatively four times more frequent in the A. E. F.
4. Combining the data for home and abroad it is seen that the total accident loss in training was 466 for approximately 950,000 hours; 2,034 men in total arrived at the front (1,281 pilots and 753 observers). For every 100 trained flying personnel arriving at the front, 24 had been killed; for every 100 pilots, 33 and for every 100 observers approximately 4 had been killed.

THE CASUALTIES OF FLIERS IN THE ZONE OF ADVANCE.

Nineteen hundred and forty pilots and observers were turned over to the zone of advance and 94 to allied squadrons. The casualties among these as listed by the personnel division, headquarters Air Service (Table II, section A), relate to the fliers in the American sector and (section B) to the American fliers serving with allied squadrons.

Of the men on the American front, 137 were killed in combat. Altogether 360 were lost outright to the service and in addition 109 were wounded. On combining the data, sections A and B, it is seen in section C that 427 were lost—killed in combat 169, missing 72, prisoners 137, killed in accidents 42, died of disease 4, interned 3. In addition, 127 were wounded. Even at the front accidents played a great rôle, since 25 per cent as many fatalities occurred in accidents as in combat.

TOTAL FATALITIES OF AMERICAN AIR SERVICE.

Deaths in the flying personnel of the American Air Service numbered 681, of which 508 were due to accidents (263 in America, 203 in training schools, A. E. F., and 42 at the front), 169 to combat, and 4 to disease. Accidents accounted for approximately 74.6, combat for 24.8, and diseases for 0.6 per cent of fatalities.

The total casualties of the flying personnel of the Air Service were 1,020;[7] killed, 681; missing, 72; prisoners, 137; interned, 3; and wounded, 127. The total flying personnel arriving at the front in

FLYING PERSONNEL AT FRONT – FATALITIES
AMERICAN AIR SERVICE

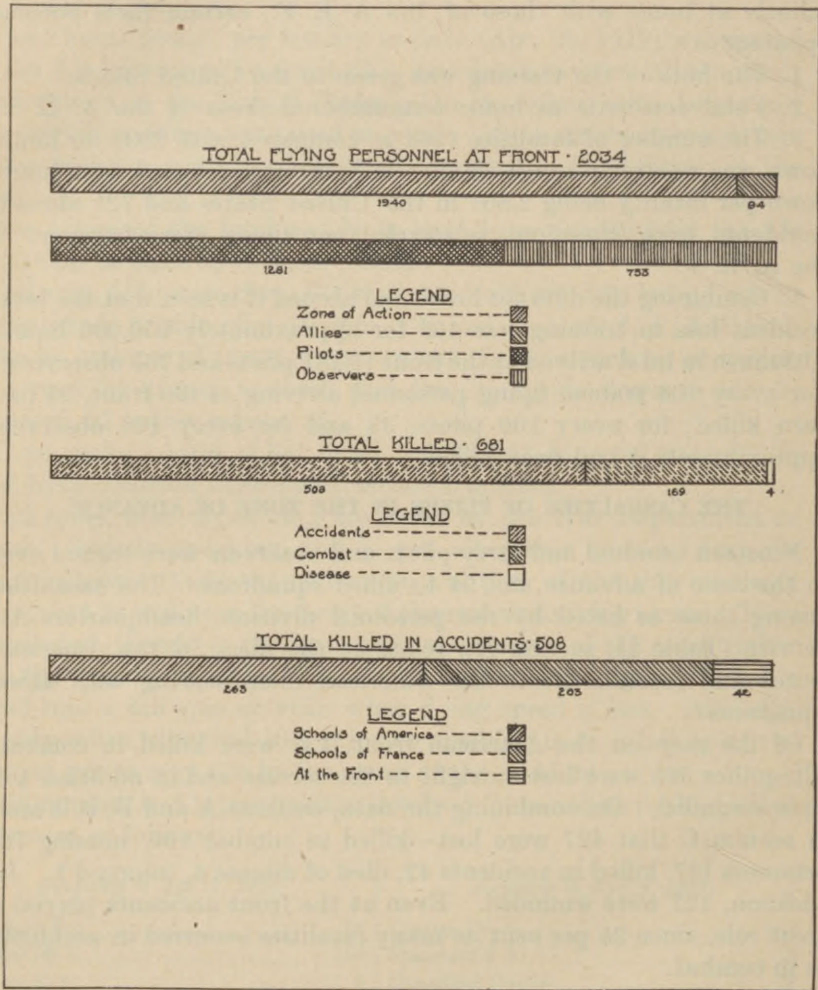


CHART · X

American squadrons and with Allies was 2,034. These facts are graphically shown in Chart X.

[7] This figure does not include nonfatal accidents occurring in training schools of America and France.

TABLE II.

A. AMERICAN CASUALTIES AT THE FRONT.

	Killed in combat.	Missing.	Prisoners.	Killed in accident.	Died of disease.	Wounded.	Interned.
May	6	....	4	5	....	4	....
June	2	....	4	5	....	6	1
July	9	6	24	1	....	11	....
August	23	3	14	4	....	10	....
September	58	25	47	8	....	28	2
October	33	18	14	16	2	38	....
Nov. 1 to 11, inclusive	6	7	12	1	....	12	....
Total	137	59	119	40	2	109	3

B. AMERICAN FLIERS SERVING WITH OUR ALLIES.

	Killed in combat.	Missing.	Killed in accident.	Wounded.	Prisoners.	Died of disease.
May	4	1	1	2	....	....
June	3	4	....	2	2	....
July	6	2	....	2	2	....
August	10	3	....	7	7	....
September	2	2	....	4	5	....
October	3	1	1	....	1	....
Nov. 1-11	4	....	....	1	....	2
Total	32	13	2	18	17	2

C. SUMMARY.

	A. E. F.	With allies.	Total.
Killed	137	32	169
Missing	59	13	72
Prisoners	119	17	136
Killed, accident	40	2	42
Died of disease	2	2	4
Interned	3	....	3
Lost to service	360	66	426
Wounded	109	18	127

Statistics such as these indicate the enormity of the problem. When it is realized that for every 100 trained pilots leaving the training institutions of France for work at the front, 15 had succumbed to accidents in training; that in October, 1918, when our training schools were at the maximum of efficiency a crash occurred, in the schools of the A. E. F., for every 241 hours flown and a fatal accident occurred for every 721 hours flown, the importance of accident problems becomes manifest. When it is further realized that many of the student fliers entering the schools of France had been already trained in America, and that even a larger number had already succumbed to accidents in training there, the problem assumes even greater importance. Finally, when it is realized that one man was killed in accidents for every three trained pilots arriving at the front, and that three fliers were killed in accidents for every one killed in combat, the accident problem establishes itself as the most important medical problem of aviation.

AVIATION ACCIDENTS IN THE ITALIAN AIR SERVICE.

The experience of America is not unique. Italy also lost more fliers in accidents in 1918 than she did in combat, as will be seen from the study of Table III, A and B, the data for which were kindly submitted to the writer by the general commanding the Sanitary Service of the Italian Army. A letter accompanying these figures stated that they were approximate only, as the final analysis was not yet complete.

TABLE III.—*Wounded, taking more than 10 days to cure, or wounded fatally in the aviation schools of the territorial zone, from Jan. 1, 1918, to Sept. 20, 1918.*

(*A*) Wounded:	
Taking more than 10 days days to cure	255
Fatally	161
(*B*) Aviators killed in the war zone in 1918:	
In aerial combat—	
Officers	26
Privates	21
In flying accidents—	
Officers	74
Privates	62
From undefined causes—	
Officers	5
Privates	8
Total—	
Officers	105
Privates	91

Those who died in the enemy's territory are not included.

It is clear that in the Italian air service 161 were killed up to September 20, 1918, in the aviation training school and that in the war zone 196 were killed throughout that entire year. But of these 196 only 47 were killed in combat and 136 in accidents. Therefore, in the Italian air service, in 1918, 357 in total, were killed and of this number 297, or 83.41, were killed in accidents. Five fliers were killed in accidents in the Italian air service for every one killed in combat.

THE CAUSES OF ACCIDENTS AND THEIR PREVENTION.

Broadly speaking, the causes of accidents can be divided into mechanical imperfections of plane or motor, bad flying judgment, weather conditions, collisions, and propeller accidents. Each of these demands most careful consideration. The first belongs primarily to the engineering and the second to the medical and training departments. An attempt should be made to control each factor to the utmost and where control is impossible, as in weather conditions, flying should be avoided except where it is absolutely necessary.

I. MECHANICAL IMPERFECTION OF MOTOR AND PLANE.

(a) Ships on Acceptance Should Be Mechanically Fit.

This is essentially an engineering proposition. The engineering world is striving to eliminate mechanical imperfections and to attain mechanical perfection, but this is a matter of evolution and evolution is a matter of time. One who is studying the accident problem is brought face to face with certain fundamental principles which he is forced to accept. Only those types of machines and motors should be accepted which represent the closest possible approach to perfection, mechanically and from the standpoint of material.

This involves the employment of the highest grade of mechanical ingenuity, skill in design and construction of the plane, and the utilization of only the best material in their production. This in turn involves absolute integrity on the part of the manufacturer, absolute adherence to specifications, and great care in the selection and testing of all material utilized, together with expert supervision of the manufacture and assembling of all parts. This is the function of aircraft production, but it is the function of the administration to see that these specifications are fulfilled and that only ships mechanically fit are accepted for service.

(b) The Machine Must Be Kept Fit.

The wear and tear on the aeroplane is great. The machine itself is a complicated piece of apparatus. Yet a loose bolt, a twisted wire, or a dirty spark plug may result in death. Each machine, therefore, should be mechanically right prior to every flight. This can not be taken for granted. A careful inspection by a competent mechanic is essential before every flight. In addition a thorough overhauling is needed every morning before placing the ship on the line. These rules should be absolute and should be enforced in every flying organization. No ship in need of repairs should be taken into the air.

The motor also requires special and expert attention. Irrespective of the way it works it should be overhauled at stated intervals. In the Third Aviation Instruction Center this was done for every 40 hours of flight. Every motor defective in any respect should be thoroughly investigated before a flier is permitted to take it into the air. Prior to every flight the motor should be thoroughly tested again by the pilot in order that he may know from personal experience what it can do and what he can demand of it. If it does not meet with his entire approval it should be again overhauled.

In the event of breakage or defects in either plane or motor, repair and replacing of parts should be done only by expert mechanics specially trained for this work, and the parts substituted should themselves be mechanically perfect. Except after very minor repairs appropriate tests should be carried out by specially trained testers before the machines are returned to the line. Obviously this involves a great expenditure of time and labor. The administration, however, should see that this is done. It is estimated that six men on the ground are necessary for every machine that flies. Too much care can not be exercised to insure ships fit for flying. "Only the fit should fly" applies to planes and motors as well as to pilots.

(c) Gas and Oil.

In addition to seeing that the ship is fit it is necessary to see that it is also supplied with suitable gasoline and oil. Special precaution must be taken to insure a gas free from water. Neglect of this, not infrequently, is the source of trouble. The aeroplane must depend on its gas and unless a good quality can be supplied the ship should not be allowed to fly.

(d) The Condition of the Ship and the Confidence of the Flier.

Fliers have marked preferences in regard to aeroplanes. Some have confidence and feel comfortable in the larger stable planes but never acquire the same attitude toward smaller fast planes. Others delight in the speed, power, and maneuverability of the Nieuport, Moran, or Spad. This is largely a matter of temperament and of training. Nevertheless, it must be recognized as a fundamental fact that a man who fails to acquire confidence in any particular type of machine will probably not make a successful pilot of that machine.

Since the machine itself and its gas and oil are all extremely inflammable and since fires originating during the flight almost always prove fatal, the question of fire is one worthy of the greatest consideration. Infinite care should be exercised in the construction of the motor, in the feed of gasoline, and in the location of the gas tank from the standpoint of fire. The fliers themselves are temperamental and greatly affected by accidents. The spectacle of a ship aflame in the air markedly affects those seeing it, and through them the entire flying personnel of the organization. A very strong prejudice was created against one of the planes used by Americans, owing to the frequency of fire. The pilots characterized this particular machine as the "Flying Coffin." The absolute and relative locations of the motor and of the gas tank are matters of great importance.

(e) Adaptability of Planes to Types of Work.

The selection of the ship should be made in relation to the type of work to be carried on. There are many types of planes and motors each with its advantages and disadvantages which will soon become apparent to skilled pilots. The administration must familiarize itself with the strength and weakness, the advantages and disadvantages, the value and limitation of each type of plane and motor. The ship should be selected for its adaptability to the desired use. A ship admirably suited for one branch of work may prove a failure in another connection. Some machines, such as the Avro, are stable, easily controlled, and admirably adapted to the teaching of acrobacy, a branch of training essential to combat. In actual combat, however, the fast and stable machines, such as the Spad and the 15 m. Nieuport, are utilized. Special bracing of the machines is frequently desirable when they are to be used in acrobacy or combat.

(f) Familiarity with Types of Plane.

As far as possible it is advisable for a pilot to use the same ship in order that he may have the advantage of his experience in handling it. It is essential that he know just what he can expect and demand of his ship, and as this varies with the individual machine it is decidedly advantageous for him to constantly use the same one. As a rule this is only possible at the front or in the case of the instructor.

During student days it is necessary to train a flier on many types of planes. It is desirable for him to receive his instruction in each type of work on the type of plane best adapted to this work. Special care should be exercised, however, that he be as thoroughly familiarized as possible with the peculiarities of each type as he encounters it prior to actual flight. All differences in control or in response to control should be clearly outlined before the machine is permitted to take to the air.

(g) Necessity of Knowing the Aeroplane and the Science of Flight.

The pilot should be instructed in the science involved in flight. He should understand his motor and plane and all that pertains to them. In this connection he should receive definite instruction and every possible assistance which can be rendered in the training schools through the senior officers, instructors, monitors, testers, and the engineering department. He should know the aeroplane and the science as well as the art of flying.

Every machine has its limits and every machine will fail if taxed beyond them. Many accidents for which the plane or motor are held responsible are caused by overtaxing the machine or by poor flying. A perfect motor will fail through faulty handling of the manettes, the feeding of imperfect admixtures, or to overtaxing, such as is encountered in prolonged zooms or climbs. The pilot should know his plane and his engine, the capabilities of both, and treat them accordingly.

Mechanically the essential features to fulfill are to supply a reliable ship and motor, to keep them fit, to supply proper gas and oil, to see that the ship is used in the type of work for which it is adapted, to see that the pilot is familiar with each new type, its peculiarities, and its limitations prior to flight.

II. POOR JUDGMENT AND BAD FLYING.

These are responsible for the majority of accidents and involve the questions of physical fitness and of training. The former chiefly concerns the medical; the latter, the training department.

(a) Physical Condition—Fitness and Lack of Fitness.

Lack of fitness may be either permanent or temporary in character. The examination of a candidate for admission involves a careful physical examination which is intended to exclude the permanently unfit (physically or temperamentally) and to admit only those in perfect somatic health with perfect sensory functions.

Too much consideration can not be given to the character of the examination, to the standards adopted,[8] and to the personnel carrying out the examinations of applicants for admission.

With these factors properly controlled, waivers should be granted not at all or only upon the rarest occasions. A waiver involves danger not only to the pilot concerned, but to other fliers, as in the following case: An applicant was rejected by several boards on account of poor vision. He persisted in his attempts and finally entered the service. During training he collided in flight with an experienced pilot who had flown many hundred hours. Evidence presented to the board appointed to investigate this accident seemed to clearly indicate that the first pilot did not see the other machine and crashed into it, killing both himself and the other flier. In addition two valuable machines were totally wrecked. This occurred at the time when both machines and fliers were most urgently needed at the front.

Temporary unfitness may result from many causes. Many of these can only be detected through the constant watchfulness of the physician who comes in close personal daily contact with the flier. For this purpose the flight surgeon has been introduced into the air service. It is his duty to assure physical fitness through personal contact with the fliers, the instructors, and the administration.

TRAINING IS ESSENTIAL TO FITNESS.

None but the fit should fly.—If medicine could enforce this rule, accidents would decrease materially in number. But medicine can not control the situation until the administration and the flying personnel recognize the necessity of making this rule absolute.

René Fonck, the leading French ace, recently made the following observations to La Guerre Aerienne:

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[8] These standards are considered elsewhere in this volume.

One must be in constant training, always fit, always sure of oneself, always in perfect health. Muscles must be in good condition, nerves in perfect equilibrium, all the organs exercising naturally.

Alcohol becomes an enemy—even wine. All abuses must be avoided. It is indispensable that one goes to a combat without fatigue, without any disquietude, either physical or moral.

It must be remembered that combats often take place at altitudes of twenty to twenty-five thousand feet. High altitudes are trying on one's organism. This indeed is, at bottom, the reason that keeps me from flying too continuously. And I never fly except when in perfect condition. I am careful to abstain when I am not exactly fit. Constantly I watch myself.

It is necessary to train as severely for air combats as for any other athletic contest, so difficult is the prize of victory. Yet if one finds oneself in prime condition, all the rest is play.

1. *Temporary indisposition or minor ailments.*—Among the temporary causes the chief to be considered are minor ailments, the use of drugs, intemperance or excess of any nature, flying stress, and staleness.

When flying, the pilot's life depends upon the quickness of his wit and the accuracy of his muscular control. A temporary indisposition such as an attack of influenza, tonsilitis, bronchitis, or migraine, while perhaps trivial in itself, absolutely unfits a man for flying for the time being. A medical principle should be laid down that *any general illness requiring medication is an indication for temporary suspension from flying.* In several instances of apparently inexplicable accidents to noted flyers it has developed, upon investigation, that the victim of the accident was suffering at the time from some temporary indisposition such as those listed above, and that he was undergoing self-administered medication. Many flyers have been killed while taking aspirin. Whether the underlying disease or the aspirin, or both, should be held responsible, is still to be determined. Three of the fifteen fatalities occurring at the third instruction center in October, 1918, were to flyers convalescing from the "flu." None of these pilots had been examined by the medical research board.

2. *Intemperance and excesses.*—Indulgence in alcohol, late hours, excessive venery, loss of sleep, unquestionably play a considerable rôle in the etiology of accidents. In the majority of instances, however, it is extremely difficult to obtain data relative to some of these factors.

3. *Flying fatigue—Staleness.*—Flying involves great stress. Two periods, two hours each, constitute a good day's work even for the experienced pilot. Fatigue is particularly complained of, if more than six hours of flying per day is persisted in for any period of time. Students called upon to fly six hours per day, as they frequently are in mastering formation flying, consider themselves driven to death. In the Third Aviation Instruction Center the commanding officer of

one of the fields demanded rest for the student pilots coming to his field because he believed that they were suffering from flying staleness. He stated that they were not fit to fly. Upon investigation it developed that these men had been flying six hours per day in the preceding field.

Flying stress results in both temperamental and physical unfitness. Judgment becomes seriously impaired. Flying efficiency is lost. The pilot's attitude toward his work is distorted and he frequently assumes a "don't care" attitude. He fails to heed even the fundamental rules of flying. Sleep becomes irregular or impossible, broken by dreams relating to flight. Imaginary accidents are nightly occurrences during his sleeping hours. Confidence is lost and with it, flying efficiency. Frequent accidents result.

Physical rather than temperamental defects are frequently the basis of these accidents. The strain of eye muscles resulting in muscular imbalance—convergence insufficiency or divergent excess—are responsible for many bad landings and many crashes. The diagnosis of flying staleness is frequently made by the commanding officer of the field or by the flight or squadron commander.

4. *Altitude.*—Altitude brings new problems which but recently have become of great practical importance in aviation. In war, originally, the aeroplane was used for reconnoissance and at relatively low levels. With the advent of the machine gun in planes, combat became a prominent feature and the value of altitude in relation to this became apparent. Consequently, planes were built with this idea in view. Whereas, in 1915, an altitude of 12,000 feet for a war plane was unusual, by the end of 1917 altitudes of 22,000 feet were of common occurrence.

Altitude involves decreased barometric pressure and decreased oxygen tension. The latter is the factor responsible almost entirely for the symptoms produced at high levels. Two forms of altitude sickness are known. The first is acute, characterized by tachycardia, lividity, headaches, nausea, vomiting, buzzing in the ears, dimness of vision, marked prostration, and fainting attacks. The second form presents many of the same phenomena but it is delayed in its onset. Nervous and cardiac symptoms are apt to predominate. Marked panting and inability to move, a weakness or paresis of the limbs and marked general asthenia. A dazed condition associated with euphoria, or even unconsciousness may supervene. In most cases the euphoria which accompanies altitude sickness is unfortunate, in that it robs the pilot of the opportunity of recognizing that he is in danger. He feels fit and believes himself to be in possession of all of his senses. He feels perfectly capable of controlling his ship, whereas, in fact, he may suddenly lose control and behave as one suffering from an attack of petit mal, or he may actually faint. Under such conditions he may, if he is fortunate, awaken to find his ship flying out of control usually at a much lower level. Providing he has a true fainting reaction he may not recover at all, in which event a crash and usually a fatality is the result.

Acute altitude effects have been carefully investigated within the last two years in the Air Service. By the use of the Henderson breathing apparatus it is possible to bring the subject to 10 or even 6 per cent oxygen within half an hour under conditions in which cardiovascular (blood pressure and pulse) and psychological conditions can be carefully noted. Roughly speaking, two types of reactions occur. First, those showing marked cardiovascular changes, ending, if the test is not interrupted, in a fainting reaction from which it takes considerable time to recover. Second, those exhibiting a dazed condition in which the subject, though he does not fall or collapse, is mentally and physically incapacitated, with failure on his part to recognize his helpless state. The condition in this respect somewhat resembles petit mal. Quick recovery ensues on resumption of breathing or the administration of oxygen. In many instances the subject must be told to take a deep breath, otherwise he makes no effort to breathe on the removal of the mouthpiece and nose clip.

The fainting reaction is the more serious. Subjects falling into this group are apt to crash before recovery occurs. Most pilots who state that they fainted in the air and awakened to find themselves thousands of feet lower probably belong to the second group.

Individuals differ widely in their ability to withstand the effects of altitude. Each individual has his own ceiling. This, however, may vary from time to time. Slight indispositions, trivial in themselves, may exercise a marked effect in decreasing capacity to withstand the effects of low oxygen tension. This fact has been clearly demonstrated by the Medical Research Board.

Experience has taught pilots that altitude flights affect their judgment of distance, and result often in poor landings. Many of the best pilots make it a rule following flight at great heights not to land without first making a "Tour de piste."

It is interesting to get the airman's point of view in regard to altitude sickness. McCudden, one of the leading British aces, in his interesting book, "Five years in the R. F. C.," speaks of air sickness which he encountered in a combat which started at the height of 21,000 feet. "I felt very ill indeed. This was not because of the height or rapidity of my descent but simply because of the intense cold which I experienced up high. The result was that when I got down to a lower altitude and could breathe more oxygen, my heart beat more strongly and tried to force my sluggish and cold blood through my veins too quickly. The effect of this gave me a feeling of faintness and exhaustion that can only be appreciated by those who have experienced it. My word! I did feel ill, and when I got on the ground and my blood returned to my veins I can only describe my feeling as agony."

(b) **Inexperience and Training.**

Inexperience is a very common cause of accidents. In 15 fatalities occurring in October, in the Third Aviation Instruction Center, 6 occurred in the first flight on a new field with a new type of plane. This tells its own story. Obviously this problem is for the training department and one difficult of solution.

In training, the student pilot is taken through the ground school and then into the air in double control. He is given the necessary instruction, allowed to pilot the ship, and is made the object of study by his monitor. When the monitor feels confidence in the student's ability to handle the ship, then, and then only, is he allowed to go "solo." But many a man who handles his ship well in double control, knowing that an accident is unlikely because of the presence of an experienced pilot, loses confidence and with it his flying ability when he realizes that his life is in his own hands. This constitutes a most difficult problem.

Training is commenced on a two-seated machine, which is relatively large, slow, and stable. The first solos are usually taken in the same type of machine in which the student has been trained. He then passes to faster and smaller machines. The peculiarities of the latter are carefully outlined before he is allowed to take them up, but if it is a single seater he must handle it alone when he takes it into the air. Slight differences in handling the control, in maneuverability, and in responses to control on different machines lead to many accidents.

After simple flying is learned, formation, acrobacy, and combat must be mastered.

1. *Formation flying.*—Inasmuch as most of the work of the chasse pilot at the front is now carried out by formations rather than by single machines, formation flying is essential and must be learned. In formation the machines aim to keep together in predetermined relative positions. This remains constant in straight flight, but in making turns, changes in relative position are also made. Rules governing changes in speed, altitude, and direction, and counting for safety are prescribed. Nevertheless, accidents are frequent. Infinite care and watchfulness are constantly needed in formation flying, especially in the execution of turns.

2. *Acrobacy.*—Acrobacy is essential to combat. In the latter days of the war, with the advent of formation tactics, it did not play as large a rôle in combat as formerly. But a good scout pilot must be able to do acrobacy in order to extricate himself from difficult posi-

tions in combat or in order to meet emergencies arising in flight. It is essential for the pilot to be familiar with the emergencies of flying and the effects of these upon the behavior of the ship. When the motor stalls, the machine tends to drop into a vrille, or it side-slips. Unless the pilot is familiar with the methods of control of the ship in a vrille or side slip, a crash is almost inevitable.

The fundamentals of acrobacy, as of simple flying, are first taught under dual control. Only after the instructor is satisfied that the student is capable of handling himself in various maneuvers, such as loops and renversements, does he permit him to attempt them alone. In mastering these maneuvers the student is taught in one of the stable machines, such as the Avro, under the supervision and guidance of an instructor. After preliminary training he actually handles the machine himself, but still under the supervision of the instructor, who notes and attempts to correct all faults in the technique of flying. Subsequently the student is obliged to execute these maneuvers alone and in faster and less stable machines. In so doing he is intentionally exposed to the emergencies, dangers, and pitfalls of flying and is obliged to extricate himself. In this work accidents occur from time to time. A few pilots are killed, but those who survive become skilled, ready to meet any contingency. Since emergencies inevitably occur, they must of necessity be met sooner or later. Training is a prophylactic measure, results in greater flying skill, and protects the pilot in emergencies and in combat.

The administration should make certain that in acrobacy only machines capable of standing the strain are utilized and that machines used in this work are effectively braced.

3. *Combat.*—Combat training is dangerous but absolutely essential. It involves mastery of the tactics and acrobacy involved in actual fighting. The machine gun is replaced by a camera gun. The student is taught how to attack, how to fight, and how to extricate himself if attacked; how to convert a defensive position into an offensive one. This work is carried out in fast single seaters.

The training involves competition, and hence excitement. In the heat of combat collisions are not infrequent. Inasmuch as the pilot must constantly watch the other machine, ample air space and altitude are requisites. In combat there is a constant tendency to lose altitude. Unless combat is taught only at a considerable altitude and desisted from also at a fair altitude, accidents are bound to occur, since the pilot's mind and eye are concentrated on the other machine.

Air sickness, nausea, vomiting, and vertigo are of frequent occurrence among students learning acrobacy and combat. In the latter, relativity of position, together with strenuous acrobacy, are the causes. Students, especially those who are known to be hypersensitive to motion, should not be rushed in training in combat or acrobacy, since vertigo and vomiting may prove great sources of danger. Nausea and vomiting may be overcome in many cases through training which involves systematic and repeated subjection to vrilles. Only after the flier has overcome vertigo and can bring his ship out of a vrille with his wings level should he be permitted to try it alone.

Training schools have attempted to formulate rules and regulations covering flying which would protect both the student and instructor. These are the result of experience and of careful investigation. They should be familiar to all the flying personnel and should be absolutely enforced in every training center.

The rules and regulations governing flying were compiled at our suggestion, by Capt. Ferguson, officer in charge of flying, at the Third Aviation Instruction Center. They are as follows:

General Rules and Regulations Governing Flying on Individual Fields.

(Oct. 21, 1918.)

[Training Department Third Aviation Instruction Center.]

GENERAL REGULATIONS.

The following regulations are in effect at all fields at this center. Each student will thoroughly familiarize himself with them and will be held responsible that they are carried out at all times.

