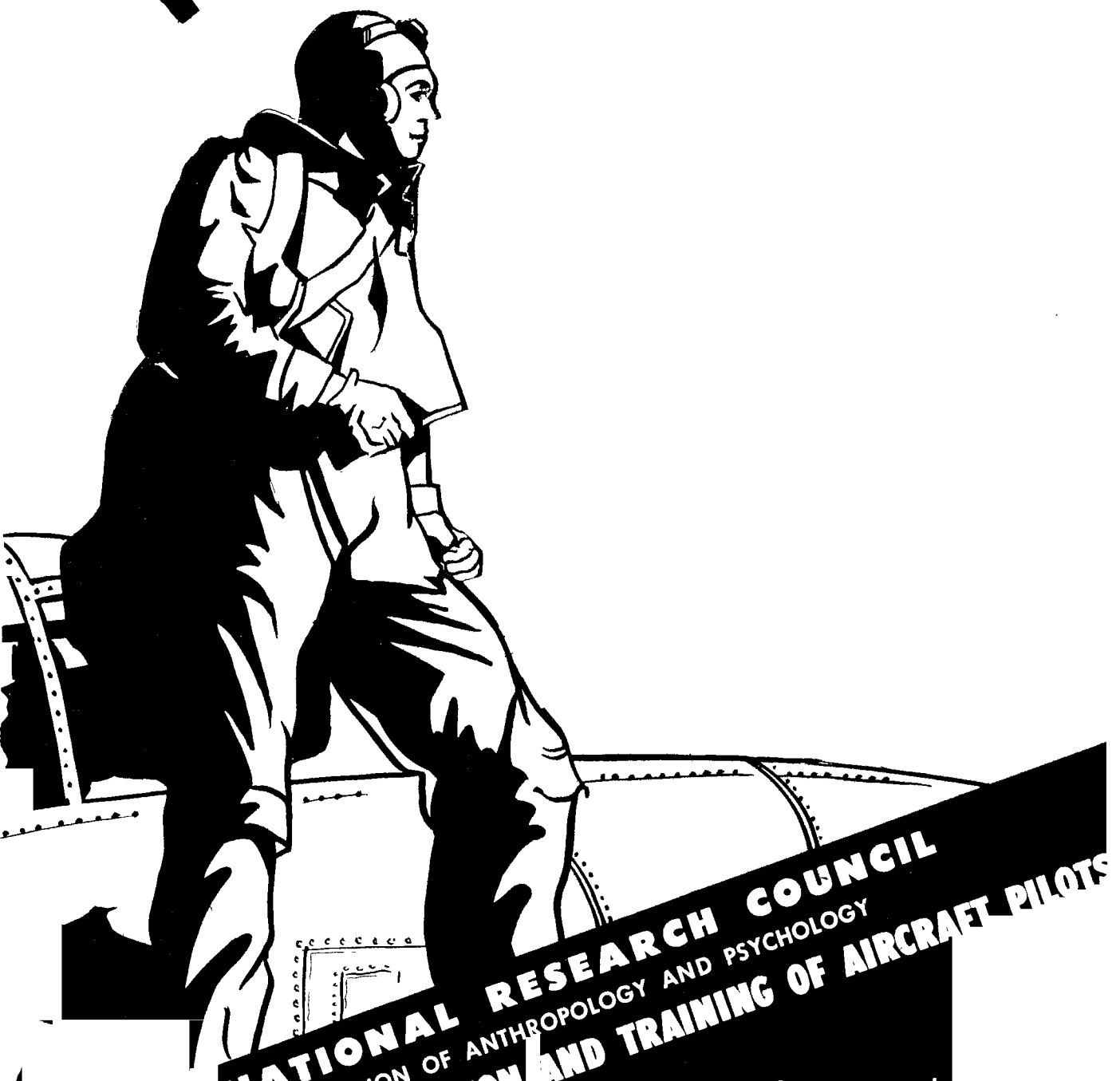
YEARS of RESEARCH

SUMMARY OF OUTCOMES



NATIONAL RESEARCH COUNCIL
DIVISION OF ANTHROPOLOGY AND PSYCHOLOGY
COMMITTEE ON SELECTION AND TRAINING OF AIRCRAFT PILOTS

A report to the
Division of Research
CIVIL AERONAUTICS ADMINISTRATION

NATIONAL RESEARCH COUNCIL
Division of Anthropology and Psychology
2101 Constitution Avenue
Washington, D. C.

THE AIRCRAFT PILOT

5 YEARS OF RESEARCH

A Summary of Outcomes

by

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COMMITTEE ON SELECTION AND TRAINING OF AIRCRAFT PILOTS

JUNE 15, 1945

A report to the
Division of Research
CIVIL AERONAUTICS ADMINISTRATION

COMMITTEE ON SELECTION AND TRAINING OF AIRCRAFT PILOTS

LIAISON OFFICERS

FOREWORD

In 1939 the Civil Aeronautics Authority (now the Civil Aeronautics Administration) undertook an ambitious program of training civilian pilots. The purpose of this was to make young men and young women air-minded and to prepare the present generation of young people to fly the private and commercial planes of the future. This program, known as the Civilian Pilot Training program, was operated through the universities of the country, making use of already established facilities in the hands of private operators while encouraging others to set up similar facilities.

The first phase of the Civilian Pilot Training program called for instruction of 10,000 pilots, which was quickly expanded to the number of 50,000. Almost simultaneously with the formulation of the program, largely through the efforts of Robert Hinckley, at that time Chairman of the Civil Aeronautics Authority, and Dean R. Brimhall, Director of Research, funds were set aside for research on selection and training of civilian aircraft pilots. This was done in the belief that an extended program of civilian pilot training should make use of every possible scientific aid for selecting those most competent to fly; for determining the best methods of training; for the appraisal of flight achievement, and for safe-guarding the adjustment of the pilot. Moreover, it was recognized that this large scale training program provided unusual opportunities for renewing the study of problems related to the human side of aviation which had been initiated during World War I and abandoned almost immediately with the signing of the Armistice.

In keeping with the operating philosophy of the Civil Aeronautics Administration, it was decided to undertake such research through existing agencies rather than to build and equip government operated research centers for this purpose. The National Research Council was therefore asked to establish a committee for the administration of research with funds allotted from the budget of the Civil Aeronautics Administration. In seeking the cooperation of the National Research Council, Mr. Hinckley wrote:

> "It is the desire of the Civil Aeronautics Authority to have the advice of scientific people in the field of psychology and physiology in making these studies. Furthermore, the Authority does not want to set up any new research laboratories, or any organization of its own to do so, but desires to use existing facilities at universities. We request, therefore, the assistance of the National Research Council, and ask that a committee be made up of men primarily from the Division of Anthropology and Psychology of the National Research Council to advise us in the procedure, including the best methods of distributing the financial help to the university laboratories at which such work will be done, the selection of the personnel to do the work, and similar problems." (Letter of 9/16/39.)

On the basis of this request, in the fall of 1939, the National Research Council appointed the Committee on Selection and Training of Civilian Aircraft Pilots (now the Committee on Selection and Training of Aircraft Pilots) including in its membership psychologists, physicians, physiologists, engineers, pilots, and representatives from the military services, with J. G. Jenkins, University of Maryland, as Chairman. Through an active Executive Subcommittee this group has for over five years conducted research at approximately 40 universities and other centers, including military establishments, scattered from coast to coast and from the Lakes to the Gulf under grants from the Civil Aeronautics Administration amounting to approximately $900,000.

The program has utilized not alone the skills of research men and resources of these universities where basic research projects were established (Appendix I), but has enjoyed the help of hundreds of other men and women and has made use of the facilities of almost 600 other centers participating in the activities of the Committee on Selection and Training of Aircraft Pilots. Research returns have been greatly extended through the contribution of such services and facilities by universities and other centers cooperating in the research program organized and supervised by the Committee on Selection and Training of Aircraft Pilots.

In general, the operation of the Committee on Selection and Training of Aircraft Pilots (Chart A) represents a striking example of research supported by a Federal agency which has allowed a unique amount of freedom from administrative restrictions while providing continuous stimulation and judicious oversight. For this, special credit is due to Dean R. Brimhall, Director of Research, Civil Aeronautics Administration. In addition, acknowledgment is owed to members of the Executive Subcommittee, a group of highly competent scientists who have given freely of their time and of their skill in planning and directing the research program, and to the project directors who administered the research activities.

The outcomes summarized in the attached report truly represent the cooperative achievements of scientists, practical pilots, and administrators (both civilian and military) utilizing the resources and facilities of government and private agencies in the interest of the aircraft pilot.

Philadelphia, Pa.
May 18, 1945

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots

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INTRODUCTION

The Committee on Selection and Training of Aircraft Pilots was established by the National Research Council in September, 1939, at the request of the Civil Aeronautics Administration.[1] Research plans were formulated in the fall of that year and research activities initiated early in 1940. The outcomes of such research have been summarized from time to time, particularly in the annual reports by the Chairman to the National Research Council and to the Civil Aeronautics Administration. The present report is devoted to an over-all review of the Committee research program for the 5-year period, 1940-44, inclusive. It is designed to help in evaluating:

1. the effectiveness with which the research program has been conducted;
2. the contributions which it has made to the progress of aviation;
3. the respects in which anticipated outcomes have not been achieved.

In considering this review it should be borne in mind that the Committee was originally organized to undertake research in the selection, training, and maintenance of civilian pilots, and that it was first known as the Committee on Selection and Training of Civilian Aircraft Pilots. The functions of the Committee were early expanded to include military as well as civilian aviation and, in 1940, its name was changed to Committee on Selection and Training of Aircraft Pilots, with the specific purpose of formally recognizing the closer integration of the research program with the growing needs of the military services.

For approximately four years, military needs were given primary consideration in the deliberations of the Committee and in planning research programs. This emphasis will undoubtedly be maintained so long as the Committee can continue to be of service to the air forces of the United States and of the Allies to whom research findings have been made available. Nevertheless, as Dean R. Brimhall, Director, Division of Research, Civil Aeronautics Administration, points out in the following quotation from an address given at the 1944 Annual Meeting of the Committee on Selection and Training of Aircraft Pilots, many of the outcomes found useful by the military services can be of very practical value in civilian aviation:

> "The CAA-NRC Committee pioneer efforts acquainted a fair-sized group of research people with aviation problems. When the war reached the United States many of our workers joined the services to continue their research and the choice of projects to be carried out by the Committee was thereafter determined by the possible contribution of the research to the war effort.
>
> "Whatever may be the particular patterns of future projects, supported by the CAA-NRC Committee, this same criterion will be used until the war needs are met. Of course, this does not mean that our current findings will not have application to civilian aviation now and in the post-war period. Selection tests devised to pick out good fighter pilots may be of little use for peace time, but selection for aptitudes such as acquisition of motor skill and the presence of desirable personality and physical qualifications will always be useful.
>
> "Increased knowledge in the field of pilot training and maintenance of physical and mental well-being of pilots are certainly useful during peace time as well as during war. So, much of what we learned during war can become immediately useful during peace."

It may be reasonably anticipated that research results will find wider application in civilian aviation as World War II comes to a close, and as such additional steps as are needed are taken to integrate the findings and conclusions of the research program with the operating ends and operating program of the Civil Aeronautics Administration.

A major objective of the Committee on Selection and Training of Aircraft Pilots and of the Civil Aeronautics Administration is the wide application of research results. This review is written chiefly for the purpose of bringing into focus the useful outcomes of research. In this connection, it should be pointed out that, in some instances, the useful outcomes were in the form of negative findings which perhaps helped to avoid the imposition upon the military services and upon the CAA of costly and cumbersome procedures which would drain available resources without adequate return.

[1] Formerly known as the Civil Aeronautics Authority.

As might be expected, not all of the research activities and investments have been productive of useful outcomes. In some instances, it was found impossible or impracticable to follow up promising leads and thereby to bring potential outcomes to full fruition. In other cases, situations beyond the control of the research project director, such as the unavailability of criterion data, or sudden changes in training plans made by governmental or other agencies, produced insuperable handicaps to the attainment of research objectives. In still other instances, the original experimental design, apparatus, administrative procedures or methods of analysis were inadequate for solving the problem under investigation. There are also projects which have failed either to turn in any final report or to provide a report of the type from which it is possible to evaluate the research findings and the possibility of applying them to meet the needs of military and civilian aviation.

In this review attention is focused upon useful outcomes. Nevertheless, it seems proper, in order to provide a basis for a complete evaluation of the research program, also to include references to those projects which have not made an appreciable contribution to the improvement either of research or of operating procedures.

PILOT SELECTION AND CLASSIFICATION

In the research program of the Committee on Selection and Training of Aircraft Pilots, considerable attention has been given to problems of pilot selection and classification. This was particularly true during the first few years of research, when the country was faced with the problem of building up a large force of pilots for both civilian and military aviation. Moreover, while the emphasis during the past few years has shifted to other areas, particularly to research in pilot training, current investigations are still concerned with problems of selection.