In addition to these regulations, each field has its own additional rules with which students must familiarize themselves before starting flying at the various fields.

1. No airplane will be taken into the air except by signal of the officer in charge of flying or his assistant, and *under no circumstances must any of the training fields be crossed by machines of another field at an altitude under 500 meters.*

2. Before going into the air the pilot will familiarize himself with the rules for turning for that field.

3. (*a*) Each pilot will make a careful inspection of the *airplane* before flying, special attention being paid to the controls, control surfaces, and landing gear.

(*b*) *Controls* should always be worked on the ground prior to a flight, to see that they function properly. Check direction of actions. Frequently in replacing cables, the cables are put in crossed. This invariably results in an accident, if mistake is unnoticed.

4. The pilot will repeat the words "*coupe*" and "*contact*" after the mechanic, but in no case will he say "*coupe*" unless the switch on the side is closed and the switch on the stick pushed down. *This is the only occasion upon which pilots may use the switch on the stick.*

5. Machines will be taken off and landed against the wind only.

6. No turns will be made under 150 meters.

7. The pilot must at all times keep within gliding distance of the field unless receiving special orders to the contrary.

8. When within 50 meters from the ground, and distance enough to land in has been assured, cut the switch on the side of the machine. Under no circumstances land with the switch cut on the stick.

9. Pilots of this post meeting French machines in the air, will not fly closer to them than 500 meters nor practice acrobatics near them.

10. No acrobatics will be performed over main field, except by testers or with special permission from the officer in charge of training.

11. No acrobatics will be performed over surrounding towns or hospitals.

12. No acrobatics will be performed at less than 1,000 meters altitude.

13. No student will carry a passenger in an airplane.

14. In case of serious accidents no one shall in any way examine or alter the damaged plane, other than that necessary in removing the pilot, until a photograph has been taken of the accident by the statistical department.

15. In any case of forced landing, it is the duty of the pilot to telephone or telegraph the field service department at once.

16. In case of machine being *wrecked*, or partially wrecked, the field service crew—if convenient, the crew of that machine—and the detachment of the Medical Corps, will go to the wreck. No one else except the officer in charge of flying, engineer officer, and their assistants.

17. All machines must be equipped with *safety belts* for pilot and passenger.

18. Always use *safety belts*. In case of accident, do not release belt until after accident. It will probably save injury, especially if the machine turns over.

19. If any flier finds something wrong with his machine which, in his estimation, makes it unsafe for the next flier to use the machine, he will instruct the next man to hold the machine on the ground, and will immediately report the trouble to the officer in charge of the field.

20. If any flier finds something wrong with the planes or the controls of the planes which he is flying, he will make his criticism to the officer in charge of field and to *no one else*. All criticisms will receive due consideration.

21. *Do not turn machine sharp in taxying*. When on starting line instead of turning short on the line, have the tail lifted around, and avoid turns which strain the fuselage.

22. Never run motor so that blast from the propeller will blow on another machine or in direction of hangars.

23. Machines *gliding into* field have preference over those about to leave. Machines *landing* have greater speed than those leaving, so be careful not to misjudge your start and be overtaken by another machine that is powerless to keep from having an accident as the result of your misjudgment.

24. Never leave a machine tail to the wind; *nose machine into the wind*. Always leave the propeller horizontal. If wind blows machine over on its nose, propeller will be broken unless it is horizontal.

25. No pilot will leave the ground if the motor is not working properly. If a motor develops a skip within 150 meters altitude, land immediately, continuing in a straight line from runway irrespective of the ground.

26. When direction of the wind is such that students are required to take off directly toward hangars, they will take off so that they will pass by the corners of the hangar group and not directly over hangars and machines on the line in front of same.

27. No pilot will get into a machine unless he is feeling well physically.

NOTE.—Each student will receive a copy of these general regulations upon his arrival for which he will sign receipt.

Upon departure he will return same to Office of the Training Department at Headquarters detachment.

Ignorance of the rules will not be accepted in any case as an excuse for violations of same.

FIELDS 1 AND 2.

ROULERS—TAKING OFF—LANDINGS—HOPS.

1. No low flying is permitted.
2. No cutting across fields in front of other machines making a tour de piste.

3. All turns will be made in the direction indicated by the flag on the cross beam of the tower in the center of the field.

4. The line to which moniteurs land will be determined by the color of the flag, red or blue, on cross beam.

5. Any form of acrobacy in a dual control plane is prohibited.

FIELD 3.—MAIN FIELD.

1. No airplane will be taken into the air except by signal of the *chef de piste, and under no circumstances must any of the adjoining fields be crossed at an altitude of less than 300 meters.*

2. Do not take to the air if motor is not working properly.

3. *Climb slowly. Do not turn under 150 meters and throttle down to 1,050 or thereabouts after first turn.*

4. Twenty-three meter singles will be used for cross country purposes under no conditions whatsoever unless authority is given in writing by either post commander, officer in charge of training, officer in charge of flying, field commander, or field adjutant. Such written permission will be presented to the senior N. C. O. at the field, and a suitable machine will be furnished. This rule will be strictly adhered to.

FIELD 4.—ACROBACY.

GENERAL RULES.

1. All machines must taxi out from the line before taking off.

2. No machine should leave the ground without a signal from the flagman.

3. The signals of the flagman will be as follows:

Red flag is a danger signal. All machines should stop where they are until the red flag is withdrawn. The signal to start will be pointing the white flag at a particular machine, followed by a wide sweep. The signal to taxi is the waving of the white flag below the waist line. When the flagman points in any direction with both flags he is giving the direction in which to take off.

4. All pilots are directed to take directly into the wind and to make the first turn only after having acquired an altitude of at least 200 meters (600 feet). All landings should be made into the wind. Side-slip landings or landings with the wings low or gliding in with one wing low are forbidden. The last hundred meters of altitude should be lost in a straight glide.

RULES FOR THE LANDING FIELD.

1. The flagman at the landing field will use the same system of signals as described above. The diıection of the "tour de piste" will be determined by the officer in charge of landing.

2. The wind direction is shown by a white "T" on the ground. All pilots landing on the landing field will land to the left.

3. Machines not occupied by pilots and those in field repair will be taxied or rolled into position on the right side of the "T."

4. Pilots will practice air work as far as possible in the air area allotted to them.

RULES FOR THE SPIRAL CLASS.

1. Pilots in the spiral class will take off at the signal from the head flagman.

2. The direction of their "tour de piste" will de determined by the officer in charge of the spiral class.

RULES FOR THE CROSS COUNTRY.

1. Pilots in the cross country class will take off and land immediately in front of the hangars and will receive their signals from the head flagman.

Field 5.

LANDINGS—SPIRALS—CROSS COUNTRY—ACROBATICS—ALTITUDE.

1. No landings will be made that in the event of misjudgment will endanger lives or property in the vicinity of hangars.

2. Motors will be throttled for all work after altitude has been gained.

3. All students when assigned to positions in the air will be very careful to remain exactly over the territory assigned to them so as not to confuse other pilots who are assigned to like positions in the vicinity.

4. No student will fly when he is not feeling well, and in the event of becoming sick in the middle of class, he will be sure to notify the officer in charge of the class, and he will be readily excused.

5. Instructors will not engage in any kind of dangerous flying around hangars or over the field, because of the bad example set for students.

6. No flying officers from this field will fly over or near any hospitals or convalescent homes, as the condition of some of the men is very serious and the noise of an aeroplane motor brings back very vividly their past experiences.

No pilots will engage in steep turns close to the ground. When meeting a machine in the air, a pilot will pass him 300 feet to the left.

Field 7.

FORMATION FLYING.

Formations from this field will not fly over any other flying field of this center at altitudes less than 1,200 meters.

Formations will not fly at less than 500 meters altitude, and will always fly above 1,000 meters when practicable. Should clouds force the leader lower than 500 meters, he will immediately return with his flight to the aerodrome.

All flying will be done within certain specified, well-marked boundaries. Lines connecting Bourges—Chateauroux—Romorantin—Vierzon are the flying limits of this field (consult map in lecture room). A forced landing outside these limits is an infraction of the rule and a breach of discipline.

Acrobatics, stunting, etc., while you are a student at this field are *absolutely forbidden.* A sharp turn or "virage" is not considered a stunt.

Your attention is again called to memorandum headquarters training department, August 19, 1918, in regard to contour flying, etc. Chandelles and dangerous turns near the ground in take-offs and landings are an infraction of this rule. Students violating this rule are liable to suspension and reclassification. Instructors who persist in this practice will be dispensed with.

Flight leaders will be responsible for the presence of members of their respective groups at all formations.

Each student during his stay at this field will prepare and hand in two papers on distance estimation. On the first he will give details of what parts of the machine he can distinguish at 50 yards, 100 yards, 200 yards, and 300 yards, and also with the observer standing at a 45° angle to the rear of the machine. The second paper will be a repetition of the first but at some later time. Distances are staked out east of hangars from last machine in line. Students will not be lached from this field until these papers are handed in and approved.

In the event of forced landings, the field service at this center (phone No. 80) will be notified direct. This is done in order to avoid delay and possible error in getting information as to the exact location of plane. Field service will in turn notify the field from which plane originated and also this department and hospital where crashes are serious and medical attendance is required.

Always look carefully at the field and well about you before landing. An accident in which one pilot collides with another in landing is inexcusable. Always give way to a pilot lower than yourself, as it is practically impossible for him to see your plane.

After you have landed, always look carefully around, both on the ground and in the air, to see that there are not other planes in your path for taxying and also so that you will not taxy into the path of another pilot who is about to land.

When coming down from an altitude flight or any flight of 2,000 meters or more, always make a tour de piste of about 200 meters before landing to accustom your eyes to the ground; otherwise you will redress anywhere from 10 to 50 feet in the air.

If, when landing you see that you have misjudged the field, it is no disgrace to make another tour and land where you originally aimed. It is not probable that you will always have a 40-acre field to land in at the front and it is invaluable to be able to land plane just where you want to.

Patrol leaders should always carry an altimeter and have a streamer on proper side of plane. *All pilots must carry watches.* Maps and other equipment are optional if pilot knows the country to be covered.

Machines which are to take the air will be started and stopped at farther line from the hangars.

BLACK SMOKE FIRES.

Black smoke fires burning on the landing field indicate danger. LAND IMMEDIATELY. Keep close watch for landing planes.

FOGS.

Leaders of formation will be especially watchful and on the alert at all times in order not to be overtaken by a fog. Land your plane; it is foolhardy to try to outfly a fog, which may last throughout the day.

Fogs generally originate from swamps, etc., and quickly gather, rolling like clouds over the surrounding country at low altitudes. When you are flying high, pay attention to the earth, for although it may be clear and sunny at your altitude, if you are surprised by a fog, the earth will be completely enveloped below you, and landings become not only extremely dangerous but often impossible.

The use of "cross-over" 90° turns in offensive and defensive formation flying at this field will be discontinued in patrols numbering more than three pilots. The "cross-over" turn will be used only in case of light patrols, i. e., a patrol of three pilots, after such pilots have practically completed their course of instruction at this field.

FIELD 8.—COMBAT.

This is a *bad field to land on.* There is a road on the ridge in front of the hangars running parallel to them which is very bumpy. *Don't land there.* If you do, don't blame your bad landing on the bump. The bump didn't come to you—you came to it. If your motor is running you have no good excuse for hitting the bump.

If you desire to fly low during solo periods, you may, but don't fly low over forests and other bad ground. It may not be your fault if your motor poops, but it is your fault if you have flown your machine into a position from which you can't land safely.

Leave other machines alone. They have their own business to attend to. Don't combat with anybody except members of this field who show an evident desire to combat. Swaying the machine from side to side will be understood as an indication of such a desire—otherwise leave the plane alone.

Never fly in a straight line for more than a few seconds. Practice turning continually. Turning adds to your skill and reduces danger of collision.

Watch out for calm air in the shelter of the hangars which may cause you to overshoot.

In case of fire remember that a side slip is the safest descent in most cases.

If you are feeling ill don't fly.

General Notes on Field Testing of Airplanes.

INSTRUCTIONS.

All motors should be warmed up at *low speed* before flight. After the motor is warm the pilot should open it up momentarily to assure himself that it is running properly and that the oil is circulating.

Pilots while taxying type 27 Nieuports will, *at all times*, hold the stick well forward to relieve the strain on the tail skid.

Pilots before making cross-country or formation flights will examine their gas gauges.

In addition to the above it is desirable to lay more emphasis to the following rules:

1. Only the fit should fly. Illness of any kind constitutes a contraindication to flying. Consult the medical officer. In the event of more serious illness, always consult the medical officer before returning to flying status. If illness arises in flight, land as promptly as possible.

2. All officers and students who have been off flying status for a period longer than one month should fly double control before going solo.

3. Do not take-off with a motor that is skipping. Never attempt a turn with a dead motor until flying speed has been acquired. This is only possible with altitude. If altitude is less than 200 meters, always land straight ahead.

4. A student who is flying poorly should be carefully watched. In the event that he goes to another field, information concerning his flying and the need of special care should be sent promptly to the new field before his first flight.

5. Rules should be made for each field concerning taking-off and hangars. Limits should be set as to how close to the hangars it is safe to take-off.

6. Students should be held and trained in acrobacy under double control until the instructors are convinced that they are capable of executing the maneuvers alone.

Fliers can not be made according to pattern. If so, they would be inefficient. Individuality, initiative, daring, and willingness to take a chance are essential to the pilot. Limits, however, are set for the protection of the student. The rules and regulations outlined above can be enforced without destroying those characteristics which count for success in work at the front.

(c) Foolhardiness—Recklessness.

Even excellence brings dangers. Many fall victims to their own prowess. Just as Capt. Webb met his death at Niagara in attempting the almost impossible, so many great pilots die as the result of their excellence and the temptation it brings in its track.

The flier fundamentally is temperamental and loves thrills. He loves to have them and loves to give them. Loops, renversements, vrilles, and barrels are attempted at low levels. The slightest miscalculation or misjudgment on the part of the pilot or a failure on the part of the motor leads to a crash and usually to a fatality.

Acrobacy at low levels is usually thrilling. The spectator as well as the pilot is constantly in doubt whether the maneuver can be successfully executed or not. The flier who indulges in it is knowingly flirting with death. Death is never far remote. Sooner or later a crash is inevitable.

In indulging in acrobacy at low level a perfect knowledge of the machine is necessary. Slight differences in the response to control, such as exist between the Nieuport 27 and 28, may prove fatal if unknown to the pilot. In this way a brilliant pilot was killed in the Third Aviation Instruction Center while doing stunts which he had done repeatedly in a Nieuport. He was sacrified through ignorance of a peculiarity of the new type of machine which he was flying. A few hours spent in practice at a good altitude would have revealed the fact that this type of Nieuport required a trifle longer to straighten out when emerging from loops.

Although stunting is constantly indulged in, in all large training centers, it is encountered in its most pernicious form during the so-called "shows" which are put on for the benefit of celebrities visiting training centers. I have repeatedly seen groups of men who have spent months in the aviation instruction centers, become highly excited in the course of exhibitions of this kind. Competition plays a rôle. Each flier attempts to outdo his fellow. Often the flying becomes utterly reckless. Some means of control is desirable in this connection.

(d) Overcautiousness.

In many instances accidents have been ascribed to overcautiousness. The pilot is apt to under control, hesitates to bank his machine in making a turn, and as a result he sideslips. In making a landing on small fields he overshoots obstacles at the proximal end of the field and crashes at the distal end. The student who is overcautious should be warned. He needs special attention just as does the reckless flier.

(e) Turning with a Dead Motor.

There exists in aviation a fatal trap through which many a trained pilot has gone to his death. It is well known to every flier. Every student is warned against it. But student and master alike fall into it.

The pilot takes off with a missing engine which later stalls or he zooms and the engine fails at an altitude of one or two hundred feet. Flying speed is just sufficient to keep the machine afloat. Instead of gliding down and attempting a landing the pilot turns in an attempt to return to the field from which he has taken off. Flying speed being lost, the machine falls into a vrille or sideslips. At this altitude redress is impossible. A crash is inevitable.

The explanation is difficult. A fundamental instinct akin to a homing instinct may be responsible. Immediately upon the stalling of the motor the maneuver is attempted without thought. Thought does not enter into it, since the instructor who has spent his time teaching the student to avoid this trap falls into it himself in many instances. Old trained pilots have attempted this turning with a perfect landing field immediately in front of them. Obviously, the reason is deep seated. Instinct appears to be responsible. By the time conscious thought is exercised the maneuver has been begun, the machine has nosed down and fallen into a vrille. Time does not permit of redress. Capt. McCudden, one of the leading British aces, was killed in this manner, after having flown five years in the R. F. C., brought down 58 enemy planes, and having served a considerable part of the time as a flying instructor. A paragraph appended to his book reads as follows:

> He flew across the Channel on a machine which he had especially chosen for his own particular style of fighting, and landed safely in France. On starting again and on the last stage of his journey he was killed in a trivial accident of the kind which has cost us so many of our best pilots. On leaving the aerodrome his engine stopped. He tried to turn in order to get back into the aerodrome, but he sideslipped into the ground.

In the official investigation of one of the fatal accidents in the Third Aviation Instruction Center a witness under examination stated that he was standing behind the commanding officer of the field as the machine in question took to the air with a missing motor, which finally stalled at an altitude of about 100 feet. The commanding officer said, "If he turns he is killed." As the words were uttered the pilot attempted to turn, fell into a vrille, and was killed.

Just how this problem is to be met is difficult to decide. Knowledge alone does not suffice. It is, however, deserving of the greatest consideration on the part of the training department. Special training, reproducing the conditions and attempting the turn at high altitude, might be of some avail.

(f) Hedge Hopping.

This is a new form of training necessitated by ground strafing which came into vogue in the later months of the war. It consists in flying at low levels in close proximity to the ground, in hurdling trees, buildings, etc. In the event of motor failure, mishaps of many kinds happen. Air holes or sudden gusts of wind give rise to frequent crashes. In this type of training it is necessary to set aside a special district. There and there only should hedge hopping be tolerated during training.

Col. Bishop, the leading British ace, relates instances in which he found hedge hopping his only recourse in returning over the lines. With the air full of enemy planes and the antiaircraft active, hedge hopping became at times the safest procedure.

(g) Fright in Relation to Flying.

Instructors and pilots not infrequently ascribe accidents to fright. In double control a student pilot occasionally loses his head in the course of some maneuver and "freezes to the control." Under such conditions the instructor may experience difficulties in bringing the machine into control. It is possible that many unexplained accidents are due to this cause. Numerous instances are known of ships falling from an altitude of four and five thousand feet in a vrille from which there has been no attempt at redress, and in the execution of which it was necessary for the control to be held in one position. It is possible that reaction time studies and fright reactions will throw some light on this subject. Trainers should study the mental and emotional reactions of the students.

(h) Rate of Training and Urgency of Needs.

In France the urgent need of men at the front was a fruitful source of accidents in the training schools. Pilots were needed and demanded.

They had to be produced. Training of necessity had to be accelerated. All due care was exercised. Some accidents occurred that under other conditions might have been avoided. A small number of student fliers were sacrificed but large groups of pilots were turned out to meet the crying need at the front. There was sacrifice, but it was legitimate.

(i) Forced Landings.

Forced landings are inevitable and dangerous. They are occasioned by the defects of plane or motor, faults or failures of pilots, lack of petrol, and by unfavorable air conditions. Altitude, the size, character, and proximity of a landing field, and the relation of the machine to the direction of wind are important desiderata. Forced landings from low altitudes are particularly dangerous since no opportunity is afforded for the exercise of judgment relative to the other factors, i. e., choice of field or attention to the wind.

Mishaps to machines in flight are not infrequent. An unusual strain, an oversight on the part of mechanics or instructors may result in a wing dropping off or in a control failing to work at the critical moment. The writer knows of one instance where the motor actually dropped out of a plane during flight. Through magnificent flying, the pilot landed his machine without mishap. In forced landings during fogs, chance reigns supreme. The machine may land in a forest, in a town, in a lake or stream, or in an open field. In the making of good landings and in the recognition of direction of motion, vision is essential. Since vision is effaced in a fog the machine is apt to land at any angle and in any position.

III. AIR CONDITIONS.

The most important air conditions from the flier's point of view are fogs, clouds, winds, and holes. Fogs prohibit flying absolutely. Unfortunately they sometimes arise suddenly and roll in under a machine which has attained great altitude. Landing in a fog, as has been indicated, is a matter of chance and not of skill.

Clouds.

Clouds constitute a danger only when they are low-hanging, under which conditions they do not afford sufficient space for maneuvering in the event of the machine coming through from above, or permit sufficient altitude in flying to furnish an adequate factor of safety. A low ceiling makes for unsafe flying.

Winds.

Winds are occasionally responsible for accidents. This occurs most frequently in machines taking off or landing with the wind or across it. Sudden gusts at low altitudes will always constitute a danger. The speed and strength of a modern aeroplane make it possible for the skilled pilot to fly successfully even in a strong wind provided altitude is attained and the rules governing taking off and landing are observed.

Holes.

With the improvement in the aeroplane and in our increase in knowledge of flying, holes constitute a decreasing menace. Nevertheless, they do exist and are apt to prove dangerous, especially in low flying.

IV. COLLISIONS.

Collisions are still frequent. The blind angles of the machine, the crowded conditions of flying centers, the neglect of regulations governing taking off and landing, momentary inattention or slight faults in maneuvers in formation flying, are the most frequent causes.

A collision may result in several deaths, since almost without fail the ships are so damaged that they fall entirely out of control. One poor flier is a menace to an entire squadron. In formation flying a man is his brother's keeper. Since formation fighting is essential to supremacy in the air, too much attention can not be centered upon this form of training. Erratic fliers should not be accepted. If a good flier becomes erratic, he should be investigated medically.

Blind angles are unavoidable in the present day construction of the aeroplane. Every effort should be made, however, to minimize them to the utmost.

In the selection of aviation fields the space element should be given due consideration, particularly in relation to acrobacy and combat. Care should be exercised that vrilles and other maneuvers in acrobacy be carried out at a sufficient distance from landing areas.

V. PROPELLER ACCIDENTS.

These constitute a larger proportion of accidents than would be assumed by the uninitiated. In starting the motor strict adherence is necessary to the regulations governing the use of the words "coupe and contact," both by the starter and the pilot.

Once the motor is started, no one should be allowed in front of it. By spectators, suicidal intent has been surmised at times in relation to propeller accidents. The possibility of a strong suction force is usually overlooked.

THE CAUSES OF ACCIDENTS AT THE FRONT.

At the front accidents are also numerous, as evidenced by the fact that in the A. E. F. 42 pilots were killed in the zone of advance while only 137 were killed in combat. This proportion seems large since all the fliers at the front were presumably skilled pilots. Forced landings due to weather conditions or to engine trouble (especially in the Spad), or running out of gas accounts for many of them. One pilot returning from the front stated that many of the accidents were due to stunting over the squadron airdrome following victory in combat over the enemy. This, of course, is a dangerous procedure since the machine may have been injured in combat to such an extent that it will no longer withstand the strain of acrobacy. Col. Bishop states that this proved so frequent a cause of accidents with the British airmen at the front that it became necessary to forbid stunting after combat.

In the event of engine trouble, lack of gas, or forced landings from any other cause, the pilot can but do his best. Altitude and landing fields are merely a matter of chance.

ACCIDENTS AND MORALE.

In the cause and prevention of accidents, morale plays a tremendous rôle. This is something which does not exist to the outsider but it is very evident to students and instructors in instruction centers, and to the flier and the administration at the front. It involves the attitude of the man toward his work, physical and mental fitness, and adherence to rules and regulations. Anything which counts for increase in morale counts for efficiency and for decrease in accidents.

Individuality is desired, but discipline is absolutely essential. If the morale is right, discipline and individuality do not necessarily conflict.

Marcel Nadaud in the "Flying Poilu" dramatically illustrates the conflict of individuality and discipline.

In a French flying squadron, Chignole, an observer, in the absence of the rest of the squadron, takes up a plane, cranking it himself and attempts to engage the enemy who were active over the aerodrome. On alighting he was met by the captain in charge who says: "Chignole, my boy, it was mad of you! Crazy! Idiotic! Chic! Wonderful! I am going to ask the military medal for you." He stopped a moment, hesitated and then deciding: "But for an act of serious indiscipline, I am obliged to ask for your transference to the Infantry." He stopped again, then grasping Chignole in his arms, "Pardon me, my boy, oh! pardon me. But understand that I just can't do otherwise!"

INVESTIGATION OF ACCIDENTS.

All fatal aeroplane accidents in the instruction centers in the A. E. F. were investigated by a special board of five, appointed for the purpose. The objects of the investigation were to fix the responsibility, to determine whether or not the accident was an aviation accident and whether it occurred in the line of duty. The board submitted a sextriplicate copy of its proceedings covering all the essential details of the accident.

The board and recorder were sworn in, after which the commanding officer of the field concerned, or one of the instructors, the engineer officer in charge, the mechanic responsible for the engines and machines, two eye witnesses (when possible), and the attending medical officer were questioned. The hospital report and the autopsy findings were appended. In addition, at the Third Aviation Instruction Center, a report on the previous health and habits of the victim was presented by the flight surgeon. This report was a result of either personal acquaintanceship or of careful questioning of the friends of the flier.

The membership of such a board is a matter of vital importance. Only those deeply interested in the care, training, and welfare of the flier should act in such a connection. The board should comprise a thinking medical man, an engineer who is in no way responsible for the condition of the machine concerned, and an officer who is either a flier himself or is familiar with all the rules and regulations governing flying generally and at that instruction center in particular. An attempt should be made to determine the fundamental cause of the accident and whether it was avoidable or not. The information obtained should be utilized immediately where possible, for the prevention of repetition of accidents and where necessary, suggestions should be submitted to the commanding officer concerning the need of rules and regulations. The attention of the proper authorities should be called to all mechanical, medical, or training deficiencies held responsible.

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Need of Investigation of Nonfatal Accidents.

Investigations have been limited entirely to fatal accidents. This is a great mistake. Since the victim is dead, only indirect and circumstantial evidence can be elicited. Every crash is potentially a fatality. If the same mechanism were utilized to officially investigate nonfatal accidents and the same thoroughness exercised, a much deeper grasp of the accident problem would result. This phase of the problem has been generally neglected. Efforts were made in the Third Aviation Instruction Center to carry out such investigations through the flight surgeon. This should be recognized as a distinct advance, but investigations by an official board would probably yield greater results.

Record of Accidents.

A new accident blank was developed in the Third Aviation Instruction Center (a copy of which will be found in the appendix). It necessitates a careful study of each accident, considering as it does information concerning the history of the accident, the condition of the plane and motor, questions relating to training and experience of the pilot, the cause of accident, the responsibility involved, and the physical condition of the flier before and after the accident. It greatly facilitates statistical and other studies of the accident problem.

Avoidable and Unavoidable Accidents.

Naturally it is desirable to divide accidents into avoidable and unavoidable classes. This is extremely difficult. It presumes an assignable cause. In a large proportion of accidents the cause is not apparent and in all but the more obvious cases it is a matter of inference. In this connection it is interesting to consider the October fatalities of the Third Aviation Instruction Center of which there were fifteen. One or more causes could be assigned for ten, while for five absolutely no explanation could be discovered. Supposedly the latter were unavoidable. Of the ten where a cause was inferred or assigned, eight appeared to be avoidable. They included one man with poor vision who collided with an experienced pilot, resulting in two deaths; one man flying while obviously ill; two men flying while recovering from the "flu," for which they did not consult the proper medical authorities; one man taking off too close to a corner of a hangar; two men breaking rules and regulations of combat, fighting without permission and prior to having received instructions; one man falling into the death trap of the fatal turn with a dead engine in an attempt to return to the aerodrome, and one man carefully avoiding hangars and wires at the proximal end of the small flying field and crashing at the distal end.

With the exception of the last two these accidents appear avoidable. They involve, however, the most widely distributed responsibility. *Until responsibility is brought home to those concerned no relief is in sight.* The solution of the accident problem is to be found, I believe, in fixing the responsibility and in holding the responsible individual accountable. This, so far as the writer knows, has never been done in the Air Service. The accident occurs, the accident is investigated, a report is made, a regret is expressed, but the responsibility is not fixed and only too frequently the source of danger continues to exist.

THE RESPONSIBILITY OF ACCIDENTS.

When one considers that only 2,034 fliers and observers were turned over to the zone of advance and to allied squadrons and that prior to the armistice 506 were killed in accidents, while only 169 were killed in actual combat, certain questions may be legitimately asked. Why is the proportion killed in accidents so large? Whose is the responsibility? Inasmuch as responsibility has not been fixed in the majority of instances, it is impossible at the present time to present statistics covering it. Nevertheless, general principles covering responsibilities can be laid down and brought to the attention of those concerned in order that all may concentrate in an effort to decrease the number of accidents.

Aircraft Production.

This department is responsible for seeing that only such ships as are mechanically fit are delivered to the service and that all parts are constructed and assembled strictly in accordance with specifications.

Engineering Department.

This department is responsible for mechanical excellence. They should see (1) that the most effective mechanical principles are utilized and that all parts are constructed to yield maximal efficiency with minimal dangers; (2) that the parts are assembled and put together in such a way as to render maximum efficiency; (3) that once the ship is placed on the line, maximum efficiency be maintained; (4) that no ship in need of major repairs be allowed on the line; and (5) that frequent inspections by competent expert mechanics be made routinely in order to discover and correct mechanical defects.

The Medical Service.

The Medical Service is responsible for physical fitness. It should see—

(1) That only those fit to fly be admitted to the service.

(2) That, through investigations (clinical and laboratory), standards be determined covering every function which relates to flying.

(3) That maximum efficiency be maintained, through supervision and regulation of the life of the flier, in regard to such matters as exercise, sleep, diet, habits, etc.

(4) That an effective mechanism to meet these needs be supplied through flight surgeons, laboratories, etc., and through the establishment of the proper relations between the flying personnel and the Medical Department.

(5) That fliers not making satisfactory progress in training be investigated medically.

(6) That fliers not making proper progress in training, who exhibit physical or mental unfitness from any point of view, be properly cared for. This includes proper medication, sound advice, periods of rest, hospitalization, etc., and involves the provision of properly equipped and properly manned institutions for this purpose.

(7) That the medical and training departments cooperate in an effort to overcome disability of any kind.

(8) That all permanently unfit be removed from flying status. These may represent mistakes in admission or may result from conditions arising subsequent to admission.

(9) That all medical information concerning the flier be available for the medical officer into whose hands the flier comes in the event of emergency or illness. This involves an adequate system of records.

(10) That the Medical Service be granted authority sufficient to render action possible for the prevention of accidents. The Medical Department should have authority to say that a man may or may not fly and in the latter event to dispose of him as it sees fit.

(11) That no flier be returned to flying status unless physically fit.

(12) That the Medical Service be allowed to participate in the investigation of accidents from the medical point of view in order to determine the responsibility involved.

(13) That men be grouped, so far as possible, relative to their aptitude or fitness for various types of work. This involves classification from the standpoint of withstanding altitude effects and from the standpoint of physical and temperamental fitness of the individual flier for various types of work.

(14) That all information concerning the progress and maintenance of efficiency of the flier be supplied to the flier and to the administration. This involves such questions as supply of oxygen, goggles, protection from cold, wind, etc.

Training Department.

The Training Department is responsible for training and for flight. It should see—

(1) That only those fit to instruct be placed in charge of training.

(2) That the best judgment be exercised in relation to when and where flying be indulged in.

(3) That the student be thoroughly familiar with all the information, rules, and regulations fundamental to flying.

(4) That the student be held in double control until the instructor is thoroughly satisfied that he is capable of flying alone.

(5) That discipline and morale be maintained and that rules and regulations be explicitly followed.

(6) That the student be thoroughly informed concerning management of types of ships new to him prior to indulging in flight.

(7) That the student be familiar with the rules and regulations of the individual field.

(8) That all cases of unsatisfactory progress be reported to the Medical Service.

(9) That all cases of illness, even though apparently trivial, be reported to the Medical Service and that cooperation be had with the Medical Service in an effort to overcome disability from any cause.

(10) That all students be warned of the sources of danger in flying and that they be prepared as far as possible to meet all the emergencies in flying. A special course of instruction in relation to accidents is desirable.

The Flying Personnel.

For the flier the danger is personal. His life is in his own hands. He pays the penalty irrespective of where the responsibility lies. It is essential—

(1) That he be satisfied to stay out of the service when he is adjudged unfit by the medical or training department.

(2) That he keep himself at his maximum efficiency and follow the advice of the medical and training departments in this connection.

(3) That he be cognizant of and conversant with all rules and regulations, general and specific, to training centers governing flight.

(4) That he follow all rules and regulations implicitly.

(5) That he understand the mechanics and science of flight and that he possess as perfect knowledge as possible of planes and motors.

(6) That he be absolutely honest and frank in his relations with his monitors and instructors.

(7) That he acquire as much information as possible concerning the maneuverability, response to control, and the strength and quickness of each type of machine and of each particular machine prior to his first flight in that machine.

(8) That he report all disabilities and indispositions to his instructor or flight surgeon immediately upon the development of same.

(9) That he inspect and test his machine personally and that he look over and try out his motor prior to flight in order to ascertain its efficiency.

Administration.

It is the function of the administration to correlate the work of the various departments, to supervise it and see that it is effectively carried out and to fix responsibility in the event of failures. The administration is also responsible to a very large extent for the morale of the service. It is desirable, also, that the administration assume charge of the dissemination to the service of all information relative to the accident problem and the responsibility concerned.

Conclusion.

The accident problem is the greatest problem of the air service. Until responsibility is fixed and accountability established, great progress can not be made. Thorough investigation of all flying accidents (nonfatal as well as fatal) and the establishment of responsibility and accountability are essential for the prevention of accidents.

Chapter VIII.

WORK OF THE UNIT ATTACHED TO THE BRITISH AIR SERVICE.

The 10 American medical men who composed this group were assigned to work with the British. After a preliminary meeting in London, the members were sent to the various examining groups and training centers. They were afforded every opportunity for observation and investigation. Our British colleagues have commended these officers most highly for their fine work, their great assistance, and their personal qualifications. It is much to be regretted that the admirable reports sent in by some of the members of this group upon the conclusion of their service in England can not be given in full.

Subsequent to the armistice this group took up work in France with the laboratories at the Second and Third Aviation Instruction Centers. Their knowledge of the British tests enhanced in no small measure the work on the monitors, on men returning from the front, and French fliers sent in for special study.

MAJ. E. S. INGERSOLL, MEDICAL CORPS.

Maj. E. S. Ingersoll, Medical Corps, was assigned to the examination of aviators at Hampstead. The following extracts are taken from the report of his observations upon the work of the Medical Service of the Royal Air Force:

Candidates for admission to training as pilots in the Royal Air Force receive their preliminary physical examinations at various stations throughout the United Kingdom. There are six such stations in England and Scotland, with others in South Africa and in the other colonies, with the exception of Canada. In Canada the candidates receive the complete examinations.

At these stations the candidates are given a preliminary examination, which is very similar to that required for ground commissions in the United States Army. The obviously defective are rejected and the others sent to London for the final physical tests.

The final examination is conducted at the Aviation Candidates' Medical Board, 9, Arkwright Road, Hampstead, London, N. W. The building used was formerly a large private home. Aside from the space used for the clerical work, there are 12 rooms devoted to the examination, divided as follows:

Medicine, 3; surgery, 1; eye, 1; otology, 4; assessors, 3. Groups of applicants are started simultaneously in the different departments. The examination blanks are looked after by orderlies during the course of the examination, and are never in the hands of the men who are being examined.

The otological work is divided into two distinct parts; the inspection of the ear, nose, throat, and teeth, with the testing of hearing by the whisper; and secondly, the testing of muscular coordination and tremor.

The inspection is done in practically the same way as in our service. Defective hearing and perforated drums are causes for rejection. Chronically infected tonsils are removed, and nasal septa, deflected in a sufficient degree to interfere with function, are corrected by operation.

In general, the teeth of the British applicants are in bad condition. Many young men of 19 and 20 have complete sets of false teeth, and it is a notable exception to find a young man who is not in immediate need of dental attention. The present dental practice in England seems to be to extract rather than to repair; and for the British to accept our standard requirement of four opposing molars would mean the exclusion of a large number of candidates.

The testing of muscular coordination and nervous control is done by the otologist as well as by the medical examiner.

The first test in this connection is to have the candidate stand with eyes closed, tongue protruded, and arms extended with hands dropped and fingers separated. Note is made of fine or coarse tremor of eyelids, tongue, or fingers.

The apparatus for the second test consists of a thin board about 14 inches long by 5 broad, and a metal spindle 5 inches long by one-fourth inch diameter, with a round metal base 1 inch in diameter. The spindle is set upright on the board 3 inches from the distal end. The candidate is instructed to grasp the proximal end of the board, protruding over the edge of a table of ordinary height, and to raise the board and spindle to the level of the shoulder with the eyes open. He is then told to close his eyes and replace the board on the table without upsetting the spindle. The spindle is very unstable, and good control is required to accomplish the test successfully.

The third muscle coordination test consists of standing (with the eyes closed) on one foot, with the other leg flexed at the knee and not touching the supporting leg. This position is maintained for 15 seconds and repeated with the other leg. Note is made of unsteadiness. Figures compiled by the British seem to show that a large proportion of men who are unsteady in this test are not successful in training. It was interesting to note in this connection that the candidates from South Africa, who were examined within three days after the completion of their sea voyage, showed uniformly poor results.

The examination blanks refer to this latter test as the vestibular test. There is no attempt to stimulate the labyrinth in any of the tests during the examination, and the term used is plainly a misnomer, except in the sense that the static function of the labyrinth is called into play.

After the applicant has been examined in all of the departments he is brought to the assessor, who repeats such tests as he may wish, and renders the final decision.

The system of routine and paper work of the Aviation Candidates' Medical Board was excellent and a tremendous amount of work was accomplished. As many as 350 men have been examined in a day.

During our stay there and for several months previously the problem confronted by the British in regard to procuring material for pilots was a very severe one, and the one that necessitated a physical standard much below that which the authorities fully realized should have been used. It was a case of selecting the best of a poor collection.

There were apparently two reasons for the scanty supply of acceptable young men. The country in the last months of the war had comparatively few men of early military age left; and, secondly, the Air Service did not appeal at this period to the better class of young Englishmen, while the public-school boy, on becoming 18 years of age, sought some other branch of the service. I have heard this latter condition commented upon several times, but no adequate reason could ever be found to account for it.

These conditions, in my opinion, render it somewhat unfair to make a strict comparison between the British standards and our own. They had to take such chances with their men, in the best interests of the service, that with us at the present time would constitute a flagrant disregard of consequences.

The question of a functionally perfect vestibular apparatus as a necessary requisite for a pilot has not received much consideration from the British. They have not been able to see that it is of fundamental importance, and have not devoted much time to its investigation.

There were several opportunities for discussing our ideas and methods with members of the British Research Committee, notably Drs. Henry Head, Sydney Scott, and Lieut. Col. Martin Flack, R. A. F., M. S. They have become interested in motion perception as appreciated by the vestibular apparatus, and they propose to carry out more extensive investigations.

There is one development in aviation medicine established by the Royal Air Force which it seems well to consider. At the Hendon Aerodrome, just outside of London, the medical administrator has established what is known as "the medical flight." This is a training field to which are sent all men under training as pilots who have been declared unfit by their instructors at the regular schools.

No cadet in training may be discharged because of temperamental unfitness without passing through the office of Lieut. Col. Flack in the Air Ministry in London. In the case where no disqualifying physical defect is found the cadet is posted to the medical flight for further flying instruction. The field is commanded by a major who has seen considerable service at the front and who, in addition to being a remarkable flier, is a man of keen judgment and sympathetic understanding. The medical officer is greatly interested in aviation medicine and is at present working on several problems relating particularly to motion perception and reaction time. The instructors are chosen largely for their qualities of patience and understanding of human nature. The figures compiled at this field show that they save to the service approximately 50 per cent of the cadets who would otherwise have been lost to the air force. This effects a large saving in both men and money, and also gives an indication of some faults in the present system of teaching.

Certain conclusions may be drawn from the work seen in England:

1. The physical examination and the requirements of the United States Air Service are much superior to those of the Royal Air Force, more because of our fortunate position in having a wealth of material than because the British consider their standards adequate for pilots.

2. The British have no adequate evidence of, or grounds for, their belief that a perfectly functioning vestibular apparatus is not necessary for a perfect pilot.

3. The medical flight established by the medical administrator of the Royal Air Force, and maintained directly under his control, is an excellent economic institution and a plan worthy of consideration.

CAPT. PAUL A. GARBER, MEDICAL CORPS.

During the three months (approximately) that Capt. Paul A. Garber, Medical Corps, worked with the British he collaborated with two different boards, the Invaliding Board and the Aviation Candidates' Medical Board, both located at Hampstead.

The Invaliding Board was composed of medical officers who had worked with the aviators either on the aerodromes in England or abroad, so the members knew from that experience the qualifications of the aviator. The aviators and cadets who appeared before the board had been in a hospital from disease, accident, or wound, or were sent direct from the front or aerodrome by the medical officer. Most of the men sent direct from the front were cases of "staleness," while those from the aerodromes at home were men who had been crashing frequently or else had "wind up."

The flier appearing before the board has his history taken and he then is given a brief physical examination. The superficial and deep reflexes are tested and tremors are elicited. Only one member of the board sees the case unless there is some doubt as to the condition. The board had the power to grant a leave of absence up to four weeks and also to take him off flying permanently.

The last two months I was with the R. A. F. were spent with this board. The men appearing before this board had previously been examined at the reception depot, and only the survivors of the depots were examined at the board. From 600 to 800 men were examined at the board every week, and from 60 per cent to 75 per cent of the candidates were passed for training. I examined only those candidates who had failed to hold their breath at least 50 seconds for the medical examiners. Of the total number I examined I kept records of 465. The records, with a report, were turned over to Maj. Bowdler, the president of the board. The breath-holding test, in my opinion, is more of a test of nerve than a physiological test. The expiratory force test requires practice. The fatigue test is the only one of the three that is of possible value. This test will show a cardio-vascular disturbance by the pulse rate, but the exercise test will be of as much value in that respect as this test.

MAJ. K. W. CONSTANTINE, MEDICAL CORPS.

With Maj. Ingersoll and Capt. Garber, Maj. K. W. Constantine, Medical Corps, was stationed at Hampstead, where he made ophthalmological examinations. The following paragraphs are taken from his report of his work there:

During the last four months of the war 600 to 800 candidates for the R. A. F. applied to the medical examining board for admission to the service.

The candidate was disqualified if the vision was below 6/18 in one eye and 6/24 in the other; if vision was better than 6/12 with a spherical +3.O. D. lens before the eyes; and if color blind. If the vision was 6/9 and 6/12 the candidate was accepted as far as his eyes were concerned, provided the color vision was normal according to the test with Eldridge-Green lantern.

The following cases were referred to the ophthalmic room: (1) All candidates with vision below 6/9 in one eye and 6/12 in the other. (2) All subjects with doubtful color vision. (3) Border-line cases from other departments. The remainder of the ophthalmologist's time was spent in making complete eye examinations of as many pilots and observers as possible. The tests comprised vision, refraction (without a cycloplegic), muscle balance (distant and near), the duction strength, stereoscopic vision (distant and near), and the determination of the master eye. Further duction tests were made only in the cases that showed more than 2° of exophoria, 4° of esophoria, or 1° of hyperphoria at 6 m. Brailey's muscle test was used. The tests were carefully recorded, with the intention of seeing later what effect eye anomalies might have upon flying capacity.

Men who made bad landings were sent to Maj. Clements at Greenwich. There they were trained with the amblyoscope and stereoscope, checking the progress of the case with Biship Harman's diaphragm apparatus.

CAPT. JOHN B. POWERS, MEDICAL CORPS.

Capt. John B. Powers, Medical Corps, was also stationed at Hampstead where he assisted in the examination of candidates for the

R. A. F. In his experience the candidates varied in age from 17 to 30 years. Nearly all of the candidates over 30 years of age were rejected on account of physical disabilities, however, rather than by reason of age. The candidates were drawn from the following classes of young men (mentioned in their order of efficiency): "Tommies," officers from other branches of the service, observers who desired to become pilots, and young boys who were just being called into service. Candidates from the colonies were examined also. Capt. Powers concluded that: "Good vision, keenness to fly, and grit" were three great essentials in the making of a good pilot.

After the armistice, Capt. Powers did most efficient work in the Department of Medicine both at the Main Research Laboratory at Issoudun and at the branch laboratory at Tours. In Chapter II, there is an extract from his talk to flight surgeons.

MAJ. A. F. BEVERLY, MEDICAL CORPS.

The following extracts are from the report made to the Medical Administrator, Royal Air Force, by Maj. A. F. Beverly, Medical Corps, upon the close of his work with the British:

GENERAL DESCRIPTION OF AIRSHIPS AND THEIR WORK.

In considering the subject of the physical requirements necessary for an Airship Officer, it was thought desirable that a few service flights should be undertaken in order that the conditions to which such airmen are subjected while in the air could be more easily appreciated.

During these flights, it was possible, to a certain extent, to form an opinion of the mental and physical fatigue associated with the piloting of an airship, whether of the small type (S. S. Zero) with its open car and single control, or of the larger types (N. S. and rigids) whose crews are more sheltered from the weather by reason of their being inclosed, and whose control is shared by the coxswain and the captain.

The types of airships generally in use at present can be simply classified, however, according to the work which they perform.

(1) Those which stay out for comparatively short periods.

(2) Those which may be called upon to remain out for 24 hours up to 3 days.

In the first class may be placed the S. S. Zero, the Coastal, and the C′ or improved Coastal.

In the second class may be placed the N. S. (or North Sea) type and the rigid type. In both of these larger ships, there are fair facilities for cooking food, taking rest, and having a certain amount of very restricted exercises. There are open closets fitted as in the Coastals.

On account of the cars being constructed of metal (aluminum) in the rigid type, there is considerable noise from the engines when in the air. This necessitates the engineers wearing sound mufflers in their ears. Some officers find this noise very tiresome.

All these types of airships are at present used for antisubmarine patrols and convoying of ships at sea. They may be likened to destroyers, with certain limitations, particularly as to the weather in which they can operate, and with certain advantages, such as increased field of observation. The larger varieties are able to operate at a greater distance from their bases than are the smaller types, but their work does not as a rule necessitate their going to greater heights than 1,500 to 3,000 feet, though they are capable of going higher. In the case of the rigid, we understand that the time is not far distant when the "ceiling" of such craft will be in the vicinity of 20,000 feet.

It will be of interest to compare the sensations of flying in an airship with those that are experienced in an aeroplane. The rush through the air, the headlong upward swing, the quivering and shaking, the sudden little upward and downward starts—all these are toned down in the airship. The noise from the engine is very much less, the vibration can hardly be felt even in the smaller types of ships, and the rush of air, which is so terrific in the speedier heavier-than-air machine, is practically absent in her lighter-than-air sister. On leaving the ground, there is no apprehension; engine failure, necessitating a hasty forced landing, ceases to cause anxiety; the ship floats into the air and when well clear of the ground, the engines are speeded up and she climbs to a few hundred feet.

The four principal causes of anxiety in the air appeared (from conversations we had with numerous airship pilots) to be:

(1) Engine failure when over the sea.
(2) Rising wind.
(3) Fog.
(4) Fire.

Lastly, sheer boredom from the dull monotony of patrolling over the sea, enters largely into the question of strain. We consider this to be more pronounced in the smaller ships, such as Zeros and Coastals. For hours, the captain of such a ship will have nothing to do but listen to his engine and steer a compass course; for hours he may see nothing save the grey sea beneath him and the seagulls hovering immediately below his ship. If it begins to blow fairly hard, he will have to struggle with the wind for hours and hours trying to get home, making possibly five knots, at other times being actually blown backwards. Such a position means that the pilot is subjected to a considerable mental as well as a physical strain, for he knows that all depends upon the holding out of his engine or engines and upon the wind velocity decreasing. From conversations with experienced airmen who have flown both in lighter-than-air and heavier-than-air craft, there does not appear, however, to be the same nervous tension constantly present when patrolling or convoying in the former as compared with service flying in the latter.

The actual physical exertion entailed in flying an airship, particularly if it be of the Zero or single control type, is considerable. Especially is this so if the wind be strong. In such a small ship, the pilot may be constantly ruddering with his feet, exerting at times nearly all of the force of which he is capable. At the same time, he has to control the upward and downward movements of the ship with his left hand on the elevating wheel, and lastly, must not forget his many instruments registering his pressure, all of which require to be frequently controlled by opening and shutting valves.

In Coastals and C′ type airships, the control is shared by the coxswain and the officer navigating the ship, thus relieving the physical exertion to some extent even though the controls are heavier.

In larger ships (N. S. and rigids) the physical exertion does not appear to be quite so great, the steering and elevating being operated separately by two people, a coxswain and the captain or some officer of the ship. In addition to this, the cabins of these ships provide a considerable degree of protection and comfort to the crew. Even in the smaller ships it is possible for the pilot to be relieved for a short spell by his engineer, and thus to stretch his cramped limbs.

In the larger ships, the question of changing position does not enter as there are relief crews and at least two officers. At the same time, it is comparatively seldom that the captain of the ship has the peace of mind to take advantage of his relief to sleep when in the air.

The hours of flying vary considerably according to the time of the year. Were it not that the periods of intensive flying were punctuated by periods of involuntary rest, due to nonflying weather, we should be inclined to recommend that the hours of flying be controlled, for undoubtedly during good flying weather both pilots and crews have long hours and little rest. This is particularly applicable to the Zero type, where the captain has to fly the ship himself practically all the time. During good weather in the summer such a ship may do as much as 60 hours a week in spells of from 6 to 10 hours. At other times weeks may elapse without any flying taking place. Therefore, it will be seen that the question of preservation of efficiency is not so much one of the limitations of the hours of flying as (*a*) that of affording facilities for absolute rest during spells of hard work and (*b*) that of the proper occupation of the relatively long hours of leisure during spells of bad weather.

The larger ships, like the smaller, are controlled at present by the elements, but owing to their ability to stay out longer may do as much as 100 hours a week in perfect summer weather.

From a medical aspect it seems most desirable that there should be proper occupation of leisure time by both officers and "ratings." The habits of pilots become increasingly of medical interest the more it is recognized that for a man to be truly fit he must be occupied in some wholesome mental or bodily exercise during the greater part of the day.

There seems to be a tendency, in consequence of lack of occupation, for the pilots and crews of airships in wintertime to become stale. All depends upon the man himself. If he has intellectual resources, he is able to make good use of his spare time studying and intellectually improving himself, as well as taking part, when possible, in all outdoor recreations. On the other hand, a man who is intellectually superficial and who has few resources within himself finds time hang heavily, and if opportunity is afforded he very easily makes it a habit to drink and smoke too much.

At some of the stations we visited there are opportunities for shooting and fishing, should an officer be interested in such sports. At the same time games of football and cricket are got up two or three times a week, and, according to the time of year and the locality, golf, tennis, and other outdoor sports may be indulged in. There are cinema shows and concerts about twice a week or oftener, in the evening, according to the individual efforts of the officers on the station. There does not appear to be lack of opportunity so much as lack of energy in many of the officers at the stations in regard to exercise. For this reason we are led to recommend some form of compulsory daily exercise.

The question of bad landings in regard to heavier-than-air machines does not apply to airships.

CONCLUSIONS.

The age of the pilot varies from 18 to 37. There does not appear to be any drawback attending either age limit, though it would seem that for the monotony of patrolling the older man is more suitable temperamentally than the younger. Provided a man is physically healthy, there would appear to be no objection to recommending that candidates be taken from 18 up to 38 years of age.

The height measurement ranges between 6 feet 2 inches and 5 feet 4¾ inches. It is recommended that no officer under 5 feet 4¾ inches be taken into the service for employment as a flying officer in Zeros, as it is thought that a man of smaller stature would find difficulty with the controls. Should it be possible, however, for an officer to be employed directly in Coastals, C′, rigids, or North Sea type, there would seem to be no objection to the usual standard of 5 feet 2 inches being adhered to. The adoption of a lower standard than this does not appear to be advisable.

The question of the past flying history in relation to altitude is not of so much importance for the present, owing to the fact that when at work an airship rarely ascends to over 1,500 feet, most of the patrols being done at 600 to 1,000 feet.

The standard of vision is good, though not perfect without glasses, in several cases examined. While it is admitted that an officer with slight visual defects may be able to carry out the actual flying of a ship, the efficiency of his work when patrolling depends largely upon his own visual acuity. It would seem, therefore, that the standard already adopted for aeroplane pilots, should be insisted upon in the case of airship officers.

The question of hypermetropia of more than 3 diopters, which might affect accommodation when landing, does not concern airship officers, and it is recommended that it should not be a bar to their acceptance.

The movement and power in all limbs should be good.

The history of seasickness or trainsickness should not be a bar to the acceptance of candidates, nor should asthma be considered a serious drawback unless the attacks are frequent or have caused physical defects.

Neither malaria nor dysentery appeared to be aggravated by flying, and it would seem that histories of either of these ailments should not in themselves debar a candidate.

On account of the low altitudes at which airships work, the former history of concussion, even if severe, would not appear to be of the same significance as in candidates for heavier-than-air machines.

Digestive trouble would seem, on the other hand, to be a drawback to a candidate, as the irregularity of meals, and the form of food consumed when actually flying are liable to increase gastric troubles.

Sunstroke or heatstroke should not be a bar to acceptance for work in a temperate climate.

Brain fever should not in itself be a cause for rejecting a candidate, though the general nervous stability of such a man should be carefully estimated.

Previous chest trouble or gassing, provided that the general health is good, would appear for the present, in view of the low altitudes at which flying is done, to be no drawback.

Provided the candidate has recovered, a history of shell shock should not be a bar

At present, on account of the low altitudes at which airships fly, the cardio-vascular condition of the airship officer does not appear to be of as much importance as in the heavier-than-air ship pilot. It would seem that, provided the heart is organically sound and there is no history of syncopal attacks, the candidate should be allowed to train for this branch.

The respiratory tests as devised by Lieut. Col. Flack, while most useful in studying the general condition of the airship officer, would appear to be less useful at present in the examination of candidates for this section of the R. A. F. It is therefore recommended that too much stress be not laid on these tests at the entry examination for airship candidates, but that they be used at airship stations as an adjunct in the periodical examination of the officers.

The relation of a flabby abdominal wall to splanchnic flooding does not appear at present to be of such moment to the airship officer as it is to the heavier-than-air ship pilot, in view of the low altitudes at which the ships work. It would therefore seem that a more lenient view might be taken in regard to this.

Little definite knowledge as to the fitness of the officers examined was obtained from an examination of the reflexes, presence or absence of tremors and balance. It may be said that in the officers who had done most flying, the reflexes were brisk or exaggerated, but exceptions to this rule were also obtained. Tremors of marked degree were noticeable by their absence. The sense of balance was on the whole poor, and did not appear to have much bearing upon the ability of the officer to do good work in airships.

Although one or two of those examined who had slight auditory defect appeared to be carrying out their duties well, it is recommended that a high standard of hearing be demanded in view of the fact that orders must be quickly heard and obeyed. Tympanic weaknesses on the other hand might be regarded more leniently in view of the fact that the alterations in atmospheric pressures are much more gradual than in the heavier-than-air machine and never so extreme.

No true mouth breathers were found. In view of the altitudes at which the majority of the work is performed, this would not appear to be of importance, provided it has not undermined the general physique.

The officers, as a whole, performed poorly in the tuning-fork balancing test. No relation could be found between their muscle sense and their ability to fly airships.

There did not appear to be any relation between the previous civilian occupation of the officer under consideration and his ultimate success in flying airships. While it may be said that those accustomed to hard work and fond of outdoor life probably make the best officers, no general rule can be laid down in this respect.