Research on selection has ranged from exploratory studies involving a large number of psychological and physiological tests to the detailed analysis of specific predictors. Practical outcomes have included:

1. the validation of a number of predictors for use in both military and civilian aviation;

2. the accumulation of data on predictors which, although not fully validated, represent promising instruments for further research and application;

3. the identification of tests and other techniques which, while having apparent face validity or originally recommended for other reasons, proved upon investigation to lack reliability or validity;

4. the identification of predictors which, although valid, represent uneconomical techniques for the selection and classification of pilots.

General Outcomes of Research on Pilot Selection and Classification

Contributions to Military Aviation. One major practical outcome of the Committee research program is the fact that by 1941, when the United States entered the war, the research program had already produced test material and findings which were used by the U. S. Navy in setting up procedures for the selection of pilots. At the Annual Meeting of the Committee on Selection and Training of Aircraft Pilots, held in 1943, Cdr. (then Lt. Cdr.) J. G. Jenkins, in discussing the Navy research program, reported that

> "We are now using in routine selection, both before and after the beginning of training, three tests. Those three tests were either developed by the Committee first of all as selective agencies in aviation, or were developed by the collaborative efforts of the Committee and the Navy."

The selection program of the Army Air Forces has also profited from Committee research. Reference to this fact is found in the following quotation from an address given by Col. (then Lt. Col.) John C. Flanagan at the 1943 Annual Meeting of the Committee on Selection and Training of Aircraft Pilots:

> "We have learned a great deal from the work of the Committee. Much of our original planning was based on what the Committee had done, and in the past two years we have continued to profit. - - - - Our program, set up two years ago in December of 1941, was built on what we could find out about what the English and the Canadians had done, and the considerable amount of work which had been done by the Committee here."

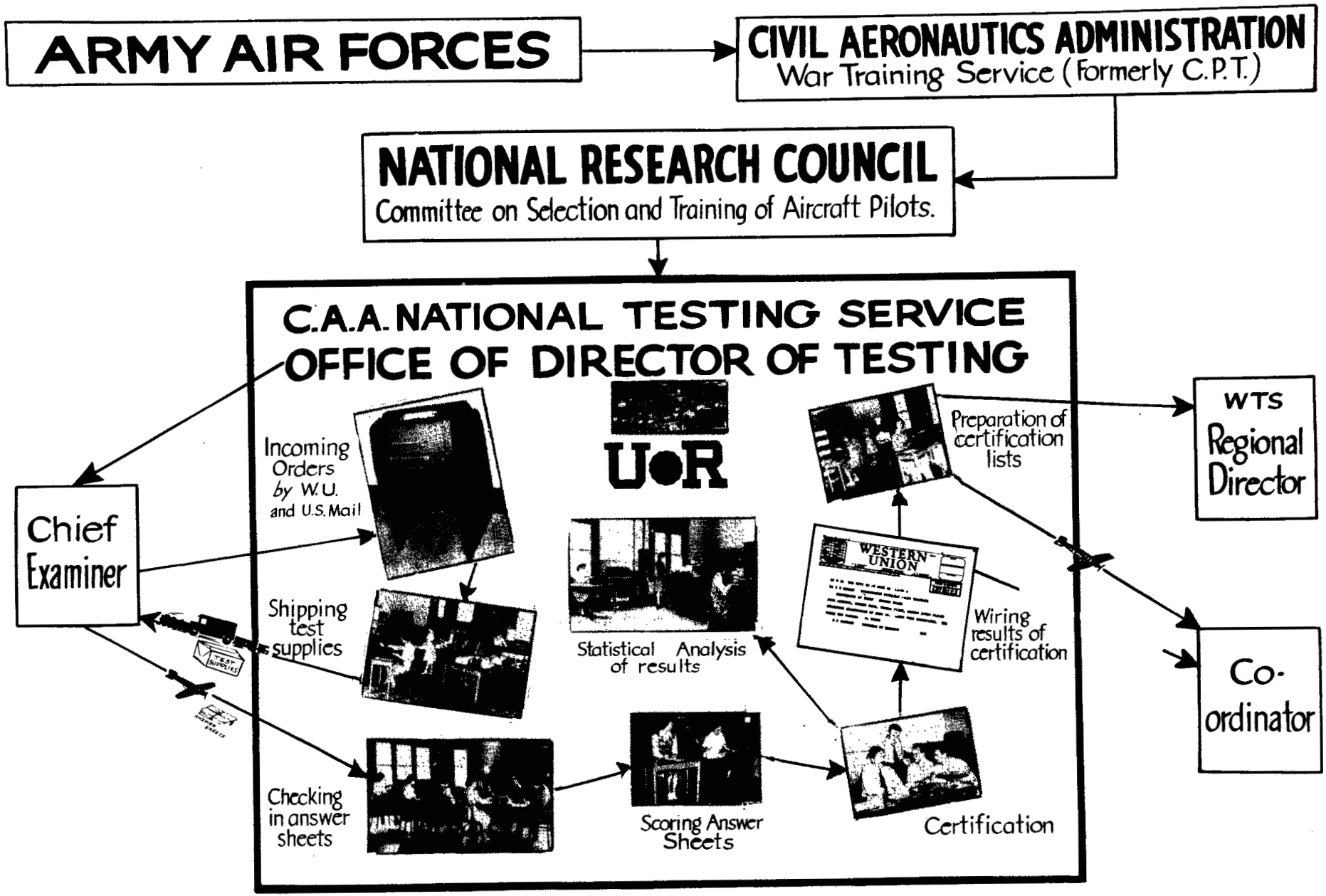

Exhibit 1

ORGANIZATION OF THE CAA-NATIONAL TESTING SERVICE

CAA-National Testing Service. Within the Civil Aeronautics Administration, the work of the Committee on Selection and Training of Aircraft Pilots in pilot selection found its most direct practical expression in the establishment of a National Testing Service (1942-43).[2] The National Testing Service (1, 2, 3, 4) was designed to provide uniform administration and scoring, on a nation wide basis, of tests for screening candidates for training in the Army phase of the Civilian Pilot Training program. Through this service, centralized at the University of Rochester, 67,067 candidates for pilot training, reporting to 571 coordinators scattered throughout the United States, were tested by 609 cooperating examiners (Exhibit 1). The administrative cost of this program was borne by the Civil Aeronautics Administration through a special contract at a cost of approximately $75,000. This means that the Committee conducted screening at the extremely low cost of a little more than one dollar per candidate.