Lastly, the question of transfer of aeroplane pilots or observers to airships and vice versa must be considered. This appears to be largely a matter of individual temperament; at the same time it would seem from conversations with several officers who have worked with both branches that to the average man the strain of flying on active service in heavier-than-air machines is infinitely more than patrolling in an airship; also it must not be forgotten that in the former the altitudes at which work is performed are much greater. On the other hand an officer may be "timid" in airships and yet do well when transferred to heavier-than-air machines.

It is difficult to dogmatize; but as a working rule it would seem that provided a man is medically sound, in the ordinary sense of the word, but with some drawbacks (age, breath-holding, balancing, exaggerated reflexes, etc.) to his becoming an aeroplane officer, he should be allowed to try airships, provided he appears to be temperamentally and nervously suitable. In regard to observers, etc., turned down for pilots in aeroplanes by the A. C. M. B., there appears to be no reason why these officers suitably chosen according to the lines of this report should not do well in airships. Above all things, however, the candidate must want to fly airships, for without "keenness" he will attain little.

MAJ. ROBERT S. McCOMBS, MEDICAL CORPS.

Maj. Robert S. McCombs, Medical Corps, was detached to work with the British at the Felixstowe seaplane station. The British tests are fully described in the chapter upon physiology. In regard to these tests Maj. McCombs has made the following report:

The chief object of these tests is to furnish the medical officer with a practical, clinical means of determining, in a short time, the fitness of any man for flying. It was impracticable, in the British service, to apply the more elaborate tests used by the American Army, owing to the impossibility of obtaining the necessary equipment and to the large numbers of candidates passing through the Arkwright Road Board, which was the only assessing unit for the Royal Air Force. Time was such an essential factor that short clinical tests were imperatively demanded.

The chief value of Flack's tests lies in their adaptability to "field service," where the medical officer, acting as a flight surgeon, is daily called upon to pass on the fitness of many fliers for duty. It is impossible, under such conditions, to refer men back to the base laboratories for reexamination unless they are obviously unfit. A ready and reliable test is of more practical value than the finest equipped laboratory if that laboratory is not available.

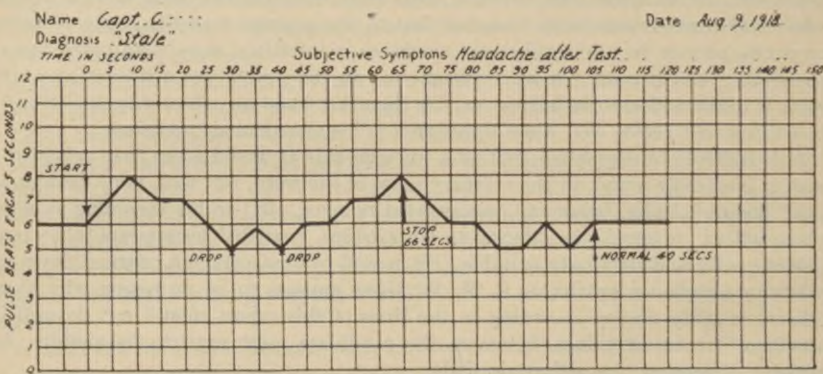
A graphic chart devised by the author is given below. It is divided into five second intervals and the number of pulse beats in five seconds is indicated on the left-hand margin.

Of equal importance to the above is the charting of the subject's sensations in response to effort. It is necessary to discover why he was forced to give up, or what sensations developed during the test. Ask immediately, "Why did you stop?' Flack claims that exhaustion in the early stages is shown by breathlessness, suffocation, tightness across the chest, palpitation, giddiness, pain, suffusion of the face. It is possible that many of these sensations may be provoked by a healthy heart when it is forced to work after its store of reserve force is exhausted; it is the too ready production of them which indicates an abnormal limitation of endurance.

In the cases where the most severe exhaustion exists without any physical sign being present, the subjective symptoms and the action of the pulse elicited by the test afford an index to the danger and prove a valuable danger signal.

SUMMARY OF TESTS.

The author's interpretation of his findings by the "sustaining-the-mercury test" are based upon the daily supervision of 82 war pilots over a period of three months of most active duty during the closing days of the war at a seaplane station in the



Royal Air Force. These men had to fly boats weighing 5 tons each, fully manned and equipped, on patrols of from three to eight hours each.

After carefully charting all examinations made, it was possible to divide the pulse reactions into three classes. These have been designated A, B, C, on the composite chart shown below, each curve representing the composite reactions of 10 pilots. Class A, 10 of the best pilots physically. Class B, 10 of the average. Class C, 10 of the men who were relieved from flying as physically stale or unfit. All the others could be placed in one of these three classes.

COMPOSITE CHART.

Class A. Ten of the best pilots physically.

Class B. Ten of the average pilots.

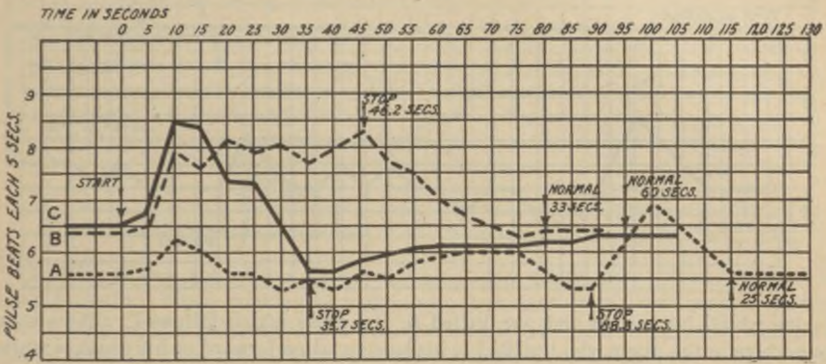
Class C. Ten who were relieved from flying.

It will be noticed that each curve shows an initial rise in the first 10 seconds, then a drop towards normal.

In "Class A," the pulse remained normal, or slightly below, until the breath had been held for 50 seconds, when there was a gradual increase in the frequency up to 75 seconds. From this point, there was a more rapid slowing until they "gave up" at 88.3 seconds, followed by a quick rebound of the pulse, which gradually fell to normal in 25 seconds.

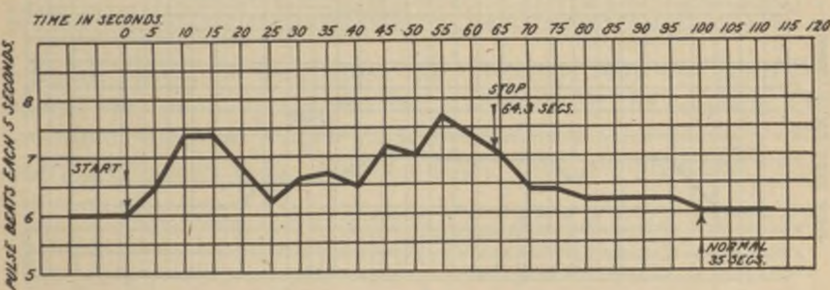
Class B shows the same initial reaction; but then the pulse remained fairly steady at about its maximum until they gave up at 46.2 seconds, followed by a gradual decline to normal in 30 seconds.

Class C shows what the writer calls the "break." There is no secondary stabilizing of the pulse, but a rapid slowing until the subject gives up at its minimum point after only 35.7 seconds—usually complaining of subjective symptoms—and the return to normal is protracted, lasting 60 seconds or more.



Classes A and B were considered normal, but Class C in the writer's experience shows beginning exhaustion.

Heart murmurs.—If a murmur exists which may be considered functional, i. e., heard during systole, only, best over the base of the heart, not transmitted, with no history of possible cardiac infection, without enlargement of the heart, and no alteration in the rhythm or other symptoms of failing reserve force in the heart's action during the test, the murmur may be disregarded. Pilots with such murmurs were permitted in the R. A. F. to perform their full duties, and no grave errors were re-



corded. *Organic murmurs*, likewise, can be assessed possibly by this method; and some valuable men were retained in the service who had organic heart lesions, but who proved by the tests that their reserve force was equal to, and in some cases above, that of the average normal individual.

COMPOSITE CHART OF FIVE CASES OF MITRAL REGURGITATION RETAINED IN FULL DUTY.

Of the pilots in the two wings over which I had supervision, the average length of time of holding the mercury at 40 mm. was 65 seconds (82 pilots). At the Medical Research Laboratory in the A. E. F., in 122 pilots returning from the front it averaged

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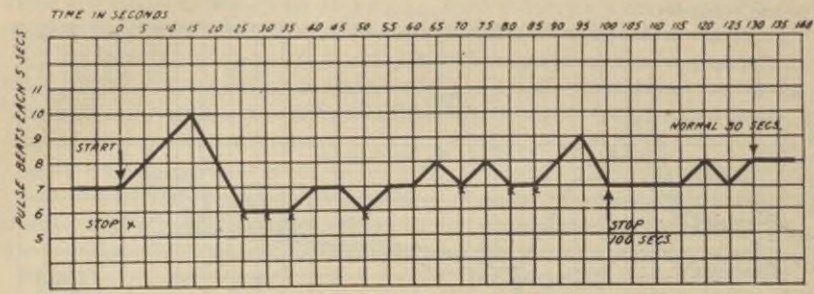
71 seconds, and in 60 Monitors it averaged 60 seconds. The Arkwright Road Board considered 60 seconds good, 40 seconds fair, and 30 seconds disqualifying. In the young and immature boys of 18, it is not so long. Therefore, taking 40 seconds as the minimum, and 65 seconds as the maximum averages for normal individuals, the approximate status of any individual case can be judged—taking into consideration his stamina. All the men I had to remove from flying fell below 40 seconds, except one who held on through sheer grit with his pulse showing a marked arythmia. One man's case in particular was instructive. He could not last over 22 seconds and was accordingly reported as relieved from flying, but through a mistake was sent on patrol

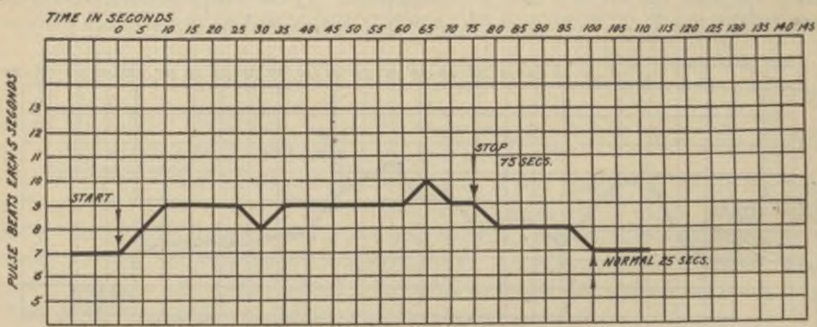


during which he fainted and was killed in the crash which followed. There were four others in the plane who testified to his having fallen forward on his controls while flying straight away, after having lifted his seaplane from the water in a rather difficult take-off.

All the pilots who were doing the routine work were well up in their tests, and all those who were stale were low.

The appended charts are tracings from individual cases:

Case I.—A captain 21 years of age, who had fought over the lines in France for three years as a scout pilot. He had 15 Huns officially to his credit, had won the



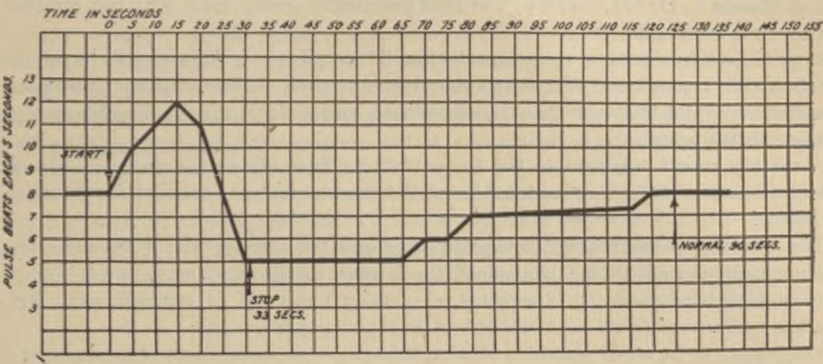
military cross and was a flight commander. He fainted from exhaustion in the air at 8,000 feet and crashed. The test was taken about 5 months after the accident, following which he had never flown. It shows undoubtedly that his previous good form had been due to the fact that his pulse is basically of the "Class A" type, but at present still intermittent while taking the test. It is not intermittent when taken at other times.

Case II.—A lieutenant, a Camel Scout pilot, one of the best men we had, taken after two hours of continuous stunting. It shows the characteristics of Class B.

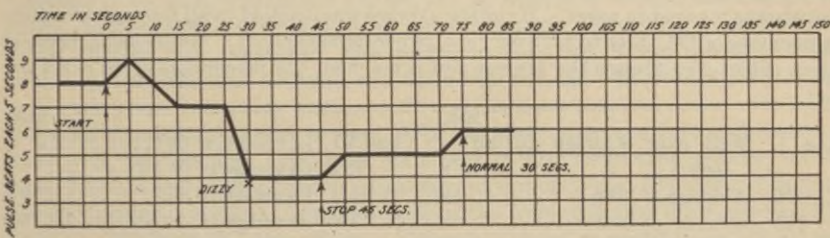
Cases III and IV.—Pilots who were relieved from all flying duties. They show the characteristics of Class C.

During the test one officer developed a headache which lasted for two hours. He was sent to the board at Arkwright Road, from whence he was returned as permanently unfitted for pilot or observer.

On repeated tests, this officer showed similar form. He was held as an observer.



Case V.—Shows the effects of excessive tobacco which the writer found to be characteristic. When smoking 50 cigarettes a day, there was a tendency to gradual acceleration of the pulse until the man gave up at its highest rate, followed by a sharp "break." The second tracing shows the improvement after two weeks abstinence.



In his report to the British Air Ministry, Maj. McCombs considered very carefully the physical standards for the seaplane pilot, because of the great weight (12,000 pounds) of these planes. After drawing attention to the desired stature, visual requirements, cardio-

vascular and temperamental requisites, he closes this report with the following:

It was possible to classify the pilots (according to the results of their tests) into 10 different classes. This was done by a purely arbitrary method. They were given a percentage of 25 for each test in which they reached the station average; if they reached the average but had some physical defect—like heart murmur or imperfect vision—they were given 12½ per cent. Attached is the result of this classification. It is of interest to note that all of the pilots who are doing the daily patrolling are in Classes I, II, III, and IV; and that practically every man, who has crashed, is in a class lower than V.

It would seem from this, that the selection of the pilots by the senior flying officer for their skill corresponds in a remarkable degree to their classification on these tests, the results of which were arrived at independently and without any previous knowledge of their ability as pilots.

A weekly report was sent to the senior flying officer giving the names of the fit pilots, those who needed reexamination and those who had not reached the standard for pilots.

The result of these frequent reexaminations and the elimination of the men who were considered unfit to fly, has raised the average of the station to the following figures: Holding breath, 69.36 seconds; expiratory force, 107.84 mm.; 40 mm. Hg., 60.04 seconds.

This seems to be a fair standard of what should be required upon these tests for a successful sea-plane pilot.

The interest of the men was maintained by designating Class I as "Berlin Bombers" and this stimulation seemed to increase the keenness of their effort.

CLASSIFICATION OF PILOTS AS RESULT OF TESTS.

Average tests taken as a standard. Twenty-five points were given where station average was reached in a test. If station average was reached in all four tests, it gives a percentage of 100, three tests 75 per cent, two tests 50 per cent. Where some physical defect exists even though the average test is reached, the percentage given is 12½ per cent.

	Men.		Men.
Class I. (Well over average in all tests.)	8	Class VI. (Average of 50)	6
II. (Average of 100)	12	VII. (Average of 37.5)	2
III. (Average of 87.5)	8	VIII. (Average of 25)	4
IV. (Average of 75)	20	IX. (Average of 12.5)	1
V. (Average of 62.5)	9	X. (Did not reach average in any test)	5

MAJ. JOHN P. GALLAGHER, MEDICAL CORPS.

Maj. John P. Gallagher, Medical Corps, during his connection with the R. A. F., was stationed at Chaltis Hill Aerodrome, England, which was the school at which scout pilots were trained. The planes used in the training there were Camels, Avros, and Bristol scouts.

In my experience at flying fields (nine months in the U. S. Air Service and three months in the R. A. F.) the number of pilots referred after crashes or bad landings that could be attributed to defective vision or muscular imbalance, were less in percentage in the U. S. Air Service. Most of the bad landings that were due to eye defects in the U. S. Air Service, in my opinion, were attributable to lack of normal convergence or muscle balance—especially the latter; and that most of these conditions were fatigue effects caused by the strain of flying and climatic conditions—especially in the warmer climates. The effect of altitude as a factor in some of the pilots referred, is undoubted, especially in pilots flying over 10,000 feet. This effect in the majority of cases was apparently slight, as most of their flying was between 2,000 to 8,000 feet. Visual acuity or astigmatic defects were not factors in the majority of cases.

The majority of these flyers after a rest of from 4 to 30 days, were markedly improved, and could make fairly good, or good landings.

In peace or war a flyer can fly and drink, but he can not drink and fly.

SUMMARY.

Good eyesight, muscle balance, muscular coordination, reaction time and cardiovascular system, with a hyposensitive ear mechanism, constitute physical requirements which meet closely the needs of the chasse pilot. By a subnormal ear mechanism, a nystagmus of 12 to 20 seconds, and not over 26 seconds, is implied; one to three past pointings; and a slight reaction to vertical stimulation or subnormal falling. Spontaneous past pointing is serious.

Only physicians especially trained in the medical aspects of aviation and the care of the flier, with practical experience in aviation as pilot or observer, should be appointed to care for the flier. Preferably he should be single and between the ages of 25 and 40 years, with physical requirements which at least would qualify for entrance into the Regular Army.

MAJ. CHAS. W. HYDE, MEDICAL CORPS.

From August 28 to November 20, 1918, Maj. Chas. W. Hyde, Medical Corps, was attached to the Medical Department of the Royal Air Force and stationed at the training depot, Shotwick, England.

This station was a permanent one, and offered training to both cadets and officers. It included patrol and combat as well as preliminary aerial gunnery. The personnel consisted of about 170 cadets and officers, and an average of 70 serviceable ships, the entire complement, including enlisted men, being 800. The ships in service were Avros, Camels, and Dolphins. The instructors consisted of two types, successful over-sea pilots, who were returned to England for rest and who were afterwards sent to this station as instructors; graduate officers from home platoons chosen with regard to special fitness for this type of work. For the observation and care of this station, there were two medical men, each with rank of first lieutenant, recently chosen from civil life and without previous military experience; also one hospital sergeant and six hospital orderlies. The hospital facilities were such that some care could be given to eight men and two officers. Seriously injured or gravely sick officers and men were sent to Chester War Hospital, 6 miles from the field. During flying hours, an ambulance and hospital orderly were stationed on the flying field. A special motor bicycle was kept at the station hospital for the use of the medical officer.

My duties were to advise and consult with the medical officers concerning the care of cadets and officers, and to make complete physical examinations of each cadet and officer at least once in two months. During my first six weeks' stay at this post, such examinations could not be made in full on account of inadequate medical equipment. Complete records were kept of the results of 150 examinations and tabulated. This tabulation included the results of the British tests which are described in another place in this history.

The range of expiratory force was from 84 to 185, the latter being made by an American boy whose height was 5 feet and weight 102 pounds. He was an especially good instructor without having had over-seas service. The lowest figure was obtained on several candidates, cadets, and officers alike. There was no apparent cause for this low reading and they were men of average type.

The facilities for study of vision were limited, consisting of Snelling test cards alone. This revealed numerous cases of subnormal vision, and muscle imbalance was occasionally found. There was an occasional candidate with minor degrees of deafness but no suppurative ears were found. Diseased tonsils were comparatively frequent and they were responsible for some sickness. When occasion demanded, separation from the service or leave of absence beyond seven days (not on account of acute illness or accident) the candidate was sent to an invaliding board, accompanied by history of case, result of physical examination, and advisory remarks. As far as I know, the medical officers' opinions were invariably followed by this board. Candidates could also avail themselves of examination by this board through military channels, by request. It is difficult for those who have been at war for a comparatively short time to appreciate the lack of medical men and of medical equipment that is the result of the long and excessive drain upon these resources by long continued warfare.

As far as medical care in selection and continued attention is concerned, it is my opinion that the personnel in the United States Air Service is indeed fortunate. The morale of the English training camp is of the best and the men and officers are without complaint, although "carrying on" under many adverse circumstances.

CAPT. EUGENE CARY, MEDICAL CORPS.

Capt. Eugene Cary, Medical Corps, whose report upon conferences with American observers from the front appears in Chapter II, was stationed, during his service with the British, at Netheravon, Wiltshire, England. This field is a pooling station for bombing and night flying. In addition to Capt. Cary, two other medical men (British) were stationed there. There were about 600 fliers, including Canadians, who had a good many Americans among their number.

CAPT. R. A. TRUMBULL, MEDICAL CORPS.

The following extracts are taken from the report of Capt. R. A. Trumbull, Medical Corps:

The 10 officers sent to England were assigned to the medical administrator of the Royal Air Force, August 22, 1918. We spent one week in London, during which time we had many conferences with the medical administrator and his assistant, Col. Martin Flack. During these conferences, the various examinations used in the Royal Air Force were fully discussed. We also visited the aviation examining board, the invaliding board, and an aerodrome where the men who had been declared unfit had their final test.

On August 28 I was sent to 50 T. D. S., at Eastbourne, Sussex. This was a six-squadron field. There were approximately 215 officers and cadets under training at this station. Camels and Avros were used in training. The aerodrome was situated a short distance from the sea. The wind was against flying, for it blew at a high rate almost daily. It rained nearly every day. The cadets were quartered in tents at the aerodrome. I did not think this particularly conducive to good flying, so took the question of quarters up with the commanding officer, and the same day the men were moved to billets. The officers on the staff and the officers under instruction were quartered in the mess, which was an old boys' school located about 2½ miles from the aerodrome. Here the surroundings were quite good although quite cold, due to the shortage of fuel. The food being rationed was practically the same each day. In this mess was a bar. The discipline at the aerodrome was rather lax. If a man wanted to fly, he flew; if he did not, it was quite easy to get out of it by simply not going to the aerodrome. This was later remedied by a new commanding officer. There was practically no physical training on the station, and each man we spoke to wanted more physical exercise. An examination was given the fliers every two months.

The British have been forced to lower their standards (as compared with ours) on account of the lack of material. This will no doubt account for some of the tests given the fliers. There were some men in the Royal Air Force who were frank in stating that they were in the Air Service only to escape the Infantry or Artillery. Men with this idea in mind are not the type of men who would make the kind of fliers necessary to win the war. It seems to me that the standards used in the American Air Service for the selection, classification, and care of the flier are superior to those that are employed in the Royal Air Force.

The medical officers who were assigned to the work in England without exception feel that they are greatly indebted to our British Allies for much useful knowledge and experience gained during their period of service. They are most appreciative of the courtesy and assistance that was afforded them everywhere in England, and they are deeply impressed by the fine spirit of the Royal Air Force. They are especially grateful to Dr. Henry Head, Dr. Sydney Scott, Maj. Bowdler and Lieut. Col. Martin Flack, in addition to many other officers. Col. Flack, by his fine scientific attainments and his executive ability, has done much to push the splendid constructive work of the medical administrative committee of the Royal Air Force.

Chapter IX.

FUTURE OF AVIATION MEDICINE.

"History repeats itself with the most monotonous reiteration. The present is the past entered through another gate," wrote Lord Roberts. That this may not prove true in any line of preparedness in the United States is the deep desire of all thinking Americans whose hearts have been in the great war; and it is their fervent hope that the history of aviation in America may not resemble the Corypha, an interesting tree of Granada, that at the end of ten years bears flowers and fruit and then dies.

The science of flying, born in America, passed through a brilliant infancy into a period of arrested development. Golden opportunities in past years had been allowed to slip by unnoticed and America was enormously behind Europe in matters pertaining to flying—even the essential features of an efficient combat plane were unknown to us. The last year before the outbreak of the great war, America's appropriation for aviation was one one-hundred-and-eightieth of the amount voted for that purpose by Germany. From almost nothing—two small flying fields, a handful of instructors, less than 100 students—America was asked to produce within a year 4,500 planes and 5,000 pilots, which was three times the production of France during the first three years of the war. But America's assets were her wonderful natural resources and her incomparable human material. No one could visit the wonderful training centers and aerodromes in France—some of which had been converted from mud holes into flying cities as if by magic—without experiencing a great thrill of pride in our country.

In addition to technical unpreparedness, the medical problems of aviation had remained practically untouched. The early method of training which was based upon the principle of the "survival of the fittest," was neither humane nor efficient. It was certainly not efficient to send a pilot to an altitude of 20,000 feet if he became ill at 15,000 feet; or to do acrobatics when he was hypersensitive to motion; or to fly at night if he were unable to see in the dark. This savors too much of the methods of Procrustes of mythological times, who made his guests fit his bed by pruning the tall and stretching the short.

The war has revealed the possibilities that lie in aviation, and it has accomplished on a broad scale investigation, experimentation, and realization relative to flying, that would otherwise have been impossible. But the great future of aviation largely depends upon the further development of the meager medical knowledge that has been acquired under the spur of war.

The deep need for this continued development is apparent from the following bulletin from the War Department which has recently been made public:

STATISTIC SERIES.

[Prepared by Statistics Branch, General Staff, War Department, Oct. 25, 1919.]

TEXT SUMMARY, AIR SERVICE.

Only 4 per cent of flying fatalities due to failure of machine.

Since January 1, 1918, the Air Service has had 390 fatalities at flying fields in the United States. Of these 14, or 4 per cent, were attributed to failure of engine, or collapse of plane; the cause of 9 per cent of all fatalities is unknown.

	Number of fatalities.	Per cent of total.
Tail spin	118	30
Collision	61	16
Nose dive	47	12
Unknown	36	9
Side slip	21	5
Stall	19	5
Fire	15	4
Failure of machine	14	4
Struck by propeller	13	3
Others	46	12
Total	390	100

That 96 per cent of these fatalities were due to faults or circumstances directly connected with the pilot himself—evidences the fact that there are many medical problems of aviation awaiting solution. To say that the pilot got into a stall, a vrille, a side slip, or a nose dive, does not explain the cause of the accident. It merely tells by what mechanical means the crash occurred. It is very important to investigate still further and to ascertain the circumstances under which the uncorrected maneuver took place, and why it was not possible for the pilot to recover his control. Such problems as these can be solved only by scientific psychological and physiological research. But the first step toward reducing the number of accidents is a full realization of the necessity of a strict adherence to the physical standards that have been adopted, and of the fact that a waiver of any physical disability is always an invitation to death.

The peace aspects of aviation have been very ably summarized by Representative Gard:

When war shall have ceased the result of invention and industry will have been such that the development of the flying machine will be no development of hazard, sport, or slaughter but afford a new and efficient means of transportation in times of peace, bringing increased efficiency and happiness to all people.

In the realms of science, aviation will open up a large field for exploration everywhere from the equator to the poles. It will be valuable also in the study of gravity, meteorology and many phases of physiology. The field for careful, painstaking peace time work seems practically inexhaustible. In fact, the use of the aeroplane may become so universal that the words of the Prophet Ezekiel will be fulfilled: "And when they went, I heard the noise of their wings like the noise of great waters." But it must be remembered that no matter how great the strides of aeronautics, the guiding spirit will still be man—man moving in an entirely new environment for which he was not specially constructed, and to which he must adapt himself by definite physiological changes. In order that man himself may keep pace with the progress of aviation, medical science should apply itself faithfully to the study and development of all matters that can influence the safety and protection of the flier. That nation is wise that learns from the past, and possesses a vision of the future and the will to do.

The signing of the armistice has but stimulated the British, the French, and the Italians (among our Allies) in the many psycho-physiological studies of aviation problems. The low-pressure tank that was so valuable in the work of the Medical Research Laboratory at Issoudun, has been placed in the laboratory at Oxford University, England, where it will be very useful in the British investigation of all questions of diminished oxygen tension. Within the last year, the French and Italians have developed new apparatus for studying the many medical problems of aviation.