In passing, it should be noted that the CAA-National Testing Service exemplifies the close integration between military and civilian applications in the work of the Committee on Selection and Training of Aircraft Pilots, since results of experimentation by the U. S. Navy were considered in the selection of tests for the screening program and in setting the cutting scores on each test. Moreover, this practical screening program has further reinforced the research program of the Committee in providing data on the extent to which the tests predict differential performance of those who meet minimun standards, and in furnishing significant findings on interrelationships among the tests (4), on differences among applicants for primary, secondary, and glider training (3), and on the influence of such factors as education, age, geographical area, etc., upon selection and upon achievement in learning to fly (4).

Specific Outcomes of Research on Pilot Selection and Classification

The broad, practical outcomes of Committee research in pilot selection and classification have been presented above. Detailed outcomes will be outlined in the form of a brief discussion of specific areas of research, of individual predictors, and of their usefulness in the selection and classification of military and civilian pilots.

Inventory of Personal Data for Prospective Pilots. This test, generally known as the Biographical Inventory (B.I.), was the immediate outgrowth of work done (5, 6, 7, 8) at Purdue University (1939-40), although investigations at the Naval Air Station, Pensacola, Florida, at Tulane University (1940-41) and at the University of North Carolina also included the analysis of biographical data (9).

The Biographical Inventory (B.I.) represents one of the first, if not the first, successful attempt to predict pilot proficiency from biographical data. Besides serving as one of the basic instruments in the aviation cadet selection program of the U. S. Navy, the Biographical Inventory (B.I.) has also provided items for similar tests employed in the Army Air Forces, as indicated in the following excerpt from a letter written by Col. L. E. Griffis, dated April 22, 1943:

> "This office has been experimenting with items included in Part A, Biographical Data, of 'An Inventory of Personal Data for Prospective Pilots.'
>
> "Permission is requested to use 28 of the 105 items contained in that part along with other items developed by this organization for the classification of aircrew personnel in the Army Air Forces."

The Biographical Inventory (B.I.) was also used to advantage in the CAA-National Testing Service (1, 2, 3, 4, 7; 8) and in the Standard Testing Program (1942), an extended research project involving the voluntary cooperation of 46 psychologists, scattered throughout the country, in the validation of a basic battery of predictors.

General Intelligence Test. A large scale study conducted in cooperation with the U. S. Navy at the Naval Air Station, Pensacola, Florida (1940-41), indicated the value of using a standard intelligence test in pilot selection (10, 11). Such a test was used by the Navy until it was replaced by the Aviation Classification Test. Because of the nature of both Committee and Navy research results, the test was included in the screening battery used by the CAA-National Testing Service (1, 2, 3, 4). The test is now in use in matching candidates for training in the current research program of the Institute of Aviation Psychology, University of Tennessee, established in 1943 through the cooperation of the Civil Aeronautics Administration, the National Research Council Committee on Selection and Training of Aircraft Pilots, and the Bureau of Aeronautics, State of Tennessee.

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[2]Throughout this report the dates in parentheses represent the years in which funds were made available to the research activity.

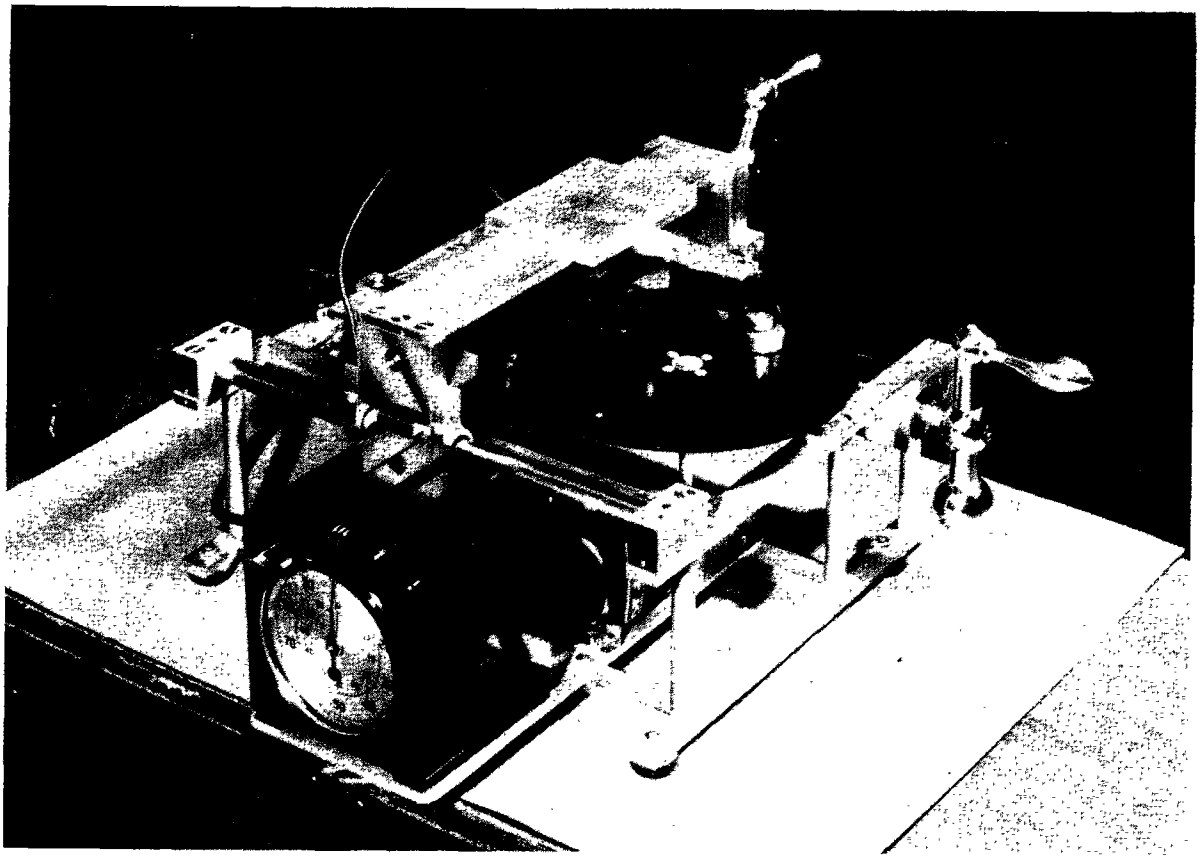

Exhibit 2

REVISED TWO-HAND COORDINATION TEST

Aviation Classification Test. Items for this test were prepared by the U. S. Navy. Work on item analysis, on construction of alternate forms, and on determining the reliability of the test was carried on as a research project of the Committee on Selection and Training of Aircraft Pilots (1942) at the University of Rochester. The test was later incorporated by the Navy into the Navy pilot selection battery. Acknowledgment of the part played by the Committee on Selection and Training of Aircraft Pilots in the development of this practical selection tool is found in the following excerpt from a letter from Cdr. (then Lt. Cdr.) J. G. Jenkins, dated August 1, 1942:

> "I understand that steps have been taken to provide sufficient printed copies of two forms of this test to the Medical Research Section for purposes of final standardization. In view of the very important role that this test has been assigned in the selection of Naval aviators, it is my intention to ask the Chief of the Bureau of Aeronautics to express the genuine gratitude of the Bureau for the large contribution that the Committee has made in the development of this test. I shall point out to him that it would have been impossible for the Medical Research Section and the H-V (S) organization to have developed such a test without the aid of the Committee except by the expenditure of a very much larger period of time."