At the Allied Medical Conference for Aeronautics held in Rome, February 15, 1919, a society was formed for the study of all medical problems connected with the future of flying. The knowledge thus gained is to be disseminated among the allied nations by means of yearly meetings. Later, at the Peace Conference, certain definite, physical standards were decided upon.

It would be deplorable if the United States, the youngest, most vigorous, and most resourceful of the Allies in the Great War, should fail to take her place among the nations in the scientific study of all the phases of aeronautics. "He that gathereth in the summer is a wise son, but he that sleepeth in harvest is a son that causeth shame" are ancient words, but they are none the less applicable to the present status of aviation in our country. There are no misgivings about the ability and the will of America in the face of an emergency—"whene'er her soul is up and pulse beats high." But with the passing of the great emergency there is grave concern that she may fail to profit by her experience in unpreparedness.

It is to be hoped that a far-seeing Congress will realize the enormous handicap under which the United States will labor in the future unless a sufficient appropriation is made for constructive development of the Air Service, with full recognition of the essential part that medical science must play in this program. Judicious yearly appropriations, efficiently administered, may save heavy expenditure of money, blood, and human sorrow in the future. If a constructive program should be determined upon—"a consummation devoutly to be wished"—it is hoped that with recognition of the indissoluble linking of medical science and the art of flying, there will be an appreciation of the value of the Office of the Chief Surgeon, of the necessity for further development of the Medical Research Laboratory and the establishment of a School of Aviation Medicine for the training of flight surgeons. Connected with this school, there should be an adequate collection of reports, records, maps, photographs, and all data and literature of our own and allied countries, in order that the training of the flight surgeons might be of the most comprehensive character.

Aviation, the dream of the past, is the realization of the present. But the human mind can only dimly surmise the wonders of the future development which will embrace all the national needs, military and economic, over land and sea.

> Men, my brethren, men the workers, ever reaping something new,
> That which they have done but earnest of the things that they shall do.

APPENDIX.

FORMS IN USE BY THE ALLIED ARMIES.

UNITED STATES.

[Forms 1 and 2.]

PHYSICAL EXAMINATION OF APPLICANTS, AIR SERVICE U. S. ARMY, A. E. F.

Place .... Date ....
Name .... Rank and organization .... Age ....
Home address .... Prev. Army service .... M. or S. ....

GENERAL MEDICAL SECTION.

I. Medical history ....
A. Family history: F. .... M. .... B. .... S. .... W. ....
Ch. ....
Tuberculosis, mental or nervous breakdown ....
B. Past illness: Have you ever had measles, mumps, scarlet fever, diphtheria, pneumonia, typhoid, malaria, tuberculosis in any form, chronic cough, chronic bronchitis, catarrh, enlarged glands, tonsil trouble, rheumatism, St. Vitus' dance, gonorrhea, syphilis, heart trouble, anemia, asthma, hay fever, nervousness or nervous breakdown, accidents, especially to head, unconsciousness, fainting, operations or any other serious trouble. (Full details and dates)..............................
....
....
C. Personal history: Education ....
Sports .... Occupation ....
Habits: Sleep.................. Alcohol.................. Tobacco ....
D. Present condition ....
II. General build: Height .... inches. Weight .... lbs. Any change? ....
III. A. Chest measurement: Expiration .... inches. Inspiration .... inches.
B. Lungs ....
IV. Skin .... Endocrine system ....
V. Circulatory system:
(*a*) Pulse rate: Standing .... Recumbent............ After exercise ....
(*b*) Blood pressure: Systolic .... Diastolic ....
(*c*) Condition of arteries ....
(*d*) Heart-Insp. P. M. I. .... Palp. P. M. I. and thrills ....
Perc. L. B. 5th I. S. .... R. B. 4th I. S. ....
(*e*) Veins .... Varicosities .... Varicocele .... Hemorrhoids ....
VI. Digestive system:
A. Teeth .... Devitalized ....
B. Abdomen: Tenderness .... Liver and spleen ....
VII. Hernia ....
VIII. Genito-urinary system ....
IX. Urinalysis: Specific gravity .... Albumen .... Sugar ....
Reaction.............................. Casts, pus and blood ....
X. Blood: Hemoglobin .... Red cell count ....
XI. Why did you choose the Air Service? ....
What is your attitude at present? ....
Attitude of your family? ....
Pupils, size, shape, and reaction ....
Coordinaton .... Knee jerks .... Tremors ....
XII. Personality..............................
Accepted .... Disqualified on No. .... Examiner ....

EAR.

XIII. A. History of ear trouble (tinnitus, discharge, mastoiditis) ....
B. History of dizziness ....
C. Sea sick, car sick or carousel; hypersensitiveness to these ....
XIV. A. External auditory canal ....
B. Membranae tympani .... R. .... L. ....
C. Hearing, watch .... R. .... L. .... Whisper, R. .... L. ....
D. Tuning forks .... E. Nasopharynx..............................
XV. Condition of nares ....
XVI. Condition of tonsils and history of tonsilitis ....
XVII. Adenoids ....
XVIII. Eustachian tubes..............................
XIX. Static tests .... Dynamic test ....
XX. Equilibrium, (vestibular) (*a*) Nystagmus R. .... L. .... (*b*) Vertigo R. .... L. ....
(*c*) Falling R. .... L. .... (*d*) Past pointing ....
Remarks ....
Accepted .... Disqualified on No. .... Examiner ....

EYE.

XXI. Visual acuity O. D. .... O. S. ....
A. Vision with plus 2 DS. OU. .... {O. D. .... / O. S. ....} V.
B. Corrected vision O. D. .... O. S. ....
XXII. History ....
XXIII. Examination (external) ....
A. Inspection .... O. D. .... O. S. ....
B. Fields (confrontation) .... O. D. .... O. S. ....
C. Lids .... O. D. .... O. S. ....
D. Ocular movements .... O D. .... O. S. ....
1-Nystagmus .... O. D. .... O. S. ....
E. Conjunctiva .... O. D. .... O. S. ....
F. Lachrymal apparatus .... O. D. .... O. S. ....
G. Cornea .... O. D. .... O. S. ....
H. Iris: 1. Inspection .... O. D. .... O. S. ....
2. Reaction .... O. D. .... O. S. ....
a. Light: 1. Direct .... O. D. .... O. S. ....
2. Indirect .... O. D. .... O. S. ....
b. Accommodation .... O. D. .... O. S. ....
XXIV. Near point of accommodation (from cornea) .... O. D. .... mm. O. S. .... mm.
XXV. Near point of convergence (from cornea) .... mm. ....
XXVI. Stereoscopic vision ....
XXVII. Color vision ....
XVIII. Muscle 6 mtrs. {eso. .... exo. .... H. R. or L. ....
{div. .... conv. .... R. sur. ....
If trouble, 33 cm. {eso. .... exo. .... H. R. or L. ....
{div. .... conv. .... R. sur. ....
XXIX Ophthalmoscopic examination ....
Accepted .... Disqualified on No. .... Examiner..................
XXX. Is the candidate physically qualified for aeronautical duty? ....

Signed ....

[Forms 3 and 4.]

AIR SERVICE, U. S. ARMY, A. E. F.

REEXAMINATION OF FLIER.

Place.............................. Date......................
Name.............................. Rank.................... Organization......................
Age...................... Duty...................... Date of commission......................
Home town...................... M. or S...................... Previous Army service..........
Referred by...................................... Why referred..............................
I. Family history...
II. Personal history...
III. Education.......................... Sports.................. Prev. occupation..................
IV. Aviation history: Total flying...................... Flying record..........................
Aviation school work...
Date, duties, and hours of flying..
Altitude...................................... Symptoms..................................
Accidents..
Reasons for choosing aviation..
Attitude at present.......................... Attitude of family..........................
V. Present condition...
VI. Personality..
VII. Physical examination: (a) Lungs..
(b) Circulatory system .... (1) Pulse: Standing.............. Recumbent..............
After exercise...
Quality.............................. (2) Condition of arteries..........................
(3) Blood pressure: Systolic.......................... Diastolic..........................
(4) Heart: Inspection, P. M. I.............. Palpation, P. M. I.............. Thrills..............
Percussion, L. B. 5th I. S.......................... R. B. 4th I. S..........................
Auscultation standing.................. Recumbent.............. After exercise..........
(c) Digestive system: (1) Teeth...................... (2) Abdomen..........................
Remarks: ....
VIII. Eye examination: Visual acuity: R...................... L..........................
Near-point of accom.: R.............. mm. L.............. mm. Near-point of conv.......... mm.
Muscle balance 6 m.: Eso.............. Exo.............. R. of L. Hyper......................
Remarks: ....
....
IX. Ear, nose, and throat: (a) Sea sick, car sick, carousel, air sick, hypersensitiveness to these........
(b) Tonsils.................................. (c) Nares..................................
(d) Equilibrium (vestibular): (1) Nystagmus: R.......... L...... (2) Vertigo: R.......... L......
(3) Falling: R.............. L...................... (4) Past pointing......................
Remarks: ....
X. Conclusions and recommendations from examinations.......................................
Dept. medicine...
Dept. ophthalmology..
Dept. otology..
Dept. neurology..
XI. Recommendation of board...

Signature..

[Forms 5 and 6.]

REPORT OF ACCIDENT TO FLIER.

AIR SERVICE, U. S. ARMY, A. E. F.

Place .... Date ....
Name.. Rank ....
Squadron or wing .... Unit .... Date of commission...................
Type of work.................................. Type of machine ....
History of accident...
Date .... Day of week .... Time of day..........
Locality .... Weather conditions ....
Exact position of airman when found ....
Was telephone fitted? .... Was he pinned down by any part of the machine? ....
Did machine catch fire? .... Was fire extinguisher used? ....
Condition of motor and plane before flight ....
Condition after accident ....
Was he pilot or passenger? .... Name of other flier ....
Condition of other flier ....
Was any mishap observed? ....
Report of eyewitness 1. ....
2. ....
At what altitude .... Attempts to redress ....
At what stage of flight did accident occur? ....
Previous flying record...
Number of hours of flying ....
Hours in this type of work .... Number of minutes in air, day of accident ....
Nature of injuries ....
Research board examination ....
Nature of medical aid first rendered ....
Time of first medical aid ....
Hospital report..
Condition after accident, fatal or nonfatal .... Fracture at base ....
If fatal, state exact cause..
Neurological findings: Unconscious .... Headache .... Vomiting ....
Nightmare..................... Amnesia .... Character of ....
Flier's personal report of accident...
Health immediately before accident .... Was doctor seen? ....
Date and result of last medical examination ....
Habits: Sleep .... Alcohol .... Tobacco ....
Report of friends on health...
Helmet worn, and type..
Belt and type .... Did belt give way? ....
Goggles and type .... Were eyes injured by goggles? ....
Chief injuries at post-mortem ....
Signature ....

[Form 8.]

AIR SERVICE, U. S. ARMY, A. E. F.

[Envelope to contain the medical history of an officer or cadet in the Air Service.]

Name: ....
Date of commission: ....
Rank: ....

1. This envelope contains the flimsy copies of forms 1, 3, 5, and the classification examination.
2. It is to be kept in the executive office of his station with other personal papers. It is to be treated as strictly confidential.
3. On the transfer of the officer or cadet to another station or hospital it is to be forwarded with other personal effects to the commanding officer of the station or hospital to which the transfer is made.

Date.	Station.	Hospital.	Date of forwarding.
....	....	....	....
....	....	....	....
....	....	....	....

Filing No. ......

MEDICAL RESEARCH BOARD, AIR SERVICE SIGNAL CORPS, U. S. A., A. E. F. AND U. S. A.

TEST OF AVIATOR UNDER LOW OXYGEN TENSION.

....
(Place.) (Date.)

....
(Name.) (Military status.) (Organization.)

Res. .... Occ. ..../12 SMW.
(Age.)
Fam. Hist. F. .... M. .... B. .... S. ....
Wife .... Ch. ....
....

Tuberculosis, chr. cough, etc., in family, contacts, etc. ....
Pers. Hist.—Educa. ....
Hab. Tob. .... Alc. ....
Experience in athletics, dates....................
....
How recently or constantly have you been in hard condition (training)? ....
....
Are you so now? ....
....
Experience in aviation.......... Hrs.......... to .... Max. Alt. .... ft. for min.......
....
Other exp. at altitudes (mountains, etc.)....................
....
Symptoms at altitudes....................

Previous medical history: Have you had measles, scarlet fever, diphtheria, pneumonia, typhoid, malaria, tuberculosis in any form, chr. cough, chr. bronchitis, enlarged glands, tonsil trouble, adenoids, nasal obstruction, catarrh, rheumatism, gonorrhea, syphilis, accidents, especially to head, unconsciousness, fainting, operations, ear trouble, any other serious illness (full details and dates)....................
....
....
....
When did you last consult a physician, why?....................
....
Previous eye hist. Use of glasses.......... Symptoms when not wearing glasses....................
lachrymation............photophobia............diplopia............headache....................
....
Present condition—Give details of present health....................
....
....
Time of last meal....................
Appetite.................... Weight.................... Digestion....................
Are you feeling fit to-day? (Loss of sleep, dissipation, nervous tension, overwork, indisposition, eye strain, indigestion, cold, etc.)....................
....
....
Other remarks....................
....
....
Physical examination—(If deviation from normal is found, note in great detail.)
General build....................
General appearance (note especially cyanosis, mottling, coldness of extremities, pallor, sweat, etc.).......
....
Eyes—Vision R. E.......... L. E.......... Muscle Bal.................Ret. Sens....................
Ergograph {Acc.................. / Conv.................} Color Vision..........Field Binoc. Fix. +
....
Ears....................
....
Nose....................
Throat....................
Lungs....................
....
Heart:
Apex felt (point farthest out) in ....sp......... cm. to L. of Mid.
L. Border (dullness) in 6th sp........... cm.; 5th sp. ....; 4th sp........... cm.; 3rd sp. .... cm. to L. of Mid.
Upper border....................R. border....................cm. to R. of Mid.
....
....
After 5 min. reclining, B. P...........Pulse..........On standing, B. P...........Pulse..............
After standard exercise, B. P...........Pulse...........2 min. after exercise, B. P...........Pulse......
Blood vessels....................
Abdominal....................
....
General impression, psychological....................
....
....
Summary of observations during low-tension tests:
....
....
....
Recommendation of board as to fitness of aviator:
....
....
....
Signed....................
....
....
....
....
(Name.) (Date and hour.)
Type of test.................... Duration............minutes............seconds.
Phys. cond. at time of test....................
....
Exact condition at close of test....................
....
Recovery....................

Remarks..

....

Observers: ....Phys. ....Clin. ....Psy. ....Oph.

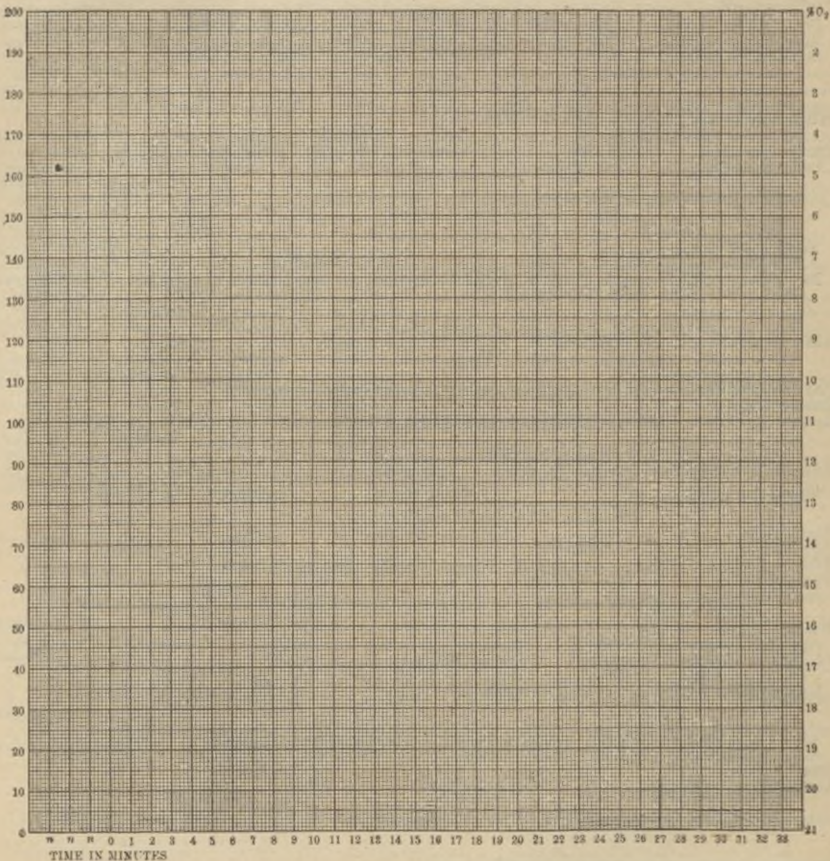
On machine.................... Plotted by........... O_2% start.......... finish............

Legend O_2% Pulse Resp. in decil. per min. Syst. B. P.

Diast. B. P. Pulse Pressure Accom. in mm. Convergence in mm.

DIAGRAM.

[Face.]



Filing No. ......

[Back.]

MEDICAL RESEARCH BOARD, AIR SERVICE SIGNAL CORPS, U. S. A.

EXAMINATION UNDER LOW OXYGEN TENSION.

Name..

Rank..

Rating..

(Date)...................

This report is to be made in triplicate. One copy will be filed at the Medical Research Laboratory, Hazelhurst Field, Minneola, L. I.; one copy filed in office of chief surgeon, A. S. A. C.; one copy will be delivered to the commanding officer of the aviator and when the aviator is transferred this copy will be sent to the commanding officer at the new station. It is not to come into the possession of the aviator himself. In case a report is lost application should be made at once to the Medical Research Laboratory, Hazelhurst Field, Minneola, L. I., for a duplicate copy.

[Form 9.]

AIR SERVICE, U. S. ARMY.

REPORT OF MEDICAL RESEARCH BOARD.

Place.................... Date....................

Name ....
Rank.. Organization...............................
Why referred...
Rcommendation of board..
....
Remarks on fitness...
....

Signature....................................

FRENCH AIR SERVICE.

[War Department. Air Service.]
[Ministere de la Guerre. Aéronautique.]

MEDICAL RECORD
Livret Médical

Of pilot
De pilote

Of observer
De observateur

Surname..
Nom..
Given names..
Prénoms..
Rank...
Grade..
Class..
Classe...
Date of joining Air Service..
Date d'arrivée dans l'Aviation ....

[War Department. Air Service. Medical Office.]
[Ministere de la Guerre. Aéronautique. Centre Médical.]

..................(Date) 19
...................., le........................19..

MEDICAL CARD (Record)
FICHE MEDICALE

No.
N°....................

of de { Student Pilot / Élève Pilote / Student Observer / Élève Observateur }

Surname
Nom..
Given names
Prénoms..
Rank
Grade..
Class
Classe...
Age..
Age..
Former branch of military service
Arme d'origine...................................

Profession
Profession.......................................
Former sporting activities or military training
Antécédents sportifs ou entrainement militaire
antérieur..
....
....
....

1. General Medical Examination
1° Examen de Médecine générale

Antecedents
Antécédents............ { .... (5 lines) }

General hygiene
Hygiène générale....... { Use of tobacco and intoxicants / Tabagisme, intoxications........................ / Height Weight / Taille.............................. Poids.............................. }

171364—20——18

Constitution
Constitution.......... Abdominal girth
Sangle abdominale..........

- **Circulatory apparatus / Appareil circulatoire...**
  - Heart
    Cœur..........
    ....
  - Aorta
    Aorte..........
    ....
  - Pulse / Pouls..........
    - (*a*) While lying on back
      (*a*) Dans le décubitus dorsal..........
    - (*b*) While standing
      (*b*) Dans la station debout..........
    - (*c*) Changes of pulse during / (*c*) Modifications du pouls à.....
      - inspiration / l'inspiration..........
      - expiration / l'expiration..........
  - Blood pressure / Pression artérielle..
    - Pachon oscillometer
      (Oscillomètre de Pachon)..........
    - Vaquez-Laubry sphygmotensiometer
      (Sphygmotensiomètre de Vaquez-Laubry)..........
  - Test of cardiac adaptability to exertion
    Epreuve d'aptitude cardiaque à l'effort..........
  - Pulse / Pouls..........
    - (*a*) In repose
      (*a*) Au repos..........
    - (*b*) After 3 minutes' exercise (not rythmic gymnastic exercise)
      (*b*) Après 3 minutes d'exercice (pas gymnastique cadencé)
      ....
    - (*c*) After 3 minutes' rest
      (*c*) Après 3 minutes de repos..........
  - Blood pressure / Pression artérielle..
    - (*a*) While lying on back
      (*a*) Dans le décubitus dorsal..........
    - (*b*) After 3 min. exercise (not rythmic gym.)
      (*b*) Après 3 m. d'exercice (pas gym. cadencé)..........
    - (*c*) After 3 minutes' rest
      (*c*) Après 3 minutes de repos..........
  - Peripheral circulation
    Circulation périphérique..........
  - Vasomotor action in the extremities
    Vaso-motricité des extrémités..........
- **Respiratory apparatus / Appareil respiratoire...** ....
- **Digestive apparatus / Appareil digestif.......**
  - Teeth
    Dentition..........
  - Stomach, intestines
    Estomac, intestin..........
  - Liver
    Foie..........
- **Renal functions / Fonctions rénales......**
  - Amount of urine
    Volume des urines..........
  - Chemical analysis / Analyse chimique..
    - (*a*) Normal constituents
      (*a*) Éléments normaux..........
      ....
    - (*b*) Abnormal constituents
      (*b*) Éléments anormaux..........
      - Albumin
        Albumine..........
      - Sugar
        Sucre..........
  - Chloride retention
    Rétention chlorurée..........
  - Uric acid in the blood
    Azotémie..........
  - Average excretion of urea
    Constante uréo-secrétoire..........
- **Skin / Appareil tégumentaire..** ....
- **Remarks and conclusions / Observations diverses, conclusions.**
  ....
  ....
  ....
  ....

Physician in charge of examination.
Le Médecin chargé de l'Examen.

2. X-Ray Examination
2° Examen Radiologique

1. Apices of lungs
1° Sommets..........
2. Limits of lungs
2° Plage pulmonaire..........
3. Hilus shadow
3° Ombre hilaire..........
4. Mediastinum
4° Médiastin..........
5. Costo-diaphragmatic border
5° Sinus costo-diaphragmatique..........
6. Movements of diaphragm
6° Mouvements du diaphragme..........
7. Wall of thorax
7° Paroi thoracique..........

8. Heart and aorta
8° Cœur et aorte..........

Remarks and conclusions. / Observations diverses, conclusions. ....

Physician in charge of examination.
Le Médecin chargé de l'Examen.

3. Neurological Examination.
3° Examen de Neurologie.

Antecedents
Antécédents..........

General psychology of candidate
Psychologie générale du candidat..........

Emotional disposition
Emotivité..........
General motor activity
Motricité générale..........
Coordination, tremors, loss of coordination, faulty coordination, dysmetry
Coordination, tremblements, asynergie, dysmétrie..........
Superficial and deep reflexes, stereognosis
Sensibilité superficielle et profonde, stéréognosie..........
Tendon reflexes
Reflexes tendineux..........
Cutaneous reflexes
Reflexes cutanés..........
Pupillary reflexes
Reflexes pupillaires..........
Sphincters
Sphincters..........

Remarks and conclusions. / Observations diverses, conclusions. ....

Physician in charge of examination.
Le Médecin chargé de l'Examen.

4.—Physiological Examination.
4°. Examen Physiologique.

			Inspiration Insp.	Expiration Exp.	Difference Différentielle
1. Respiratory physiology. / 1 Physiologie respiratoire.	Thoracic measurements / Ampliométrie thoracique	a) At the Xyphoid / a) Xyphoïdienne			
		b) Axillary / b) Axillaire			
		c) Umbilical / c) Ombilicale			
	Spirometry / Spirometrie				
	Spiro-manometry. / Spiro-manométrie.	a) Inspiratory pressure / a) Pression inspiratoire			
		b) Expiratory pressure / b) Pression expiratoire			
	Time breath can be held. / Durée de la suspension resp.	a) During rest / a) Au repos			
		b) After moderate exercise. / b) Aprés un exercice modéré			
	Holding breath under pressure of .... cm. of mercury / Tenue respirat. sous pression de .... cent. de mercure				
	Resistance to lowered atmospheric pressure / Résistance à la dépression atmosphérique				
2. Muscular physiology.—Ergography / 2° Physiologie musculaire.—Ergographie					
3. Psychomotor reactions. / 3° Réactions psycho-motrices.	Sight / Visuelles				
	Hearing / Auditives				
	Touch / Tactiles				

Remarks and conclusions. / Observations diverses, conclusions. ....

Physician in charge of examination.
Le Médecin chargé de l'Examen.

5.—Examination of Ear, Nose, and Throat.
5° Examen Oto-Rhino-Laryngologique.

I. Upper respiratory passages.
I. Voies respiratoires supérieures.

Nasal fossae Fosses nasales	....
Expiratory defects Taches expiratoires	....
Inspiratory pressure Pression inspiratrice	....
Naso-pharynx Cavum	....
Pharynx Pharynx	....

II. Hearing (cochlear apparatus).
II. Audition (voies cochléaires).

	Left ear. O. G.	Right ear. O. Dr.
Tympani Tympans	....	....
Tubal permeability Pérmeabilité tubaire	....	....
Weak whispering voice Voix chuchotée faible	....	....
Speaking voice Voix parlée	....	....
Telephone inductor (dist. 0.5 meter) Inducteur téléph. (dist. 0m-50)	....	....
Tuning-fork Ut-1 (32 V. D.) Diapason Ut-1 (32 V. D.)	....	....
Tuning-fork Ut-7 (4096 V. D.) Diapason Ut-7 (4096 V. D.)	....	....
Weber test Weber	....	....
Rinne test Rinne	....	....
Cochlear-palpebral reflex Réflexe cochleo-palpébral	....	....
Accommodation (Gel'é test) Accommodation (Gellé)	....	....
Auditory orientation Orientation auditive	....	....

III. Equilibrium (semicircular canals)
III. Equilibration (voies vestibulaires.)

1. Spontaneous disequilibration
1° Déséquilibration spontanée.

- Romberg test (feet together)
  (feet one behind the other)
- Stationary marching (marking time)
- Romberg (pieds joints) ....
  (pieds l'un devant l'autre) ....
- Marching blindfolded forward and back (Babinski-Weill)
- Marche sur place (marquer le pas) aveugle alleret retour (Babinski-Weill) ....

III. Equilebrium (semicircular canals.)
III. Equilibration (voies vestibulaires.) (Suite.)

2. Provoked loss of equilibrium
2 Déséquilibration provoquée.

a) Romberg test after 3 complete rotations (note delay in recovering balance) (R. Foy) a) Romberg après 3 tours complets sur soi-même (noter en retard de l'équilibration) (R. Foy).	Right side Left side Flanc Dr. .... Flanc G. ....
b) Stick test (Moure) b) Epreuve du bâton (Moure)	....

c) Galvanism: c) Galvanique:	+to left +à G.	+to right +à Dr.
Vertigo, sitting Vertige assis	....	....
Vertigo, standing, feet together Vertige debout pieds joints	....	....
Vertigo, standing (one foot in front of other) Vertige debout pieds l'un devant l'autre	....	....
Test of marking time (R. Foy) Epreuve du marquer le pas (R. Foy)	....	....

d) Marching blindfolded or Romberg test after thermic test (cold air) d) Marche aveugle ou Romberg après épreuve thermique (air froid)	Labyrinth right Labyrinth left Lab Dr. .... Lab. G. ....

3. Provoked reactions (pointing with the finger)
3° Mouvements réac. provoqués (indic.) ....

a) Post pointing after 5 rotations (Grivot) a) Indication après 5 tours de rotation sur soimême (Grivot)	Right side Left side Flanc Dr. .... Flanc G. ....
b) Post pointing after thermic test (cold air). b) Après épreuve thermique (air froid).	Right labyrinth Left labyrinth Lab. Dr. .... Lab. G. ....

c) After test in rotating chair c) Après épreuve giratoire (fauteuil-kynémétrigue		Sagittal deviation Dév. sagit.	Lateral deviation Dév. latér
	To the right To the left Par flanc Dr.	....	....
	Par flanc G.	....	....