Mechanical Comprehension Test. The Mechanical Comprehension Test was included in research conducted in the Midwest Project (1941-42), in the Boston Project at Harvard University (1941-42), and also in the Standard Testing Program. Prior to the completion of these studies, this test was included in the battery used by the CAA-National Testing Service on the basis of experimental findings provided by the U. S. Navy. Results available from the Midwest and Boston studies provided evidence on the usefulness of this test for initial selection (12, 13, 14). The analysis of CAA-National Testing Service data has furnished interesting information on the relationship of this test to other predictors, as well as to age, geographical area, etc. (4). The Mechanical Comprehension Test is one of the battery employed in matching research groups at the Institute of Aviation Psychology, University of Tennessee.

Psychomotor Tests. The Pensacola Study of Naval Aviators furnished evidence on the value of three psychomotor tests, viz., the Mashburn Serial Action Test (15), the Eye-Hand Coordination Test, and the Two-Hand Coordination Test (16) in differentiating "good" from "poor" pilots, including washouts and those who had Board appearances (10). The Committee on Selection and Training of Aircraft Pilots cooperated in producing an improved model (Exhibit 2) of the Two-Hand Coordination Test, later adapted for use in the early experimental program of the Army Air Forces, which led to the extended use of psychomotor tests in the classification of Army aircrew personnel. In addition, according to a research report by Lt. Col. A. W. Melton, appearing in the Journal of Aviation Medicine (1944, Vol. 15, pp. 116-123), the Rotary Pursuit Test "was originally introduced in the psychomotor classification battery (of the Army Air Forces) on a hunch supported by a bit of data which had come from a study sponsored by the National Research Council Committee on Selection and Training of Aircraft Pilots" (17, 18).

While the number of cases was small, the Midwest Project (19, 20, 21) and the Boston Project (13, 22, 23) of the Committee on Selection and Training of Aircraft Pilots have produced further evidence on the validity of the Mashburn Serial Action Test and of the Two-Hand Coordination Test for pilot selection. These tests are also currently being used in connection with research at the Institute of Aviation Psychology, University of Tennessee.

Productive cooperation with the Army Air Forces is illustrated in service rendered by the Committee staff in connection with a special experimental program for the investigation of psychomotor tests conducted at the University of Rochester and at the University of Buffalo (1943). Studies at the State University of Iowa (1942-44) on the effect of lateral distraction lights on performance on the Mashburn Serial Action Test, conducted in close collaboration with the staff of the School of Aviation Medicine, AAF, have produced results on learning rate and on reliability of performance under differing procedures of administration (24), of practical interest in the Army Air Forces Testing Program. There has also been cooperation with the Army Air Forces on research conducted at the State University of Iowa (1942-44), concerned with the effect of various combinations of work and rest periods on (a) the rate and level of performance, (b) the reliability of scores, and (c) the intercorrelations among scores based on different learning segments for the Rotary Pursuit Test (25) and the Two-Hand Coordination Test (26). In another study, made at the request of the staff of the School of Aviation Medicine, AAF, with the cooperation of the U. S. Navy, attention has been centered on the validation, in relation to learning to fly, of initial, terminal, and segment scores obtained through the administration of a variety of psychomotor tests (27).

In the case of a number of the psychomotor tests referred to above, the Committee on Selection and Training of Aircraft Pilots has also made a practical contribution through improvements in apparatus

use of statistical techniques peculiarly applicable to this problem. The results of the investigations were made available to the U. S. Navy for use by this service in connection with a program designed to develop simplified and improved tests of physical fitness. The Committee program has included plans for further work in this area designed to lead to practical results in the formulation of standards for the certification of civilian pilots.

Studies of the Interview. Since considerable emphasis had been placed on the interview as a method of pilot selection, a standardized interview and rating procedure (Exhibit 3) were developed, and extensive investigations of the interview (1941-43) carried out under the auspices of the Committee at Wesleyan University, Harvard University, Ohio State University, Purdue University, and the University of Michigan (51, 52, 53). The economic aspects of research conducted by the Committee are illustrated in the conclusion that the contribution of even a reliable interview appears to be slight in terms of the time, effort, and cost involved in the interview procedure, since it adds little to the predictive information obtained through the use of much less expensive and more easily administered paper-and-pencil tests.

A study of the psychiatric interview used in the Massachusetts General Hospital Project (1940-42) revealed little promise for this particular type of interview (44). However, measures of the interaction between interviewee and interviewer, as recorded on the interaction chronograph, showed promise and this technique has been subjected to further validation in the examination of aviation cadets at Williams College (54), conducted through the cooperation of the U. S. Navy (1943-44).

Among the practical outcomes of Committee research are several new tests and other predictors which, although not fully validated, appear to represent promising materials for future research and possible use. The following may be included in this category:

Test of Aviation Information. This test was developed (1941-43) in the research program of the Committee on Selection and Training of Aircraft Pilots at the University of Rochester (55, 56, 57). Preliminary results on the test were obtained in the Standard Testing Program (35, 36, 37). The test was released to the U. S. Navy for further research and also used by the CAA-National Testing Service for the selection of applicants for flight training. A comparison of the test results with achievement in learning to fly indicates that it can be included among the more promising predictors developed in the Committee's research program (4).

Personal History (P-H) Inventory. This test was originally developed largely through the cooperation of the staffs at the University of Rochester and Wesleyan University (1941-43) for use in connection with the study of the aviation interview (53). Scoring keys, data on reliability, and some preliminary data on validity are available from the Standard Testing Program (58). The test is now being used in connection with research at the Institute of Aviation Psychology.