4. Nystagmus
4° Nystagmus ....

a) After rotating a) Post-giratoire	To the right To the left Par flanc Dr. .... Par flanc G. ....
b) After thermic test (cold air) b) Post-thermique (air froid)	Right labyrinth Left labyrinth Lab. Dr. .... Lab. G. ....

Interpretation..
Interprétation..
Conclusions...
Conclusions...

Physician in charge of examination.
Le Médecin chargé de l'Examen.

6.—Ophthalmic Examination.
6° Examen Ophtalmologique.

1. Lachrymal ducts, eyelids, conjunctivas
1° Voies lacrymales, paupières, conjonctives..
2. Pupils during repose or during exertion
2° Pupilles a l'état statique et dynamique..
3. Deep membranes
3° Membranes profondes...
4. Visual acuity a) Right b) Left
4° Acuité visuelle. a) Droite.............................. b) Gauche..............................
5. Field of vision a) Right b) Left
5° Champ visuel. a) Droite.............................. b) Gauche..............................
6. Color vision
6° Sens chromatique...
7. Binocular vision
7° Vision binoculaire...

Supplementary tests
Épreuves complémentaires.......

1. Rapidity of normal acuity
1° Vitesse de l'acuité normale..
2. Acuity above normal
2° Acuité hypernormale...
3. Nocturnal vision
3° Vision nocturne...
4. Vision in dazzling light or toward sun
4° Vision d'éblouissement ou à contre-soleil...
5. Stereoscopic vision
5° Vision stéréoscopique...

Remarks and conclusions ....
Observations; conclusions. ....

Physician in charge of examination.
Le Médecin chargé de l'Examen.

7.—Remarks and Conclusions.
7° Observations et Conclusions.

....
....
....
....
....

The Chief Physician.
Le Médecin-Chef.

ITALIAN AIR SERVICE.

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES

Ufficio di Ricerche Psicofisiologiche sui Candidati dell'Aviazione

TURIN 30 Corso Raffaello.

TORINO — Corso Raffaello, 30 — TORINO

POINTING TEST

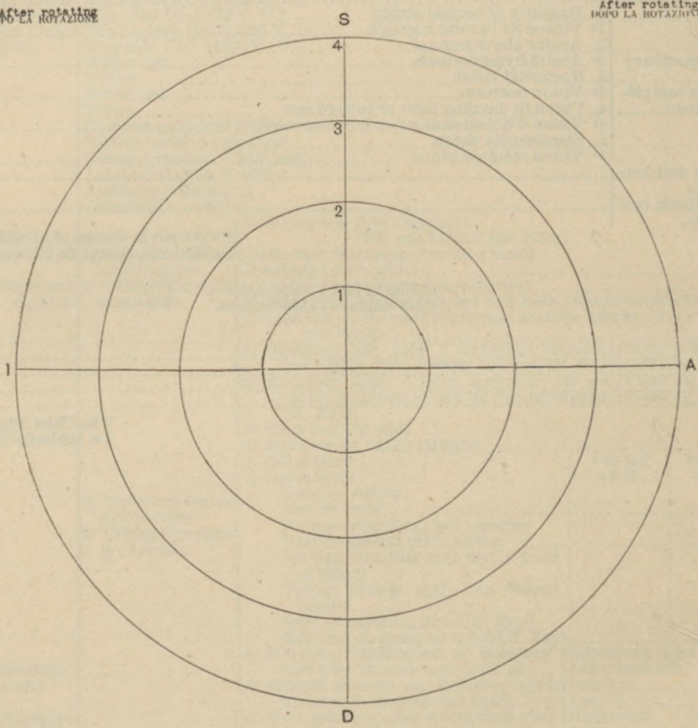
PROVA DELL'INDICAZIONE

LEFT HAND
MANO SINISTRA
Before rotating
◯ PRIMA DELLA ROTAZIONE.
After rotating
◯ DOPO LA ROTAZIONE

α' D → S
β' S → D

RIGHT HAND
MANO DESTRA
Before rotating
PRIMA DELLA ROTAZIONE ◯
After rotating
DOPO LA ROTAZIONE ◯

γ D → S
δ S → D



N. ____________________ Turin Torino, li ____________ 19

____

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____

____

(No. 1.)
(N. 1.)

COMMAND OF AVIATORS.
COMANDO AVIATORI.

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATION OF AVIATION CANDIDATES.
UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL'AVIAZIONE.

Examination No. Turin..............................19..
Esame N............. TORINO, LI..............................

RECORD OF EXAMINATION.
RELAZIONE DI VISITA.

Undergone by pupil
Subita dall' allievo..
Rank Corps
Grado..Corpo..
Full name
Cognome e nome...
Son of
Figlio di..
of the class from
della classe........................da..
The result of the examination made in this office is that the above-named soldier is
Dalle visite praticate in questo ufficio risulta che il sunnominato militare è..........................
....
to flying service
al servizio in volo..
....

The Director of the Office.
Il Direttore dell' Ufficio
....

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATION OF AVIATION CANDIDATES.
UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL'AVIAZIONE.

1. PHYSICAL EXAMINATION.
1. ESAME SOMATICO.

No. Rank Corps
N..................Grado..............................Corpo......................................
Surname and given name
Cognome e nome...
....
Date
................., LI..............................

Past history
Anamnesi..
Heredity
Gentilizio...
Habits
Abitudini:
(a) Tobacco
(a) Tabagismo...
(b) Alcohol
(b) Alcoolismo...
Former sporting activities
Precedenti sportivi..
Former illnesses
Malattie pregresse...
So far as you know have you ever had syphilis
Ammette lue..
(If so, account of infection)
(Eventualmente storia dell'infezione)...
Wounds (date, circumstances, description, outcome)
Traumatismi (data, circostanze, descrizione, esito)...........................
Former medico-legal proceedings
Provvedimenti medico-legali precedenti...
Subjective symptons
Sintomi soggettivi...
I declare that the information given by me concerning my personal and family medical history is true, complete, and faithfully recorded.
Dichiaro che le notizie da me date, sui miei precedenti personali e famigliari, sono vere, complete e fedelmente registrate. Dichiaro anche che sono stato avvertito delle conseguenze di una dichiarazione errata.

Signature
Firma: ....

Objective examinations
Esame oggettivo..
External examination—Constitution and defects of skeleton and joints
Esame esterno—Costituzione e alterazione dello scheletro e articolazioni..........................
Muscular development and hypertrophies
Sviluppo muscolare e ipotrofie..

Gait
Deambulazione..
State of nutrition and adipose tissue
Stato di nutrizione e pannicolo adiposo...
Weight and height Weight in kg Height in meters and cm.
Peso e statura....................Peso kg........................Statura m. 1 e cm...............
Measurement of chest and abdomen Chest .. cm. Abdomen .. cm.
Perimetro toracico e addominale. Torace cm..........Addome cm.................................
Skin and mucous membranes (color, abnormalities, cicatrices)
Cute e mucose (colorito, alterazioni, cicatrici)...
Peripheral lymphatic glands
Ghiandole linfatiche periferiche..
Thyroid and ductless glands
Tiroide e ghiandole endocrine...
Remarks
Osservazioni..
Respiratory organs
Organi respiratori...
Inspection, palpation, percussion, and auscultation
Ispezione, palpazione, percussione e ascoltazione..
....
....
Spirometry
Spirometria...
Remarks
Osservazioni..
Cardio-vascular system
Sistema cardiovascolare...
Heart and large blood vessels
Cuore e grossi vasi..
Inspection, palpation, percussion, and auscultation
Ispezione, palpazione, percussione e ascoltazione..
....
....
Remarks
Osservazioni..
Peripheral vessels with Riva Rocci sphygmomanometer
Vasi periferici: col "Riva Rocci" m/m..
Blood pressure at .. o'clock by Pachon method Max......mm Min..mm.
Pressione arteriosa a ore col "Pachon" massima m/m minima m/m.............................
Quality of pulse, frequency
Qualita del polso, frequenza...
....
Varicose veins, cyanosis, etc.
Varici, cianosi, ecc..
Abdominal walls and organs
Pareti ed organi addominali..
Genitals
Organi genitali...
X-Ray
Radioscopia..
Nervous system responsiveness
Sistema nervoso. Mobilità attiva..
Tremors
Tremosi..
Romberg's sign
Fenomeno di "Romberg"..
Abdominal and cremasteric reflexes
Riflessi addominalie e cremasterici...
Tendon and periosteal reflexes
Riflessi tendinei e periostei..
Pupils and pupillary reflexes
Pupille e riflessi pupillari...
Dermography
Dermografismo...
General sensibility (touch, heat, pain)
Sensibilità generale (tattile, termica e dolorifica)..
Psychopathic signs
Fenomeni psicopatici...
Remarks
Osservazioni...
Urine
Orina:
    Appearance
    Aspetto..
    Color
    Colore...
    Reaction
    Reazione...
    Density
    Densità..
Albumin
Albumina...
Sugar
Glucosio...
Microscopic examination of sediment
Esame microsc. del sedimento...
Remarks
Osservazioni...
....

Special annotations
Annotazioni speciali..

Conclusions
Resultato complessivo..

Signature
(Firma) ....

MOTORIST.
MOTORISTA.

ASSEMBLER.
MONTATORE.

No.
N. ....
Rank. Corps.
Grado.. Corpo..
Full name.
Cognome e nome..
Father.
Paternità..
Date of birth.
Giorno di nascita..
Place.
Luogo di nascita..
District.
Distretto..
Civilian occupation.
Professione da borghese..
Date of enlistment.
Data di arruolamento..
Have you ever flown? When?
Ha mai volato............................; quando..
In what capacity?
In che qualita..
Since what date?
Al fronte dal..
In what capacity?
In che qualità..
Is at the school of. since.
Si trova alla Scuola di....................................; dal..
Date of presentation at the office.
Data di presentazione all' ufficio..

FORMER ILLNESS AND RELATIVE MEDICO-LEGAL STATUS.
MALATTIE PREGRESSE E PROVVEDIMENTI MEDICO LEGALI.

Do you desire to fly?
Se desidera volare..

The undersigned declares that all the above answers are correct and that he has been warned of the punishments incurred in the case of false statements.

Il sottoscritto dichiara che quanto sopra corrisponde alla verita ed è stato avvertito delle punizioni in cui incorre nel caso di false dichlarazioni.

Signature.
Firma..

MEDICAL EXAMINATION.
VISITA MEDICA.

Pathological and abnormal conditions.
Fatti patclogici o anormali..

Fit. Unfit for.
Idoneo Inabile per..

Signature.
Firma..

EXAMINATION OF EARS.

VISITA OTOIATRICA.

Pathological and abnormal conditions.
Fatti patologici o anormali..
....
....
....

Fit. Unfit for.
Idoneo Inabile per..

Signature.
Firma..

VACUUM CHAMBER.

CAMPANA PNEUMATICA.

Effects.
Comportamento..
....
....

Signature.
Firma..

FINAL DECISION.

CIUDIZIO FINALE.

....
....
....

The Director.
Il Di rettore
....

Office of Psychophysiological Examinations of Aviation Candidates.

Ufficio di Ricerche Psicofisiologiche sui Candidati dell'Aviazione.

VII. VARIOUS PHYSIOLOGICAL EXAMINATIONS.

VII. ESAMI FISIOLOGICI VARI.

No. Rank. Corps.
N. .... Grado.................................. Corpo..
Surname and given name.
Cognome e Nome..
....
........................., li..

I. EXCITABILITY.

I. EMOTIVITÀ.

General reaction.
Reazione generale..
Vasomotor.
Reazione vasomotoria..
Pulse.
Reazoine del polso..
Respiration.
Reazoine del respiro..
Tremor.
Reazione del tremito..
Conclusion; excitability.
Giudizio complessivo; emotività..

II. MUSCULAR SENSE.

II. SENSO MUSCOLARE.

Type.
Tipo..
Regularity.
Regolarità..
Fitness.
Idoneità..

III.
III. ....
....

Signature.
Firma..

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES.

UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL'AVIAZIONE.

IX. PSYCHICAL EXAMINATION.

IX. - ESAME PSICHICO.

No. / N........................ Rank / Grado.................................. Corps / Corpo.................................

Surname and given name / Cognome e nome..

....

Date / Data................,..................

Progression of times of exposure
(Progressione dei tempi di esposizione...)

(a) Speed of perception. (a) Velocità di appercezione.		(b) Extent of perception. (b) Estensione di appercezione.						(c) Speed of comparison. (c) Velocità di comparazione.	
Series. Segno.	Minimum time. Tempo minimo.	Series. Serie.	Minimum time. Tempo minimo.					Series. Serie.	Minimum time. Tempo minimo.
			1	2	3	4	5		
1	....	1	....	....	....	....	....	1	....
2	....	2	....	....	....	....	....	2	....
3	....	3	....	....	....	....	....	3	....
4	....	4	....	....	....	....	....	4	....
5	....	5	....	....	....	....	....	5	....
6	....	6	....	....	....	....	....		
7	....	7	....	....	....	....	....	Mean minimum time. Tempo minimo medio.	
8	....	8	....	....	....	....	....	....	
9	....	9	....	....	....	....	....	....	
10	....	10	....	....	....	....	....	....	

(d) INTENSITY OF ATTENTION.

(d) INTENSITÀ DI ATTENZIÒNE.

Mark to be canceled. Segno da cancellare.	No. of marks to be canceled. N.° dei segni da cancellare.	No. of marks canceled. N.° dei segni cancellati.	Ratio of errors. Rapporto errori.	Total time. Tempo totale.
....	....	....	....	....

REMARKS. OSSERVAZIONI.	CONCLUSION. GIUDIZIO.
(a)	(a) ....
(b)	(b) ....
(c)	(c) ....
(d)	(d) ....

Psychical behavior (from all the tests in the psychological examination)
Comportamento psichico (dal complesso delle prove per l'esame psicologico)..............................

....

Signature / Firma..

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES.

UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL'AVIAZIONE.

VIII. RESISTANCE TO PRESSURE VARIATIONS.
VIII - RESISTENZA ALLE VARIAZIONI DI PRESSIONE.

No. N°........................ Rank Grado................................ Corps Corpo..................................
Surname and given name
Cognome e nome..
Barometric pressure Pressione barometrica.............. Temperature Temperatura................ Date li...............................191...
Past history and present status
Note anamnestiche e stato presente...
....
....
....

Hours and minutes. Ora e minuti.	Pressure. Pressione.	Temperature. Temperatura.	Annotations. Annotazioni.
....	....	....	....
....	....	....	....
....	....	....	....

Remarks
Osservazioni..
....
....
....

Conclusion
Giudizio complessivo..
....
....
....

Signature
Firma..

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES.
UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL' AVIAZIONE.

IV. EXAMINATION OF VESTIBULAR APPARATUS.
IV. ESAME DELL' APPARECCHIO VESTIBOLARE.

No. N............. Rank Grado.......................... Corps Corpo..

Surname and given name
Cognome e Nome...

Place and date
..........................li..................................

Past history as to psychophysiological data
Anamnesi speciale...
....
The undersigned declares that the above data are true and complete
Il sottoscritio dichiara che i dati surriferiti sono veri e completi. Signature, Firma........................
Spontaneous nystagmus
Nistagmo spontaneo..
Duration of rotary nystagmus Durata del nistagmo postrotatorio.......... Right D............................ Left S..........................
....
Behavior during rotation:
Comportamento nella rotazione:
With head erect
A capo eretto...
With head bent at 90°
A capo flesso a 90°...
Character of gait after excitation
Comportamento della deambulazione dopo eccitazione.......................................

Standing tests Prova statica............	On both feet Sui due piedi............	On right foot Sul piede D.............	On left foot Sul piede S...............
....	....	....	....

Pointing tests
Prova dell' indicazione..
Static sense of position:
Senso statico della posizione:

Ahead. In avanti.		Behind. Indietro.		Right. A destra.		Left. A sinistra.	
Degrees. Gradi.	Mean error. Errore medio.	Degrees. Gradi.	Mean error. Errore medio.	Degrees. Gradi.	Mean error. Errore medio.	Degrees. Gradi.	Mean error. Errore medio.
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

Verticality (falling tests):
Verticalità:

Inclination—forward—backward. Inclinazione antero posteriore.			Inclination—lateral. Inclinazione laterale.		
Mean error forward. Media errori in avanti.	Mean error backward. Media errori indietro.	Mean error. Errore medio.	Mean error right. Media errori a destra.	Mean error left. Media errori a sinistra.	Mean error. Errore medio.
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

Remarks
Osservazioni..
....
Result
Resultato..
....

Signature
Firma..

Error in estimating the inclination:
Errore nell'apprezzare l'inclinazione:

Incline forward Inclinazione in avanti			Incline backward Iclinazione indietro			Incline to right Inclinazione a destra			Incline to left Inclinazione a sinistra		
Deg. Gradi	Estimate Apprezzati	Error Errore	Deg. Gradi	Estimate Apprezzati	Error Errore	Deg. Gradi	Estimate Apprezzati	Error Errore	Deg. Gradi	Estimate Apprezzati	Error Errore
......	....	......	......	....	......	......	....	......	......	....	......
......	....	......	......	....	......	......	....	......	......	....	......
......	....	......	......	....	......	......	....	......	......	....	......

Error in estimating vertical position:
Errori nell'apprezzare la posizione verticale:

In inclination—forward—backward. Nell' inclinazione antero posteriore. A=forward. D=backward.										In lateral inclination (right, left). Nell' inclinazione laterale. D=right. S=left.									
A	D	A	D	A	D	A	D	A	D	D	S	D	S	D	S	D	S	D	S
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
				Mean of forward error. Media degli errori in avanti.................. backward. Media degli errori in indietro................ Mean error. Errore medio............										Mean error to right. Media errori a D......... left. Media errori a S......... Mean error. Errore medio............					

Office of Psychophysiological Examinations of Aviation Candidates.
Ufficio di Ricerche Psicofisiologiche
Sui Candidati Dell'Aviazione.

V. REACTION TIME IN THOUSANDTHS OF A SECOND
V. TEMPI DI REAZIONE IN 0''001

No. Rank Corps
No. .... Grado............................ Corpo..................................
Surname and given name
Cognome e Nome..
....
Date
......................., li................................ .

Information furnished by the subject No. of flights Maximum altitude Maximum duration
Notizie fornite dal soggetto............. No. dei voli..... Quota massima... Durata massima.......
(Specialmente per il personale navigante)
(Especially for the flying personnel)
Just coming from (service, rest, furlough, hospital, etc.) for
Proviene da (servizio, riposo, licenza, ospedale, ecc.)................................per.......................
Incidental happenings
Incidenti...
....
At present he states that
Attualmente accusa: ....
....
....
Troubles in flight, former
Disturbi in volo: precedenti..
Troubles in flight, present
Disturbi in volo: presenti...
....
Sensitivity in flying
Sensitività di volo: ....
Equilibrium Orientation
Equilibrio.. Orientamento...................................
Disturbances of attention (before) (after)
Disturbi dell'attenzione: (prima)................................ (dopo)................................
Disturbances of memory (before) (after)
Disturbi della memoria: (prima)................................. (dopo)................................
Disturbances of will (before) (after)
Disturbi della volontà: (prima)................................... (dopo)................................
Disturbances of (after)
Disturbi della carattere: (prima)................................ (dopo)................................
Sleep Dreams
Sonno.. Sogni..
He attributes the present disturbances to
Attribuisce i presenti disturbi a...
Remarks
Osservazioni varie: ....
....

General remarks. Osservazioni generali.		Conclusion. Risultato complessivo.
1. Normality 1. Normalità............	6. Distractability 6. Distraibilità..........	....
2. Regularity 2. Regolarità............	7. Liability 7. Labilità..............	....
3. Short reaction 3. T. R. brevi..........	8. Instability 8. Instabilità...........	....
4. Long reaction time 4. T. R. lunghi..........	9. Adaptability 9. Adattamento.........	....
5. Variability 5. Variabilità...........	10. Bearing 10. Contegno...........	....
		Signature Firma....................................

To visual stimulus.
A stimolo visivo.

Reading a watch. Letture orologio.					Values of reaction time. Valori dei T. R.				
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....

Remarks. Osservazioni.						
	No. T. R..........	....	....	....	....	....
....	Discarded Scarti..............	....	....	....	....	....
....	Total Totale.......	....	....	....	....	....
....	Mean Media.............	....	....	....	....	....
....	Extreme values Valori estremi.....	....	....	....	....	....
....	Normal group Gruppo norm......	....	....	....	....	....
....	Mean deviation Deviaz media......	....	....	....	....	....
....	Coefficient of variability Coefficiente di variabilità..........	....	....	....	....	....
....	Errors Errori.............	.......%	.......%	.......%	.......%	.......%

To acoustic stimuli.
A stimolo acustico.

Reading watch. Letture orologio.					Values of reaction time. Valori dei T. R.				
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....

Remarks. Osservazioni.						
	No. T. R..........	....	....	....	....	....
....	Discarded Scarti..............	....	....	....	....	....
....	Total Totale.......	....	....	....	....	....
....	Mean Media.............	....	....	....	....	....
....	Extreme values Valori estremi.....	....	....	....	....	....
....	Normal group Gruppo norm......	....	....	....	....	....
....	Mean deviation Deviaz media......	....	....	....	....	....
....	Coefficient of variability Coefficiente di variabilità..........	....	....	....	....	....
....	Errors Errori.............	.......%	.......%	.......%	.......%	.......%

Curve frequency.
Curve di frequenza.

	Total value. V. S	Per cent. Ac.		Total value. V. S.	Per cent. Ac.
— 100			Discarded		
101–110			Scarti		
111–120					
121–130			Total		
131–140			Totali		
141–150					
151–160			Mean		
161–170			Medie		
171–180			Extreme values		
181–190			Valori estremi		
191–200			Normal group		
201–210			Gruppo norm.		
211–220			Mean deviation		
221–230			Deviaz media		
231–240			Coefficient of variability		
241–250			Coefficiente di variabilità		
251–260			Errors		
261–270			Errori	%	%
271–280					
281–290					
291–300					
301+					
Total Totali					

Candidate Pilot
Candidato Pilota
Candidate Observer
Candidato Osservatore
Pilot
Pilota
Observer
Osservatore

Office of Psychological Examination of Aviation Candidates.
Ufficio di Ricerche Psicofisiologiche sui Candidati dell'Aviazione.

Examination No.
Esame No. .... Date
.................., li ....

RESULT OF EXAMINATION.
RESULTATO DELL'ESAME.

taken by (rank) (Corps)
subito dal (grado) .... (Corpo) ....
Surname and given name
Cognome e Nome ....
Father Birth place Date of birth
paternità .... luogo di nascita .... data di nascita ....

INFORMATION FURNISHED BY CANDIDATE.
INDICAZIONI FORNITE DALL'INTERESSATO.

Date of enlistment
Data dell'arruolamento ....
Declaration of citizenship
Professione da borghese ....
Former aeronautic experience (if pilot, date of commission, where located, etc.)
Precedenti aeronautici (se pilota, data del brevetto; dove prestò servizio, ecc.) ....
....

Accidents and injuries
Incidenti sofferti e traumi ....
....
Malattie famigliari e personali pregresse ....
....
Medico-legal proceedings
Provvedimenti medico-legali ....
Subjective disturbances
Disturbi soggettivi ....
Habits / Abitudini { Tobacco
tabacco ....
Alcohol
alcohol ....

RESULT OF EXAMINATIONS.
ESITO DEGLI ESAMI.

I. PHYSICAL EXAMINATION.
I.—ESAME SOMATICO.

General condition—Skin and mucous membrane
Stato generale.—Cute e mucose..
1. Weight and measurements
1. Peso e misure..
Weight in kg. Height in meters
Peso Kg..Statura m..
Chest in cm. Abdomen in cm.
Perimetro toracico cm..............................Perimetro abdominale cm........................
2. Respiratory organs
2. Apparecchio respiratorio..
3. Cardio-vascular apparatus
3. Apparecchio cardiovascolare....Pulse (frequency) Blood pressure at o'clock
Polso (frequenza)......Pressione arteriosa.....a ore..................
4. Abdominal and genital organs
4. Organi addominali e genitali..
5. Lymphatic and glandular organs
5. Linfatici ed organi ghiandolari..
6. Urine
6. Orine..
7. Nervous system
7. Sistema nervoso:
(a) Motility
(a) motilita..
(b) General sensitivity
(b) sensibilità gener..
(c) Reflexes
(c) riflessi..
8. Psychopathic symptoms
8. Sintomi psicopatici..
9. Motor organs
9. Organi di moto..
10. Are these objective symptoms of infection?..
10. Se esistono sintomi obiettivi di infezione

II. EXAMINATION OF VISUAL APPARATUS AND ITS FUNCTIONING.
II.—ESAME DELL'APPARECCHIO E DELLA FUNZIONE VISIVA.

1. Objective examination
1. Esame obiettivo..
2. Refraction Right eye Left eye
2. Rifrazione..................Occhio destro..........................Occhio sinistro......................
3. Sight Right eye Left eye
3. Visus........................Occhio destro..........................Occhio sinistro......................
4. Crepuscular vision
4. Visione crepuscolare..
5. Field of vision..
5. Campo visivo..
6. Campo di sguardo..
7. Accommodation Right eye Left eye
7. Accomodamento..........Occhio destro..........................Occhio sinistro......................
8. Stereoscopic vision
8. Visione stereoscopica..
9. Color vision
9. Senso dei colori..

III. EAR EXAMINATION.
III.—ESAME OTORINOIATRICO.

1. Auditory apparatus
1. Apparecchio uditivo:
(a) Objective examination
(a) esame obiettivo..
(b) Auditory acuity
(b) acuità uditiva..
2. Nose
2. Naso:
(a) Objective examination
(a) esame obiettivo..
(b) Perviousness
(b) pervietà..
3. Pharynx
3. Faringe..

171364—20——19

IV. EXAMINATION OF VESTIBULAR APPARATUS.
IV.—ESAME DELL'APPARECCHIO VESTIBOLARE.

1. Dynamic
1. Dinamico:
   (a) Rotation
   (a) rotazione..
   (b) Gait
   (b) deambulazione..
2. Static
2. Statico:
   (a) Verticality (falling test)
   (a) verticalità..
   (b) Inclination.
   (b) inclinazione..

V. REACTION TIMES.
V.—TEMPI DI REAZIONE.

	Mean value (with error) and extreme values. Valore medio (con errore) e valori estremi		Normal deviation (with error). Deviazione normale (con errore)	Coefficient of variability. Coefficiente di variabilità	Errors %. Errori %.
1. Visible without previous information 1. Visivo senza preavviso........	.... ± ...	(.../...)	... ± ...	....	....
2. Visible with previous information 2. Visivo con preavviso........	... ± ...	(.../...)	... ± ...	....	....
3. Hearing 3. Uditivo........	... ± ...	(.../...)	... ± ...	....	....

Remarks
Osservazioni: ....
....

VI. TIME OF CHOICE AND DETERMINATION.
VI.—TEMPI DI SCELTA E DETERMINAZIONE.

1. Mean comprehensive value
1. Valore medio complessivo..
2. Ratio of mistaken reactions to the whole
2. Rapporto delle reazioni sbagliate sul totale..
3. Existence of systematic errors
3. Se esistono erroi sistematizzati..

Remarks
Osservazioni: ....

VII. EXCITABILITY EXAMINATION.
VII.—ESAME DELL' EMOTIVITÀ.

....
....
....