Desire-to-Fly (D-F) Inventory. This test was developed in research conducted at the University of Rochester (1941-43). Scoring keys and data on validity are available from studies at the University of Rochester (59) and additional data are being accumulated through the use of the test at the Institute of Aviation Psychology.

"Ability-to-Take-It" Tests. The investigation (1940-43) of tests designed to measure "ability to take it," conducted at the University of Rochester, Northwestern University, and the University of North Carolina, provided support for the point of view that this is not a unitary trait and produced a number of measures considered sufficiently reliable for use in further research (17, 60, 61, 62). Nine units of one of these tests, a Recording Dynamometer, have been purchased from the Committee on Selection and Training of Aircraft Pilots by the U. S. Navy for use in further research. However, a recent study (1943-44), involving an analysis of examiner differences in testing 550 Naval aviation cadets at Williams College, has raised serious questions concerning the ultimate usefulness of the "Ability-to-Take-It" Tests (63).

Stability of Orientation Test. This test (Exhibit 4), developed at Brooklyn College (1942-44), yields a measure of a subject's ability to recognize changes in his lateral and longitudinal position with respect to the earth when the visual cues from his immediate environment are deliberately falsified through tipping or rotating a "room" to a position other than the horizontal (64, 65, 66). The test has been made available for validation by the Army Air Forces (1944). Progress has been made in the validation of this test on approximately 1000 aviation cadets. In addition, this test is being used in a program at Brooklyn College (1944), designed to determine the extent to which improvement in spatial orientation can be effected by training (67).

"Self-Description" Test. Each item in this "personality" test, developed at the University of North Carolina (1939-41), consisted of two descriptive phrases, one of which the subject was required to select as describing him better than the other (68). This arrangement of descriptive terms greatly reduced the

used in Committee research, in providing drawings and wiring diagrams, and in the standardization of apparatus and procedures for administering the tests (15, 16).

Statistical Developments. Studies sponsored by the Committee on Selection and Training of Aircraft Pilots have also led to the refinement of methods for selecting combinations of predictors and determining the best cut-off points through the use of multiple chi (28). Various memoranda devoted to a discussion of such techniques have been prepared (29, 30, 31) and made available to research workers in both military and civilian aviation. These include an analysis of results obtained from the use of multiple chi as compared with those obtained from use of multiple correlation techniques (32, 33, 34), using results from the Standard Testing Program (35, 36, 37, 38). Interesting statistical developments are also to be found in steps taken for the scoring, analysis and interpretation of physiological data (39, 40, 41, 42).

Physiological Tests. An important practical outcome of Committee research bears on relationships between physiological measures and pilot performance. Of 21 physiological items included in the Pensacola Study of Naval Aviators, vital capacity and the smallest pulse pressures subsequent to tilt proved to be the only items showing promise in the differentiation of "good" pilots and "poor" pilots, including washouts and Board appearances. Even these measures failed to differentiate the criterion groups at an accepted level of significance (10, 11, 39).

Analysis of the Pensacola data drew attention to the significant fact that the low validity of the physiological tests studied may be a function of low reliability in the sense that the test as administered provided merely a measure of a biological instant not consistently representative of the physiological function extending over a long period of time. Similar findings on unreliability of physiological measures were obtained in other studies at Harvard University (13, 22). Constructive outcomes of such findings appear in the steps which have been taken towards the exhaustive analysis of respiratory measures, with a view to arriving at items that give sufficiently consistent measures to permit their further use in the determination of validity for pilot selection or in the maintenance of pilots (42).[3]

While many items were included in the studies of physiological measures, independent and extended treatment has been given to the electroencephalogram, somatotypes, visual measures, and to certain cardiovascular functions in investigating the relationships with achievement in learning to fly.

Electroencephalography. Records were obtained in studies (1940-41) at Harvard University (43, Supplement), Massachusetts General Hospital (44) and Naval Air Station, Pensacola, Florida (10, 43, 45). Results were not sufficiently promising to warrant the recommendation that this elaborate technique be included in a pilot selection battery.

Somatotyping. Somatotype measures obtained in the Pensacola Study were subjected to an extended statistical analysis (10, 45). The results showed the need for further investigation and cross validation of somatotyping techniques on less selected populations before the procedures could be recommended for use in the selection of aircraft pilots.

Visual Functions. An analysis of the relationship between visual functions and the achievement of RAF cadets in learning to fly (1941-44) has led to the tentative conclusion that visual deficiencies, such as are accepted by the RAF, are not related to achievement in learning to fly (46). The findings and conclusions are entirely tentative because of the fact that early eliminations were not included in the investigation. The study is now being repeated on another population of RAF cadets which does include early eliminations. The final findings and conclusions will have an important practical outcome in providing experimental evidence as a basis for arriving at decisions with respect to lowering the visual standards in the certification of pilots in this country.[4]

Physical Fitness. Experiments (1939-42) at Stanford University (47, 48, 49), supplemented by exhaustive statistical analyses, have pointed to the inadequacies of the Schneider Index and to the need for simpler and more reliable measures of physical fitness (40, 50). These studies have been marked by the

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[3]It should be noted that the relationships between physiological measures and pilot performance over extended operational periods have not so far been studied in Committee research.

[4]A further development of research in this area is a recent request from the Civil Aeronautics Administration, at the initiation of the Civil Aeronautics Board, that the Committee on Selection and Training of Aircraft Pilots undertake further studies of the relationship between visual measures and flight performance to provide experimental data of significance in the certification of private pilots.

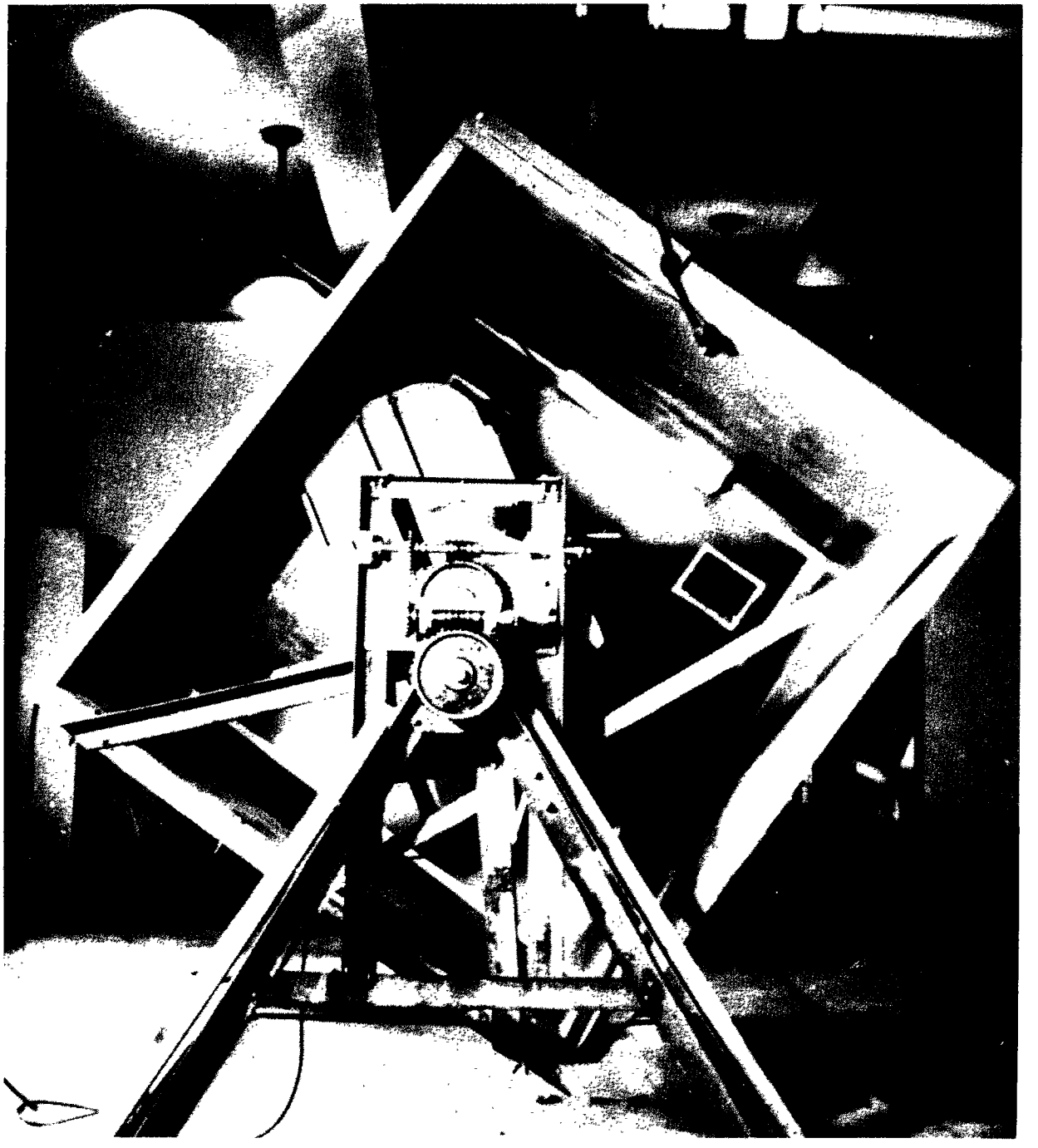


Exhibit 4

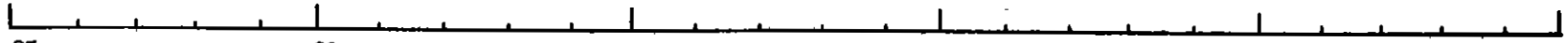
STABILITY OF ORIENTATION TEST

Name of Candidate _____

INTERVIEW CHART

Name of Rater _____

D. DESIRE TO FLY



25	20	15	10	5	1
AN ARDENT, IRREPRESSIBLE DRIVE TO BECOME A FLYER	A STRONG INTEREST IN FLYING	A MILD INTEREST IN FLYING	ONLY A SLIGHT INTEREST IN BECOMING A FLIER	NO FUNDAMENTAL INTEREST IN FLYING	
___has a very strong and sincere interest in becoming a flier; ___would rather fly than eat; ___bubbling over with enthusiasm for flying; ___knows a lot about flying already; ___can't wait until he gets in the air; ___heart is set on flying; ___has always wanted to fly	___has a genuine desire to fly; ___wants very much to fly; ___has paid for flying instruction; ___has read widely about aviation	___would like to be a flier; ___is an average candidate; ___has a moderate desire to become a flier	___is nonchalant about flying as a career; ___prefers other things to flying; ___is prompted primarily by money	___has pseudo-interest in becoming a flier; ___is a "draft-dodger"; ___drifted into flying; ___flying is a means to some other end; ___is only curious about flying	

EXPLANATION OF RATING:

_____

_____

_____

_____

Exhibit 3

SAMPLE RATING SHEET USED IN THE STUDY OF THE AVIATION INTERVIEW

subject's chance of inferring the correct answer to individual items, since both descriptive phrases constituting one item were frequently derogatory or commendatory. Preliminary validation data were obtained on Civilian Pilot Training students, but further work is needed to make this a practical addition to a test battery.

Scholastic Grades. Several studies of scholastic grades and flight performance (1940-41) showed little relationship of such grades to achievement in learning to fly (69). Further studies in this area may be of significance in formulating scholastic requirements for civilian pilot training. However, there has been no follow-up in this area of investigation.

Included in Committee research on pilot selection and classification are investigations, undertaken particularly in the early or exploratory phase of the research, which produced generally negative or questionable results in terms of application. Failure to arrive at practical outcomes resulted, in some cases, from the fact that the research projects were intended merely to select predictors for further study. A study (1939-40) of 39 psychological and physiological tests at Purdue University (70), investigations (1939-40) at the University of Alabama (71), and several studies at the University of North Carolina (72, 73, 74) are representative of this group. Moreover, practically all such early investigations were handicapped by limitations of criteria and of size of sample. In other instances, however, as suggested in the Introduction to this report, failure to arrive at practical outcomes can be laid not to the exploratory nature of the research, but, at times, to defects inherent in the nature of the experimental design; at other times, to conditions not subject to control by the investigator; and, in still other cases, to the fact that the investigators failed to provide adequate reports on the investigations conducted by them.

Work on the development of a key for the Strong Vocational Interest Blank for use in pilot selection was initiated (1939-40) under Committee auspices at Stanford University (75), and other studies on this instrument were conducted (1939-40) at Ohio State University (76) and at Purdue University (1939-41). However, such studies have not led to the recommendation that this instrument be used in selection batteries.

The Humm-Wadsworth Temperament Scale, Guilford STDCR Test, and the Maslow Dominance Test were investigated at various research centers, including Northwestern University (1940-43) and Purdue University (1939-40). Preliminary results indicated in general that these tests had little value as predictors of flight proficiency. However, questions regarding scoring procedure, criteria, and analysis of data rendered conclusions equivocal.

Studies of interest and attitude scales were conducted at George Washington University (1939), but inadequacies in design rendered it impossible to reach definite conclusions concerning the value of the measures analyzed (70).