VIII. RESISTANCE TO PRESSURE VARIATIONS.
VIII.—RESISTENZA ALLE VARIAZIONI DI PRESSIONE.

Speed variations. Velocità delle variazioni	Diminution of pressure. Diminuzione della pressione	Diminished pressure. Pressione diminuita	Increase of pressure. Aumento della pressione
	Depression in mm... =ascent of m...in mm... Depressione mm. ...... pari a .....ascensione di m. ....in.... minuti	*Pressure in mm..... = ...meters per minute Pressione mm. .... pari a ...... m ...... per minuti........*	*Compression of....mm. =descent of ..m. in mm. Compressione di mm. .. pari a discesa da m. .... in .... minuti*
General behavior Comportamento generale........	....	....	....
Cardio-vascular reaction Reazione cardiovascolare........	....	....	....
Respiratory reaction Reazione respiratoria........	....	....	....
Hearing apparatus Apparecchio uditivo........	....	....	....
Remarks Osservazioni........	....	....	....

IX. PSYCHICAL EXAMINATION.
IX.—ESAME PSICHICO.

		Behavior (including all tests) Comportamento (dal complesso delle prove)
1. Speed of perception 1. Velocità de appercezione........	....	....
2. Extent 2. Estensione di appercezione........	....	....
3. Attention 3. Attenzione........	....	....

CONCLUSION.
GIUDIZIO COMPLESSIVO.

....
....
....

DECLARATION OF FITNESS.
DICHIARAZIONE DI IDONEITÀ.

....
....
....

The Director of the Office.
Il Direttore dell' Ufficio
....

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES.
UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL' AVIAZIONE.

III. EXAMINATION OF EAR, NOSE, AND THROAT.
III. ESAME DELL' ORECCHIO, DEL NASO E DELLA GOLA.

No. / N........ Rank / Grado........ Corps / Corpo........
Surname and given name
Cognome e nome........
....
(Date)
(Data)........, ...
Anamnesi riguardante la specialità........
....
The undersigned declares that the above data are true and complete.
Il sottoscritto dichiara che i dati surriferiti sono veri e completi.
Signature
Firma........

	Right ear A D	Left ear A S
Objective examination Esame obbiettivo........		
Otoscopic examination Esame otoscopico........		

....
....
....
Rhinoscopic examination
Esame rinoscopico........
....
....
Pharyngoscopic, Rhinopharyngoscopic and laryngoscopic examination
Esame faringoscopico, rinofaringoscopico e laringoscopico........
....
....

Functional examination Esame funzionale		Right ear A D	Left ear A S
Hearing acuity Acuità uditiva........	Phonometer at .... meters Fonometro a........m. gradi	....	....
Whispering voice Voce afona........	Low .... meters Fonemi bassi........metri	....	....
	Medium Fonemi medi........metri	....	....
	Sharp Fonemi acuti........metri	....	....
	Standard watch Orologio campione........	....	....
	Tuning fork Esame coi diapason........	....	....

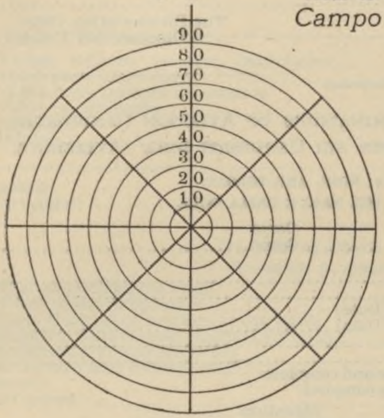
Perviousness of nasal passages:
Pervietà nasale:
Catheter in the nostril
Catetere nella narice..........
Inspiration pressure mm H_2O-
Pressione nell' ispirazione mm H_2O-..........
Expiration pressure mm H_2O+
Pressione espirazione mm H_2O+..........
Tracing
Tracciato
Remarks
Osservazioni..........
....
....
....
Conclusion
Risultato..........
....
....
....

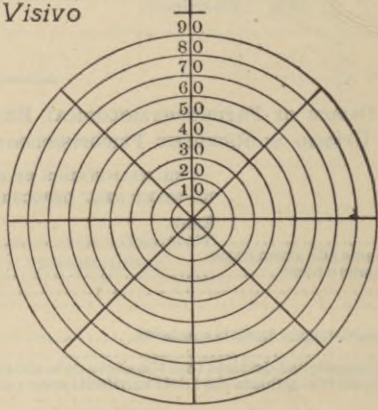
Signature
Firma..........

Right Eye
O D

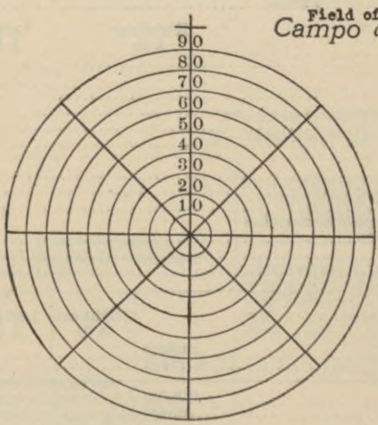
Field of Vision
Campo Visivo

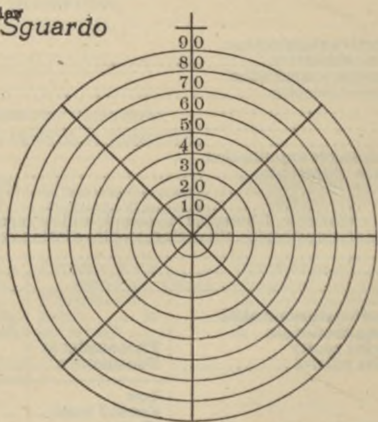
Left Eye
O S





Field of view
Campo di Sguardo





Signature
Firma

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS OF AVIATION CANDIDATES.
UFFICIO DI RICERCHE PSICOFISIOLOGICHE SUI CANDIDATI DELL' AVIAZIONE.

II. EYE EXAMINATION.
II. ESAME DELL' OCCHIO.

No. / N. .... Rank / Grado .... Corps / Corpo ....

Surname and given name
Cognome e nome ....
....

.................., Date / li ....

Past history as to eyes
Anamnesi riguardante la specialità ....

	Right eye O D	Left eye O S
Objective examination Esame obbiettivo		
Surrounding parts of eyeball Annessi		
Refracting media Mezzi rifrangenti		
Inner membranes Membrane interne		
Refraction Rifrazione		
Functional examination Esame funzionale: Visus		
Crepuscular vision and luminous sense Visione crepuscolare e senso luminoso: Photometry Fotometro		
Photometric tables Tavole fotometriche		
Field of vision Campo visivo		
Field of view Campo di sguardo		
Accommodation Estensione accomodativa		
Stereoscopic vision Visione stereoscopica		
Color sense Senso cromatico: Examination with the tables Esame con le tavole		
Examination with wool Esame con le lane		
Examination with instruments Esame con strumentale		

CREPUSCULAR VISION.
VISIONE CREPUSCOLARE.

With daylight sees at a distance of ..... meters Right eye test type No. .... Left eye test type No.....
Least visual angle Least visual angle
A luce diurna vede alla distanza di m .... O D segno N........... O S segno N...............
angolo visivo minimo = ... angolo visivo minimo = ...

		Minimum light required Luce sufficiente minima. Distance in cm. Distanza in cm.	Luminosity of the fundus Luminosita del fondo.									
			Initial Iniziale =1	9/10	8/10	7/10	6/10	5/10	4/10	3/10	2/10	1/10
R. E. O D	No. of smallest test type recognized N. del segno minimo riconosciuto											
	Corresponding visual angle in seconds Angolo visivo (Av) corrispondente in secondi											
	Visual angle 100 Av 100											
	Initial visual angle Av iniziale											
L. E. O S	No. of smallest test type recognized N. del segno minimo riconosciuto											
	Corresponding visual angle in seconds Angolo visivo (Av) corrispondente in secondi											
	Visual angle 100 100 Av											
	Initial visual angle Av iniziale											

Remarks
Osservazioni ....
....
....
....

Conclusion
Resultato complessivo ....

Signature
Firma ....

OFFICE OF PSYCHOPHYSIOLOGICAL EXAMINATIONS
UFFICIO DI RICERCHE PSICOFISIOLOGICHE
Of Aviation Candidates.
SUI CANDIDATI DELL'AVIAZIONE

VI. TIME OF CHOICE AND DECISION
VI. TEMPI DI SCELTA E DI DETERMINAZIONE

No. Rank Corps
N...................... (Grado)..................... (Corpo)..
Surname and given name
Cognome e Nome..
....

Torino, li..

Commands Comandi	Average values Valori Medi	Mean deviation Deviazione Media	Coefficient of variability Coefficiente Di Variabilità	Index of Error Indice Di Errore
1. Forward 1. Avanti..........	....	....	....	....
2. Backward 2. Indietro..........	....	....	....	....
3. To left 3. A sinistra..........	....	....	....	....
4. To right 4. A destra..........	....	....	....	....
5. Negative 5. (Negativo)..........	....	....	....	....
Mean values Valori medi......	....	....	....	....

Is there any regularity in the errors and what
Esiste ana regolarita negli errori e quale?..

....

....

DECISION

GIUDIZIO

....

....

....

Signature
Firma..

Series of successful tests
Serie delle prove successive

Reading watch
Letture orologio

2	....	3	....	5	....	1	....	4	....
4	....	1	....	2	....	4	....	3	....
1	....	2	....	5	....	2	....	5	....
5	....	4	....	3	....	1	....	2	....
3	....	1	....	1	....	3	....	1	....
5	....	3	....	4	....	4	....	2	....
1	....	2	....	3	....	2	....	1	....
2	....	5	....	5	....	5	....	3	....
4	....	4	....	2	....	3	....	5	....
3	....	5	....	1	....	1	....	4	....
1	....	2	....	4	....	4	....	3	....
4	....	3	....	5	....	2	....	5	....
......	....	......	....	......	....	......	....	......	....

REMARKS

OSSERVAZIONI

....

....

....

Values of reaction time for single commands
Valori dei TR ai singoli comandi

	Forward 1. Avanti		Backward 2. Indietro		Left 3. Sinistra		Right 4. Destra	
	N.	Valore dei TR	N.	Valore dei TR	N.	Valore dei TR	N.	Valore dei TR
	1		1		1		1	
	2		2		2		2	
	3		3		3		3	
	4		4		4		4	
	5		5		5		5	
	6		6		6		6	
	7		7		7		7	
	8		8		8		8	
	9		9		9		9	
	10		10		10		10	
	11		11		11		11	
	12		12		12		12	
Sum Somme								
Means Medie								
Extreme values Valori estremi								
Mean deviation Deviazione media								
Coefficient of variability Coefficiente di variabilità								
Errors Errori								

Errors
Errori

Quality of error. Qualita degli errori		Value of TR Valore dei TR
Comandi	Errori	

No. of errors
N.° Degli errori

at command 1	on 12
al Com. 1	su 12
" " 2	su 12
" " 3	su 12
" " 4	su 12
" " 5	su 12
Total	on 60
Totale	su 60

BRITISH AIR SERVICE.

[F. S. Form 205.]

Aviation Candidates' Medical Board, R. A. F.

EXAMINATION OF CANDIDATE FOR COMMISSION IN THE ROYAL AIR FORCE.

Rank and number.................... Name.................... Date.................... Age......

1. SURGICAL EXAMINATION.

Vision. R. E.................................... } With glasses..................................
L. E....................................

Color vision..
Physique..
Wounds and injuries..
Surgical abnormalities..
Mentality.. Initials........................

2. MEDICAL EXAMINATIONS.

Habits: Cigarettes and pipes p. d. Inhales........................ Alcohol { T. T........................ Moderate.................... Mod. B. B.................. }

Games and sports..
Occupation, civil life..
Army (period and unit)..
Foreign service { France.. Elsewhere.. }

Illnesses (to be underlined, and notes made below): Asthma, hay fever, malaria (residence in hot climate), rh. fever, digestive disturbances, nervous debility, migraine, petit mal, chorea, sea sickness, train sickness, operations, accidents, wounds, gassing, shell shock, concussion, syphilis, gonorrhea, other illnesses.

Family history. Tuberculosis, heart disease, nervous, mental.
Heart. Size..
Sounds..
Rate (I) at rest............................ (II) after exertion............................
(III) returning to normal..
Pulse. (I) Horizontal............................ (II) Raise............................
Thorax. Expansion..
*Vital capacity..
Breath held (I) at rest..
*(II) after exercise..
*Reasons for giving up..
Abdomen. Muscular tone..
*"Splashing"..
Nervous system. Deep reflexes..
Tremor, etc..
Mentality..
Summary..Initials........................

3. AURAL EXAMINATION.

History..
Hearing R. ear.................................... L. ear....................................
Membrane R.................................... L....................................
Teeth..
Pharynx..
Naso-pharynx..
Nose..
Muscle sense..
Nervous stability..
Vestibular stability..
Mentality..
Summary.. Initials..................................

4. ASSESSING.

Found:
Fit as..
Unfit as..
Temporarily unfit owing to..

Signature..
President Aviation Candidates' Medical Board.
Date......................

[F. S. Form 48.]

Royal Air Force.

[Envelope to contain the medical history of an officer, probationer, warrant officer, N. C. O. or man of the air force.]

Name.. { Official No. or Date of Commission }....................
(Surname first.)
Rank..

---

* These tests need only be applied in doubtful or special cases.

(1) This envelope is to contain the flimsy copies of F. S. Forms 35, 39, 40, 42, 44, and 46.
(2) It is to be kept in the station office with other personal papers. It is to be treated as strictly confidential.
(3) On the transfer of the officer or man whom it concerns to another station or hospital (whether Air Force, Naval, Military or Civil) it is to be forwarded with other personal papers to the commanding officer, of the station or hospital to which the transfer is made.

Medical category.	Unit.	Station or hospital.	Station or hospital transferred to—or—inoculation or vaccination.	Date.	Date of forwarding.
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

[F. S. Form 35.]

Entry Card, Royal Air Force.

Unit.......... Date..........
Squadron, wing, etc.......... Height..........
Rank.......... Official No. or date of commission..........
Name..........
Age.......... Weight.......... Where recruited..........
Residence (town and county only)..........
Address of nearest relative..........
Body marks..........
Vision:
Right eye..........+2
Left eye..........+2
With glasses..........
*Color vision..........
Physique..........
Wounds and injuries..........
Surgical abnormalities..........
Mentality..........
Summary (surgical)..........
*Habits:
Smoking..........
*Alcohol..........
*Any special athletic record..........
Previous occupation (civil)..........
Army: Period and unit.......... Foreign service..........
Illnesses..........
*Family history..........
Heart: Size..........
Sounds..........
*Rate (*see* F. S. Form 36)—I.......... *II.......... *III..........
Pulse—*I.......... *II..........
Thorax—expansion.......... *Vital capacity..........
*Breath held—(i) At rest.......... *(ii) After exercise..........
*Reasons for giving up..........
*Abdomen..........
*Nervous system:
Deep reflexes..........
*Tremor..........
*Mentality..........
*Summary (medical)..........
Hearing..........
Teeth..........
Nose..........
*Muscle sense..........
*Nervous stability..........
*Mentality..........
Summary (aural)..........
....
Signature of medical officer..........

[F. S. Form 39.]

Royal Air Force.

Discharge Card, U. K.

[All Air Force cases except from expeditionary forces.]

Name of hospital or station..........
Serial No. in admission list (F. S. Form 38)..........
Unit..........
Official No. of date of commission..........
Squadron, wing, etc..........
Rank..........
Grading..........

*These items need not be filled up for ground duty candidates.

Name ....
Age .... Total service ....
Date of arrival at hospital:
(*a*) As an admission ....
(*b*) As a transfer (state where from) ....
Date of discharge:
To duty ....
By change of disease ....
As an invalid ....
Date of death ....
Date of transfer (state where to) ....
Number of days under treatment ....
Observations (to be filled in by the medical officer in charge of case):
*Disease ....
Operations ....
Result of operation ....
Complications in order of occurrence ....
....
....
Signature of medical officer ....
One of these cards is to be completed for every patient of Air Forces received into hospital, except those from expeditionary forces.

[F. S. Form 40.]

ROYAL AIR FORCE.

DISCHARGE CARD FOR EXPEDITIONARY AIR FORCE CASES.

.... Hospital or Station.
State from which Force .... Serial No. in Admission List (F. S. Form 38) ......
Unit ....
Official No. or Date of Commission ....
Squadron, Wing, etc. ....
Rank ....
Grading ....
Name ....
Age .... Total Service ....
State Service with Field Force in Months ....
(Last period only if more than one)
(*a*) Date of arrival at hospital as an admission ....
(*b*) As a transfer (state where from) ....
Date of discharge to duty ....
Date of discharge by change of disease ....
Date of discharge as an invalid ....
Date of death ....
Date of transfer (state where to) ....
(Name of hospital to be given)
No. of days under treatment ....
Observations ....
To be filled in by the medical officer in charge of case ....
Disease (final diagnosis)* ....
Operations ....
Result of operation ....
Complications in order of occurrence ....
....
....
....
....
....
....
....
Signature of medical officer ....
One of these Red cards is to be completed for every Expeditionary Force patient of Air Forces received into hospital. Black cards for U. K. Air Force.

[F. S. Form 44.]

ROYAL AIR FORCE.

REPORT OF ACCIDENT TO A FLYING OFFICER, PROBATIONER OR N. C. O. (FLYING).

Unit .... Official No. or date of commission ....
Squadron and wing ....
Rank and grading .... Age ....
Name ....
History of accident:—Date .... Locality ....
Name and type of machine ....
Did machine catch fire? ....
Was fire extinguisher fitted? ....
Were telephones fitted? ....
Exact position of airman when found ....
Was he pinned by any part of machine? ....

---

* To be in accordance with the official nomenclature.

Was there blood, hair, etc., on any part of machine?
Was he pilot or passenger?
Was any mishap observed?
At what stage of flight did accident occur?
Helmet worn and type
Goggles and type
Belt and type
Did belt give way?
Nature of injuries

Nature of aid rendered

Condition after accident, unconsciousness, etc.
Any headache? Any vomiting?
Signs of fracture of base
Nightmare?
No. of hours flying done
Health immediately before accident
Date of last special report
If fatal, state exact cause (if thrown out, head struck, etc.)

Chief injuries observed at post mortem

Signature of medical officer

[F. S. Form 35.

Entry Card, Royal Air Force.

Unit Date
Squadron, wing, etc. Height
Rank Official number or date of commission
Name
Age Weight Where recruited
Residence (town and county only)
Address of nearest relative
Body marks
Vision {R. E. / L. E.} +2 With glasses
*Color vision
Physique
Wounds and injuries
Surgical abnormalities
Mentality
Summary (surgical)
*Habits—Smoking
*Alcohol
*Any special athletic record
Previous occupation (civil)
Army, period and unit Foreign service
Illnesses
*Family history
Heart (size)
Sounds
*Rate (*see* F. S. Form 36)—I *II *III
Pulse—*I *II
Thorax—Expansion *Vital capacity
*Breath held—(i) At rest * (ii) After exercise
*Reasons for giving up
*Abdomen
*Nervous system—Deep reflexes
* Tremor
*Mentality
*Summary (medical)
Hearing
Teeth
Nose
*Muscle sense
*Nervous stability
*Mentality
Summary (aural)

Signature of medical officer.

Sickness and inoculations (for use at air ministry only).

Serial No.	Disease or injury or inoculation.	Hospital or station.	Date of admission or inoculation.	Date of discharge.

* These items need not be filled up for ground duty candidates.

[F. S. Form 42.]

ROYAL AIR FORCE.

SPECIAL REPORT ON A FLYING OFFICER, PROBATIONER OR OTHER FLYING RANK.

Hospital or station.. Date..............................
A (i) Name........................(ii) Age................(iii) Weight........................
Rank and grading (official number or date of commission)..
(iv) Total number of hours flying.................. (v)Maximum flying height (feet)...................
(vi) Average flying height (feet).................. (vii) Average hours flying per week..................
(viii) Nature of aerial work..
B Habits—(i) Smoking.....................(ii) Alcohol..
C (i) Condition of lungs..
(ii) Respiratory rate and movement...
(iii) Time breath held in seconds.......................... (iv)................................
(v) Time breath after exercise.....................(vi) Expiratory force.................. mm. Hg.
D (i) Condition of heart and pulse...
(ii) Pulse rate at rest............................ (iii) After regulated exercise..................
(iv) Time of return to normal (seconds)..
(v) S. P...................... D. P...................... P. P..............................
(vi) Evidence of defective peripheral circulation...
E (i) Condition of muscles (generally)..
(ii) Condition of abdominal and respiratory muscles.......................................
(iii) Condition of stomach (*e. g.* splashing)..
F (i) Knee jerks.................................... (ii) Other reflexes...........................
(iii) Tremor (fingers, eyes, tongue)..
Drawing line..
(iv) Sleep...
(v) Self-balancing (at rest)......................... (vi) In action.............................
(vii) Vision..
(viii) Mentality..
G Fatigue test (U tube, etc.)..
....
H Urinary system—(i) Albuminuria...................... (ii) Glycosuria.............................
(iii) Venereal disease, history or signs of..
J (i) Condition of ears..
(ii) Condition of tonsils, etc...
(iii) Condition of teeth, etc..
(iv) Any special conditions of other systems..
K General opinion..
....
....
....
....
Signature and rank of medical officer.

[When used to report on a cadet or P. F. O. the other side should be used also.] [P. T. O.]

WHEN USED FOR CADET THIS SPACE ALSO SHOULD BE FILLED UP

Length of time under training...
Number of hours dual..
Summary of report by C. O. (temperament, suitability, etc.)...................................

[F. S. Form 37.]

ROYAL AIR FORCE.

ROUGH NOTES OF MEDICAL OFFICER FOR FILLING UP ENTRY CARD F. S. FORM 35, WHEN USED FOR CANDIDATES FOR GROUND DUTIES ONLY.

Unit............................... Date...............................
Squadron, Wing, etc............................ Height.............................
Rank.................................... Official No.........................
Name (surname first)...
Age..................... Weight.................... Where recruited................................
Residence (town and county only)...
Address of nearest relative...
Body marks..
Vision—R. E...................L. E.................... With glasses..............................
Physique..
Wounds and injuries...
Surgical abnormalities..
Mentality...
Summary (surgical)..
Previous occupation, civil..
Army.................................. Foreign service...................................
Illnesses...
Heart—Size.............................. Sounds...
Thorax—Expansion..
Hearing...
Teeth...
Summary...
Signature of medical officer..

[F. S. Form 41.

ROYAL AIR FORCE.

ROUGH NOTES OF MEDICAL OFFICER FOR FILLING UP DISCHARGE CARD F. S. FORM 39 OR 40.

Name of hospital or station...
Serial No. in admission list (F. S. Form 38)...
Unit... Squadron, wing, etc...
Rank and grading... Official No. or date of commission...
Name (surname first)...
Age... Total service...
Date of arrival—(*a*) as an admission...
(*b*) as a transfer (state where from)...
Date of discharge to duty...
Date of discharge by change of disease...
Date of discharge as an invalid...
Date of discharge death...
Date of transfer (state where to)...
No. of days under treatment...

[To be filled in by the medical officer in charge of the case.]

Observations:
Disease (in accordance with official nomenclature)...
Operations...
Result of operation...
Complications in order of their occurrence...
Signature of medical officer...

[F. S. Form 36.]

ROYAL AIR FORCE.

ROUGH NOTES OF MEDICAL OFFICER FOR FILLING UP ENTRY CARD F. S. FORM 35 FOR CANDIDATES FOR AVIATION DUTIES.

Unit... Date...
Squadron, wing, etc... Height...
Rank... Official No...
Name (surname first)...
Age... Weight... Where recruited...
Residence (town and county only)...
Address of nearest relative...
Body marks...
Vision {R. E... / L. E...} +2. With glasses...
Color vision...
Physique...
Wounds and injuries...
Surgical abnormalities...
Mentality... Initials of M. O...
Habits. Smoking, cigttes. and pipes, p. d. Inhales. Alcohol {T. T... / Moderate... / Mod. B. B...}
Any special athletic record...
Occupation, civil...
Army (period and unit)...
Foreign service {France... / Elsewhere...}
Illnesses...
Family history...
Heart. Size...
Sounds...
Rate I. At rest... II. After exertion... III. Returning to normal...
Pulse I. Horizontal... II. Raised...
Thorax. Expansion... Vital capacity...
Breath held—I. At rest... II. After exertion...
Reason for ceasoning...
Abdomen {Muscular tone... / Splashing...}
Nervous system. Deep reflexes...
Tremor, etc...
Mentality...
Summary (medical)... Initials of M. O...
History (aural)...
Hearing {R. ear... L. ear... / Membrane, R. ear... L. ear...}
Teeth...
Pharynx...
Naso-pharynx...
Nose...
Muscle sense...
Nervous stability...
Vestibular stability...
Mentality...
Summary (aural)...
Initials of M. O...

[F. S. Form 43.]

Royal Air Force.

ROUGH NOTES OF MEDICAL OFFICER FOR FILLING UP F. S. FORM 42, SPECIAL REPORT ON A FLYING OFFICER, PROBATIONER, ETC.

Hospital or station .... Date ....
A. (i) Name .... (ii) Age .... (iii) Weight ....
Rank and grading .... Official No. or date of commission ....
(iv) Total number of hours flying .... (v) Maximum flying height ....
(vi) Average flying height .... (vii) Average hours per week ....
(viii) Nature of aerial work ....
B. Habits: (i) Smoking .... (ii) Alcohol ....
C. (i) Condition of lungs ....
(ii) Respiratory rate and movement ....
(iii) Time breath held, in seconds .... (iv) Reasons for ceasing ....
(v) Time breath held after exercise, in seconds .... (vi) Expiratory force .... mm. Hg.
D. (i) Condition of heart and pulse ....
(ii) Pulse rate at rest per minute ....
(iii) Pulse rate after regulated exercise ....
(iv) Time of return to normal, seconds ....
(v) Systolic pressure .... Diastolic pressure .... Pulse pressure ....
(vi) Evidence of defective peripheral circulation ....
E. (i) Condition of muscles generally ....
(ii) Condition of abdominal and respiratory muscles ....
(iii) Condition of stomach (*e. g.*, splashing) ....
F. (i) Knee jerks .... (ii) Other reflexes ....
(iii) Tremor (fingers, eyes, tongue) ....
Drawing line ....
(iv) Sleep ....
(v) Self balancing (at rest) ....
(vi) Self balancing (in action) ....
(vii) Vision .... (viii) Mentality ....
G. Fatigue test (U tube, etc.) ....
....
H. Urinary system: (i) Albuminuria .... (ii) Glycosuria, etc. ....
(iii) Venereal disease, history or signs of ....
J. (i) Condition of ears ....
(ii) Condition of tonsils, etc. ....
(iii) Condition of teeth, number requiring treatment, etc. ....
(iv) Any special conditions of other systems, skin, etc. ....
K. General opinion:
....
....
....

When used for a cadet:
Length of time under training ....
Number of hours dual ....
Summary of report by commissioned officer (temperament, suitability, etc.) ....
Signature of medical officer ....

[F. S. Form 45.]

Royal Air Force.

ROUGH NOTES OF MEDICAL OFFICER FOR FILLING UP F. S. FORM 44, REPORT OF AN ACCIDENT TO A FLYING OFFICER, PROBATIONER, ETC.

Unit .... Official No. or date of commission ....
Squadron, wing, etc. ....
Rank and grading .... Age ....
Name (surname first) ....
History of accident: Date .... Locality ....
Name and type of machine ....
Did machine catch fire? .... Was fire extincteur fitted? ....
Were telephones fitted? ....
Exact position of airman when found ....
Was he pinned by any part of the machine? ....
Was there blood, hair, etc., on any part of the machine? ....
Was he pilot or passenger? ....
Was any obvious mishap observed? ....
At what stage of flight did accident occur? ....
Helmet worn and type ....
Were goggles worn and type? ....
Belt and type? .... Did belt give way? ....
Nature of injuries ....
....
Nature of aid rendered ....
Condition after accident, length of unconsciousness, etc. ....
....
Any headache? .... Any vomiting? ....
Any signs of fracture of base? .... Any nightmare? ....
Number of hours flying done ....
Health immediately before accident ....
Date of last special report ....
If fatal, state exact cause (if thrown out, head struck, etc.) ....
....
Chief injuries observed at post-mortem ....
Signature of medical officer ....

[F. S. Form 38.]

Royal Air Force.

List of Cases Admitted and State of Station (or Hospital) During Week Ending (Saturday Night) ——————

I. Admissions, Inoculations, and Reinoculations, Vaccinations.

Serial No. of case.	Name.	Rank and grading.	Official No. or date of commission.	Date of admission.	Whence	Provisional diagnosis or inoculation, etc.	Probable duration of treatment.	Remarks.	Date of discharge.	Number of days sick.
									For use at Air Ministry only.	

II. LIST OF CASES EXCUSED FLYING.

III. CHANGES OF DIAGNOSIS DURING THE WEEK.

NUMERICAL STRENGTH.

Units at station.	Pilots.	Observers.	K.B.O.	Other officers.	Wt. officers (flying).	N. C. O's (flying).	Other W.O's.	Other N. C. O's.	Men.	Total officers.	Total men.

STATE OF SICK QUARTERS OR HOSPITAL.

Number of beds equipped..

Number of cases in sick quarters..

Weather and flying.

	Number of hours flying.	Weather.
Sunday..........	....	
Monday..........	....	
Tuesday..........	....	
Wednesday......	....	
Thursday........	....	
Friday..........	....	
Saturday........	....	

....

Signature of medical officer in charge.

AIR SERVICES OF THE CENTRAL POWERS.

K. U. K. (Royal and Imperial) Army High Command, Chief of Air Service.

Health Report.

Record No. ....

PERSONAL HEALTH RECORD FOR THE AIR SERVICE. (AVIATORS, BALLOONISTS) OF ....

Surname and Christian name..........
Rank..........
Age..........
Last arm of service before applying..........
Employed with the K. U. K. air forces since when..........
As..........
Date of examination..........
....
....
....

Military Medical Examination Office for the Air Service.

[Student pilots and observers, aircraft pilots and observers, airship personnel (captive and dirigible balloons).]

K. U. K. MILITARY HOSPITAL NO. 1 IN VIENNA.

Record or register number..........
Place of appointment..........
Purpose of examination (original examination, reexamination, confirmation)..........
....
Surname and christian name..........
Rank..........
Birth date..........
Last arm of service before applying..........
Employed with the K. U. K. Air Forces since when..........
As..........
Examination day..........
....
....
....

A. PREVIOUS HISTORY.

I. The answers to questions 1-29 are, so far as possible, to be filled out by the person being examined and affirmed by his signature.

Questions 1-10 refer to the candidate for flying.

1. Has there been any case of mental disorder, nervous diseases (epilepsy) among his parents, brothers, sisters, or other near relatives?..........
   Is there in his family any case of tuberculosis of the lungs or other organs? ....
2. Has the applicant himself ever suffered from severe bodily sickness or nervous diseases: Such as unconsciousness, dizziness, cramps, nightmares, bed-wetting, etc? When and how long? ....
   Has the applicant suffered syphilitic infections and did it receive professional medical treatment? ....
   ....
3. Has he as a boy or later engaged in athletic sports and which? ....
4. Has he in connection with athletic sports or other activity suffered any accident? ....
   What bodily injuries, especially concussion of the brain and broken bones, resulted therefrom? ......
   ....
   Did he have any nervous trouble as the result of such action? Of what nature and how long? ....
   ....
5. Has he any tendency to dizziness (in swinging or dancing) or to sea or mountain sickness?..........
   Does he suffer from palpitation of the heart or colic?..........
6. Has he, from examinations in school or later in connection with his work or from any other causes, exhibited occasional nervous symptoms (headache, uneasiness, lack of mental concentration, becoming easily fatigued, sleeplessness, melancholia, etc.) and how long? ....
7. What was his civilian occupation before entering the air service or military service? ....
8. Was he employed at the front before entering the air service and in what capacity? ....
9. During this time, did he show symptoms of organic diseases, especially of the heart, lungs, and ears, or signs of nervous exhaustion (when and how long) and to what cause were they traced?..........
   ....
   Has he suffered from injuries or wounds? ....
   When? ....
   Describe them. (Hemorrhage.) What complications resulted and how long was treatment required?
   ....
   When did he begin service at the front again? ....
10. Why was he transferred to the air service? ....

Questions 11-29 apply to active aviators or balloonists.

11. Where, and by what medical commission, was his fitness for the Air Service determined? ....
    ....
12. Date and report of this confirmation ....
13. When and where was he trained as pilot or observer? ....
    ....
14. To what aviation school does he belong? ....
    Is he a student pilot or observer? ....
    Is he pilot, observer, aircraft gunner, radio operator, or balloonist? ....
15. Has he had any sickness during his education? What, when, and how long? ....
    ....

171364—20——20

16. During his training has he been involved in any special difficulties; for example, unlucky landing (break, crash), bad starts, etc., and did he thereby receive any bodily injury or contract any nervous trouble?
Was he on that account obliged to give up flying for a time? Did his self-possession and confidence suffer?
How long did these disturbances continue?
17. After how long a time and after how many flights, and how many flights alone, did he take the prescribed tests?
When did he come to an aerodrome, to a flying division or to a combat or bombing squadron, etc.?
18. Number of flights made up to date; average duration and altitude?
How does the candidate get along with flying in dense fog, clouds, or in the dark?
Can he do the loop?
19. How many flights or air trips, ascents in a captive balloon over the enemy lines, or how many tasks has he executed (air siege)?
Were most of the flights made over high mountains or level land or the ocean?
20. Was he frequently and successfully under fire and how did it affect his nervous system, his self-confidence, and how long did such disturbances last?
21. Was his airplane (or balloon), his pilot (or observer), or he himself hit during these flights (ascents or trips), or did he see another aircraft near him fall, burn, or the like?
Mention each occasion with date
How did these incidents affect his nervous system, his self-confidence, and how long did the consequent disturbances endure?
22. During his service at the front, did he experience forced landings, crashes and the like, or threatened disaster, although fortunately escaped, like plunging of the airplane with recovery, catching on fire, which was extinguished before landing, plunging into the sea, etc.?
Has he made parachute descents? Mention each instance of the above incidents with date and cause
State whether or not injuries resulted
How did these events affect his self-confidence, and how long did the consequent disturbances last?
23. Did he get into difficulty during flights over enemy territory through stalling of the engine or strong head wind or shortness of fuel or other causes (squalls, thunderstorms, the sea)?
How did these events affect his nervous system, his self-confidence, and how long did the consequent disturbances last?
24. When did he first notice bodily or nervous disorders and in what form did they appear?
(a) Disorders before flights or balloon ascensions (uneasiness, anxiety, palpitation of the heart, etc.)
(b) Disorders during or immediately after flight in an airplane or captive balloon
During rapid ascent (pressure in his ears, feeling of suffocation, etc.)
During rapid descent (pressure on his ears, temples, forehead, headache, numbness, feeling of becoming dark before his eyes, shortness of breath, etc.)
During steep spiral flight (dizziness, etc.)
While remaining at high altitudes:
At what altitude do the troubles begin and when do they disappear again?
Did the high flights first have bad effects, after the appearance of other nervous troubles apart from flying (feelings of suffocation, numbness, sleepiness, anxiety, distress, heart trouble, dizziness, vomiting, etc.)?
Did the inhalation of oxygen always produce prompt results
From escaping gas, oil vapor, etc. (headache, distress, vomiting, etc.) In which type of airplane or airship?
From engine noise: (deafness, weakening of ability to distinguish, etc.)
From wind and cold (frostbites, chafing from the goggles, irritation of the upper air passages, rheumatism, etc.)
From the strong light (inflammation of the eyes, disturbances of vision)
From physical exertions in steering, operating machine gun, etc. (pains and cramps in the muscles, exhaustion of certain muscles, general exhaustion, etc.)
Injuries on an airship
(c) Troubles during periods of relief from flying:
25. Since his training, has he had any illness?
What, when, and how long?
26. Has his mental activity during this time been influenced in any manner?
27. When and how long has he already had furloughs or been under medical care and with what results
Did he regain his accustomed confidence as flyer after his furlough?
28. Did the disorders come on gradually or by what circumstances were they hastened?
What causes started the present disorders or increased them to such an extent that the examinee believes himself compelled to relinquish his occupation temporarily or permanently?
29. Describe any other troubles not above enumerated

Signature of

B. PRELIMINARY DOCUMENTS.

What knowledge or observations of his superiors or of the Army doctor tend to official confirmation of the advisability of granting a furlough for recuperation or initiating proceedings for discharge? (Report of injury, doctor's certificate, protocol, petition, etc.)

C. REPORT OF EXAMINATION COMMISSION.

I. EYE.

Record No.
Position and movements of the eyes and lids

Condition of the lid edges, conjunctiva, and lachrymal organs....................
Functioning of the muscles of the lid and eye (squinting and seeing double)....................
Visual acuity: R.................... with D.
Visual acuity: L.................... with D.
Field of vision, perimeter (scotoma)....................
Vision for distance....................
Color vision: (Do any of his relatives have color blindness?)....................
Adaptation and night sight....................
Eye fundi....................

....
Signature.

II. EAR.

Mirror examination of nose, the nose-throat cavity (side cavities)....................
Mirror examination of ears (residue of secretions of the middle ear)....................
Obstructions of auditory canal....................
Acuity of hearing: R....................
Acuity of hearing: L....................
Ability to distinguish sounds....................
High and low tones (hearing relief, according to Von Bezold)....................
Rinne test....................
Schwabach test....................
Weber test....................
Testing sense of balance or equilibrium (static sense)....................
Statements concerning subjective dizziness....................
Spontaneous nystagmus....................
Chair rotated to the R....................
Chair rotated to the L....................
Caloric reaction (most favorable positions)....................
Galvanic reaction....................
Hearings in space, sense of angular speed....................

....
Signature.

III. SURGICAL SECTION.

Residuum of healed wounds or injuries (adherent scars)....................
Functional defects of the larger muscle groups (ankylosis)....................

....
Signature.

IV. PHYSICAL EXAMINATION—INTERNAL MEDICINE.

Record No....................
Ordinary bodily characteristics, appearance, condition (thymolymphatic status) bearing and gait....................
Alcohol....................
Tobacco....................
Height.................... Weight....................
Shape and mobility of chest (measurement expanded and contracted), breathing, lung capacity....................
Condition of the respiratory organs....................
Condition of the circulatory organs....................
Size and form of heart (orthodiagram)....................
Heart rhythm (liability)....................
Pulse rate, in rest....................
Pulse rate after knee-bending....................
Blood pressure, in rest....................
Blood pressure, after knee-bending....................
Functional or organic disorders of the heart....................
Malaria....................
Stomach-intestine-tract (colic)....................
Urinalysis (was diabetes observed in the family?)....................

....
Signature.

V. NERVES (PSYCHOLOGICAL EXAMINATION).

Record No....................
Neuro and psychopathic constitution....................
Sense of power and muscular strength, of rest and motion (kinetic sense)....................
Coordination (walking up an inclined plane with eyes closed)....................
Reflexes....................
Babinski....................
Gordon....................
Kernig....................
Oppenheim....................
Rossolino, etc....................
Sensibility (power of feeling)....................
Noticeable symptoms of irritation (neuralgia, migraine, etc.)....................
Psychopathic reactions....................
Reaction time for hearing....................
Reaction time for sight....................
Reaction time for touch....................
Reaction time for fright....................
Effect of fright on respiration and circulation....................
Attention....................
Choice or decision (division of attention)....................
Suggestibility....................
Will preparedness....................

Fatigability..
Space perimeter..
Estimating distance...
Are there functional or organic disorders?...

....
Signature.

NET RESULT OF EXAMINATION: JUDGMENT.

The examined is, on the ground of official examination (recommended or not) to active air service, as pilot, observer, balloonist...
....
....
....

PROPOSAL.

The examined is to be relieved from active air service until ....
A furlough will be granted of .... The examined must present himself .... for a new examination or confirmation.
(date).

....
Signature.

PRESENT ORDERS ON THE PHYSICAL EXAMINATION OF FLIERS IN U. S. AIR SERVICE.

[Regulations governing "Physical Examination for Flying" are contained in Special Regulations No. 65c.]

WAR DEPARTMENT,
OFFICE OF THE DIRECTOR OF AIR SERVICE,
Washington, September 29, 1919.

ORDERS
No. 45.

1. Orders No. 31, O. D. A. S., July 24, 1919, are rescinded and the following substituted therefor:

2. All applicants for heavier or lighter-than-air flying training will be subjected to a rigid physical examination before being authorized to proceed with such training. These examinations will be made only by such medical officers as are authorized in writing by the Surgeon General of the Army to conduct such examinations and will be conducted as prescribed in existing orders.

3. A record of the examination, in triplicate, will be made on Form 609, A. G. O. Two copies will be forwarded to this office direct, attention Chief Surgeon, Air Service, and the third copy retained by the Flight Surgeon at the station of the candidate. Upon receipt of the two copies of Form 609 at this office, they will be approved or disapproved by the Chief Surgeon, Air Service, and one copy returned to the station from which received and one copy retained in this office for permanent file.

4. Upon receipt back at the station of the copy of Form 609, the action of this office contained thereon will be transcribed to the retained copy of the form and the same certified as a "true copy"; candidates will not be allowed to proceed with their flying training until an approved copy of Form 609 in their case has been received back at the station.

5. Whenever an individual is transferred to another station, the copy of Form 609, with the action of this office certified thereon, as provided in Par. 3 above, will be forwarded to the Flight Surgeon of the new station. The other copy of Form 609 will be retained at the station for permanent file.

6. Commanding officers of Air Service stations will require the Flight Surgeon or Post Surgeon in the absence of the former, to investigate the physical examination records of all commissioned and enlisted personnel engaged in flying or under flying instruction.

7. A report of this investigation covering the flying personnel, as of November 1, 1919, for all personnel for whom reports have not been submitted under the provisions of Par. 6, Orders No. 31, O. D. A. S. (rescinded by this order) giving name, rank, and organization and whether qualified or disqualified for flying status, as shown by the record on Form 609, will be forwarded through the commanding officer to this office, attention Chief Surgeon, Air Service. If the record on Form 609 is not found, or is incomplete in any case, these facts will also be reported.

8. In cases where the physical examination record is incomplete, unsatisfactory or missing, the commanding officer will immediately direct discontinuance in flying until the physical qualifications have been properly determined, recorded, and certified, as required by this order. This restriction will not apply to officers who have

already received either the reserve military aviator, junior military aviator, military aviator, observer, reserve military aeronaut, junior military aeronaut, or military aeronaut ratings.

9. Officers making physical examinations will under no circumstances waive physical defects.

10. Reexaminations will be required from time to time, as deemed expedient by this office, or as considered necessary by commanding officers, to determine the physical fitness of any one to continue on flying training or duty. Commanding officers are authorized, upon recommendation of the flight surgeon, to suspend the flying training of, or to relieve from flying duty, any individual considered physically incapacitated, and to authorize the resumption of such training when the individual is found physically fit. Whenever such incapacity is not the result of a disability incurred as a result of participation in aerial flights, the individual will be relieved from flying status until the disability is removed.

11. No rating as reserve military aviator, junior military aviator, military aviator, observer, reserve military aeronaut, junior military aeronaut, or military aeronaut will be given until the report of the board of officers received at this office has been furnished the Chief Surgeon, and same has been received back from the Chief Surgeon with a statement to the effect that the candidate is considered physically qualified for the rating recommended. A copy of the statement will be filed with the report of the board of officers on the candidate under consideration.

12. Attention is invited to the provisions of G. O. No. 63, W. D., 1914. G. O. No. 13, W. D., 1917, Special Regulations No. 50, W. D. (Aviation Section, Signal Corps), and Circular No. 49, O. D. A. S., 1919, which should be studied in connection with this order in so far as the physical examination of applicants for flying training is concerned.

By direction of the Director of Air Service:

WM. F. PEARSON,
Colonel, A. S. A., Administrative Executive.

WAR DEPARTMENT,
OFFICE OF THE DIRECTOR OF AIR SERVICE,
Washington, December 1, 1919.

ORDERS
No. 52.

1. The last sentence, paragraph 8, Orders No. 45, O. D. A. S., September 30, 1919, is rescinded.

2. All officers and enlisted men on flying status, including observers, "heavier or lighter-than-air" service, will be subjected to a physical reexamination on Form 609 in January and July of each year. These examinations will be made only by such medical officers as are authorized in writing by the Surgeon General of the Army to make physical examinations for flying training, and will be conducted and recorded as prescribed in Orders No. 45, O. D. A. S., September 30, 1919.

3. In cases where a 609 physical examination has been made since July 1, 1919, in compliance with Orders No. 31 or 45, O. D. A. S., 1919, a reexamination will not be required in January, 1920.

4. When the Medical Division of this office reports either an applicant for flying training or a flier as physically disqualified, the personnel division will issue an order definitely fixing the status of each individual case.

5. All persons on a flying status prior to rating as reserve military aviator, junior military aviator, etc., will be reexamined physically by a properly authorized medical officer, and a report submitted to this office on Form 609 as a part of the proceedings of the examining board.

6. A list of stations having medical officers authorized to conduct this examination will be furnished all commanding officers. At stations or places where the examination can not be made, the commanding officer will communicate with the Director of Air Service, giving names of officers and enlisted men who require examination under the provisions of this order.

7. Nothing in the provisions of this order will be construed to restrict commanding officers from removing a flier from flying duty whenever the physical condition of a flier warrants such action. Commanding officers are authorized to direct such other physical examinations from time to time as they may deem necessary. Whenever a flier has been removed from flying duty under the conditions mentioned in this paragraph, he will not be allowed to resume such duty until the flight surgeon, or the post surgeon in the absence of the flight surgeon, certifies that he is physically fit for flying duty.

8. The physical examination required for ratings of aviation and balloon mechanicians, by paragraph 310, Compilation of Orders, as amended by Changes No. 19, September 20, 1919, is not as complete a physical examination as is prescribed for fliers. No mechanician will, therefore, be allowed to take flying training or to pilot an airship until he has been found physically qualified by the prescribed physical examination for fliers (Form 609).

9. When officers or enlisted men, including those who are physically disqualified as pilots, are required to participate in frequent and regular aerial flights in the performance of duties other than those of pilots, the provisions of paragraph 1269½, Army Regulations, will govern the question of increased compensation. Under no circumstances will they be allowed to take flying training or act as pilots if they are physically disqualified for such duty.

10. Commanding officers of all Air Service stations are charged with the responsibility of enforcing the provisions of this order.

By direction of the Director of Air Service:

Wm. F. Pearson,
Colonel, A. S. A., Administrative Executive.

War Department,
Office of the Director of Air Service,
Washington, October 15, 1919.

Circular
No. 123.

1. Commanding officers of Air Service stations where flying is being carried on will consult with the flight surgeon in all matters pertaining to the mental and physical fitness of the flying personnel of his command. The term "flying personnel" will include all who make aerial flights, such as instructors, flying officers and individuals undergoing instruction.

2. Commanding officers will take full advantage of the assistance that can be rendered by the flight surgeon and the physical director of his field. Such matters as the amount and kind of physical exercise required by individuals engaged in flying; the state of fatigue of the individual flyer; the amount of sleep necessary; food problems; reexaminations and all field conditions affecting the welfare of the flying personnel will be made the subject of conferences between the commanding officer and the flight surgeon or physical director. Commanding officers should obtain the recommendation of the flight surgeon on application for leaves or furlough from any one engaged in flying when physical incapacity is made the basis of the application.

3. The flight surgeon will be listed on any form for clearance in vogue at an Air Service station, and no flying officer or any one undergoing flying instruction will be transferred from a station without first obtaining a clearance from that officer. Upon

notification of transfer, the flight surgeon will forward to the flight surgeon of the new station the reexamination report and laboratory rating chart of the individual being transferred. This will be in addition to Form 609, record of examination required to be forwarded to the flight surgeon of the new station, by Par. 4, Orders No. 31, O. D. A. S., 1919.

4. Flight surgeons will be encouraged in every way to take flying instruction. Upon completion of the prescribed test, flight surgeons will be rated in the same manner as other flying officers. Applications for flying training should be made through the surgeon to the station commander and will be accompanied by the necessary report of physical examination.

5. Upon recommendation of the surgeon, station commanders will authorize medical officers of the command, who are physically qualified and make application to take flying instruction. This will enable one of these officers to take the place of the flight surgeon when the latter for any reason is not available for that duty.

6. Unless an absolute necessity exists therefor, flight surgeons and physical directors will not be diverted from their regular duty to perform routine post administrative duties when this service can be performed by another medical officer. Flight surgeons and physical directors should devote all the time possible to the close and constant supervision over flying personnel, as indicated in paragraph 2.

7. The flight surgeon and the physical director of an Air Service station will not be detailed as a member of a board of officers convened to examine into the efficiency of a flying officer when it can be avoided. Their services will be of more value when called before a board as an expert witness, to give testimony relative to physical fitness, etc., of the officer under investigation.

By direction of the Director of Air Service:

Wm. F. Pearson,
Colonel, A. S. A., Administrative Executive.

Physical Examination for Flying.

.... Age..............
(Surname.) (Christian name.)

....
(Rank.) (Regiment or arm or corps or department.)

EYE EXAMINATION.

1. Visual acuity: R. E. .... L. E. ....
2. Depth perception at 6 meters .... mm.
3. Maddox Rod Screen Test at 6 meters:
   Eso. .... Exo. .... R. H. .... L. H. ....
4. Maddox Rod Screen Test at 33 cm.:
   Eso. .... Exo. ....
5. Prism divergence ....
6. Associated parallel movements ....
   ....
   Tangent curtain diagnosis ....
   ....
   Nystagmus ....
7. Inspection ....
   ....
   Pupils: equality ....; shape ....; reaction ....
8. Accommodation: R. E. .... D. L. E. .... D.
9. Angle of convergence: PcB..............mm. Pd..............mm. Angle..............°
10. Retinal sensitivity ....
11. Central color vision. R. E. .... L. E. ....
12. Field of vision. Form: R. E. .... L. E. ....
    Color: R. E. .... L. E. ....
13. Refraction (Homatropine). Tension ....
    R. E. .... L. E. ....
14. Ophthalmoscopic examination:
    R. E. ....
    L. E. ....

EAR EXAMINATION.

15. History of ear trouble:
(a) Ever have ringing or buzzing in either ear, earache, discharge or mastoiditis? ....
(b) Ever have attacks of dizziness from any cause? ....
(c) Ever been seasick? .... If so, how often..
and how long does it last? ....
(d) Ever had a severe injury to head? ....
16. (a) Appearance of external auditory canal: Right .... Left ....
(b) Appearance of membrani tympani: Right .... Left ....
(c) Hearing (watch, No. of inches; whisper, No. of feet).
Right ....inches; /40(40/40 normal) .... feet.
Left............inches; /40(40/40 normal) .... feet.

NASO-PHARYNX.

17. Condition of nares (if obstructed, state degree, character and cause):
Right ....
Left ....
18. Condition of tonsils and history of attacks of tonsilitis:
Right ....
Left ....
19. Presence of adenoids ....
20. Condition of eustachian tubes (if obstructed, state character and degree) after politzerization or per catheter ....
....
21. Equilibrium (vestibular), head tilted forward 30 degrees. Eyes closed. Rotation nystagmus normal 26 seconds, a variation of 10 seconds allowable:
(a) *Right:* Applicant to be turned toward his right, 10 turns in exactly 20 seconds, horizontal nystagmus to left for .... seconds.
Left: Applicant to be turned toward his left, 10 turns in exactly 20 seconds, horizontal nystagmus to right for .... seconds.
(b) Pointing tests:
(1) Before turning:
Right arm................................, left arm....................
(2) After turning 10 times in 10 seconds to right:
Right arm................................, left arm....................
(3) After turning 10 times in 10 seconds to left:
Right arm................................, left arm....................
(c) Falling tests:
(1) Turn to right, 5 turns in 10 seconds—Falls to..
(2) Turn to left, 5 turns in 10 seconds—Falls to..
22. Caloric Test when 21 is unsatisfactory.

Douche right ear.
Amplitude of eye movements.
After............Min. ....Sec.
Nystagmus.
Vertigo.
Past-pointing.
Falling.
Head back.
Amplitude of eye movements.

Douche left ear.
Amplitude of eye movements.
After............Min. ....Sec.
Nystagmus.
Vertigo.
Past-pointing.
Falling.
Head back.
Amplitude of eye movements.

23. Previous medical history.	DATE.	DURATION.	COMPLICATION.
(a) None..........	....	....	....
(b) Tonsilitis..........	....	....	....
(c) Scarlet fever..........	....	....	....
(d) Measles..........	....	....	....
(e) Mumps..........	....	....	....
(f) Pneumonia..........	....	....	....
(g) Typhoid..........	....	....	....
(h) Lues..........	....	....	....
(i) Gonorrhoea (acute)..........	....	....	....
(j) Rheumatism, No. attacks..........	....	....	....
(k) Asthma, No. attacks..........	....	....	....
(l) Hay fever, No. attacks..........	....	....	....
(m) Malaria, No. attacks..........	....	....	....

24. Temperature...................... Height.................inches. Weight......................pounds.
25. Chest measurement: Expiration....................inches. Inspiration.........................inches.
Waist measurement at umbilicus..inches.
26. Respiratory..
27. Bones and joints..
28. Skin..
29. Vascular system..
(a) Pulse: Rate (sitting)..................per minute; quality..
(b) Condition of arteries..
(c) Condition of veins..
(d) Blood pressure (sitting): Systolic.................... Diastolic..........................
(e) Heart..
1. Murmurs..
2. Arrhythmias..
(f) Hemorrhoids..

30. Digestive system..........

		Right.	Left.	
Missing teeth.	Upper,	8, 7, 6, 5, 4, 3, 2, 1	1, 2, 3, 4, 5, 6, 7, 8	(Strike out those that are missing.)
	Lower,	8, 7, 6, 5, 4, 3, 2, 1	1, 2, 3, 4, 5, 6, 7, 8	

31. Hernia..........
32. Genito-urinary system..........
33. Urinalysis:
    Specific gravity..........
    Reaction..........
    Casts..........
    Albumen..........
    Sugar..........

NERVOUS SYSTEM.

34. Family history of insanity or other nervous diseases..........
....
35. Intemperance: Tobacco.......... Alcohol.......... Drugs..........
36. Syphilis.......... Epilepsy.......... Dizziness..........
    Fainting.......... Headaches.......... Stammering..........
    Enuresis.......... Somnambulism.......... Insomnia..........
    Dreams..........
....
37. Memory.......... Will grasp.......... Phobias.......... Worries..........
    Anxieties.......... Conflicts..........
    Complexes.......... Irritability..........
    Apathy.......... Elation.......... Depression..........
....
....
38. Pupillary reactions.......... Secondary dilatation (Normal)..........
    (Prolonged)..........
39. Station..........
40. Patellar reflexes.......... Tic.......... Tremor..........
41. Psychomotor tension: Normal.......... Peripheral circulation:
    Increased.......... (Normal)..........
    Decreased.......... (Relaxed)..........
42. Is the candidate physically qualified for flying?
    If not, reason for disqualification..........
....

....
(Place.)

....

....
(Date.)

....
Medical Corps, U. S. A.

INSTRUCTIONS.

1. Physical examinations for flying will be made only by such medical officers as are authorized in writing by the Surgeon General of the Army to conduct such examinations and will be conducted as prescribed in Special Regulations Nos. 65 and 65c.
2. Officers making physical examinations will, under no circumstances, waive physical defects.
3. A record of the examination, in triplicate, will be made on this form. Two copies will be forwarded directly to the office of the Director of Air Service, attention Chief Surgeon, Air Service, and the third copy retained by the flight surgeon at the station of the candidate. Upon receipt of the two copies of this form, they will be approved or disapproved by the Chief Surgeon, Air Service, one copy retained for permanent file, and one copy returned to the station from which received.
4. Upon receipt back at the station of the copy of this form, the action of the Chief Surgeon, Air Service, contained thereon will be transcribed to the retained copy of this form and the same certified as a "true copy."
5. An applicant will not be allowed to proceed with his flying training until an approved copy of this form in his case has been received back at the station of the applicant.
6. Whenever an individual is transferred to another station, the copy of this form with the action certified thereon, as provided in paragraph 3 above, will be forwarded to the flight surgeon of the new station. The other copy of this form will be retained at the station for permanent file.

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