Studies of the Link Trainer (Contact) as a device for selection and training of pilots were early undertaken at the University of Michigan (1939-41). Later, methods were developed at Harvard University (1941) for obtaining objective records of performance on this trainer, and further studies of the device were undertaken in the Boston Project at Harvard University (1941-42) and in the Midwest Project (1941-42). Preliminary data indicated that the reliability of scores obtained through methods devised in this research were too low to justify the use of the Link Trainer (Contact) for selection purposes (77, 78, 79). In general, findings from such studies proved to be ambiguous because of apparatus and administration difficulties, and, in some instances, because of inadequacies in reports on findings (78).

Apparatus was developed at the University of Colorado (1939) for testing eye-hand-foot coordination similar to that required for aircraft operation. Adjustments were required in response to flight situations projected on a screen. However, no data were presented in the report submitted by this project (80).

The Seashore Serial Reaction Time Test and the Ranseen Coordinator showed some slight promise in early investigations (1940-43) at Northwestern University (17), but further investigation of these instruments was never carried out.

Snoddy Star Test. This test was administered to subjects in the Standard Testing Program (81). While apparently showing some merit, the test has not been included in selection batteries, partly because of difficulties involved in administering the test.

The interrelationships of cardiovascular-respiratory variables were studied by factor analysis techniques at Springfield College (1940). Inadequacies in design and statistical treatment have prevented practical applications of this work (41).

Projection Tests. A number of projection tests were employed in a study conducted by the staff of the Massachusetts General Hospital, through the cooperation of the U. S. Navy, at the Naval Air Station, Squantum, Mass. (1940-42). While results on most of these tests (44), including a modification of the Rorschach, were negative, promising findings were obtained on a number of items which have recently been subjected to further study (1943-44), again through the cooperation of the U. S. Navy, in an investigation by the Massachusetts General Hospital group at Williams College (54). Criterion data furnished on approximately 500 subjects are now being subjected to analysis at the University of Rochester.

PILOT TRAINING

During the early years of the Committee on Selection and Training of Aircraft Pilots the major emphasis was on the development of improved methods for the selection and classification of pilots and on associated criterion problems. This emphasis was not only in accord with the needs of the time, but also a natural outcome of the fact that exploratory steps in the selection of pilots had been taken during World War I which provided some basis for immediate practical research by the Committee (82). During the past few years, as the selection situation in the military services became stabilized, the emphasis has shifted from research in selection to research in training. Here the Committee entered a field of investigation which was largely uncharted. As is apparent below, Committee activities in this area represent pioneering efforts which have produced new tools of importance both to civilian and military aviation.

In research on training, the Committee has considered two aspects of the training situation. The first centers around problems experienced by student pilots in learning to fly. Secondly, consideration has been given to the methods employed by instructors in teaching students, since the learning of the student is dependent upon methods used by the instructor. The latter naturally leads into problems of curriculum revision.

Practical outcomes from research in pilot training can be divided into two categories;

1. the development of basic research tools and methods for use in the investigation and improvement of pilot training.
2. the development of training aids for field use.

As might be expected, there is very close interrelation between these two categories since, in some instances, the availability of newly developed tools and methods led directly to practical applications, and in others, the development of new training aids led to further research productive of additional outcomes in the way of improved training methods. Following is a brief analysis of the major practical outcomes of research on pilot training, supplemented by a brief statement concerning incomplete research and areas in which anticipated outcomes have not yet been achieved.

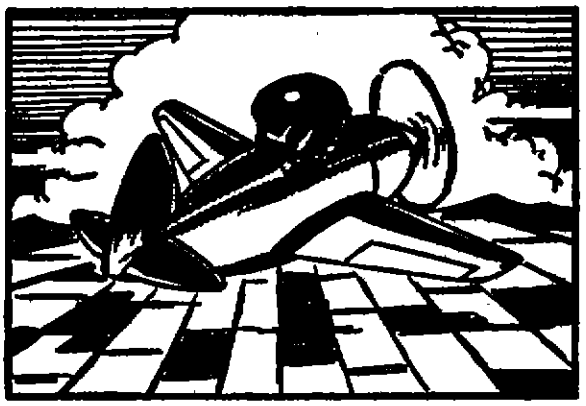
Development of "Patter" and "Fundamentals of Basic Flight Maneuvers." One of the early and extremely fundamental research projects on pilot training was that carried on at Purdue University (1940-42). When Committee research was initiated, little or nothing was known about the nature of actual air instruction, since such instruction was generally conducted in a two-place plane, and student and instructor were in a situation where the instructional process could not be directly observed.

A short-wave transmitter and electrical interphone suitable for use in a light plane were developed. Through the use of these, for the first time in history, elementary flight instruction could be observed, and evaluated, in light of modern scientific and educational principles. By means of this equipment, instruction was transmitted to a receiver on the ground, recorded, and later transcribed. Over 100 hours of instruction, both at Civilian Pilot Training schools and at the Naval Air Station, Glenview, Illinois, were recorded. Qualitative and quantitative studies (83, 84, 85, 86, 87), besides indicating the good points of instruction, revealed many areas in which instruction could be improved.

One immediate outcome of this preliminary research was an opportunity to examine variations among instructors with respect to the vocabulary or terminology used in training pilots. For example, an analysis of 10 hours of instruction by each of 4 instructors revealed a total of 500 technical or specialized terms, many of which were unique to an individual instructor (87). In addition, it was found that (a) much instruction was given in the air which could better have been given on the ground, and (b) pilot training suffered from inadequate methods of presentation by instructors unaware of the fundamentals of good teaching procedures.

10. CLIMBING TURNS

C. A. B. No. 5: P. 153
C. A. B. No. 23: P. 61–62



Talk over while gaining altitude. **Check traffic.** Turns may be executed in the normal and the maximum climb. In both of these, the turn is made with a shallow bank. The only difference is that the normal climb is accomplished with100 engine R. P. M. above cruising speed, while the maximum climb is accomplished at full throttle, so a slightly greater angle of climb is possible.

Left climbing turn. We will first do a gentle, 90-degree left climbing turn. First after making sure that there will be no other planes in the way, open the throttle until the engine R. P. M. is approximately 100 R. P. M. above cruising. Then, assume a normal climb as we have done before.

Now, since we know that additional back pressure is needed in a turn, we decrease this angle of climb by approximately one-third. This will provide for the additional lift needed when we are turning.

Point to left wing. Point to nose. Now we coordinate our controls until our left wing tip is in this relation to the horizon. You can see, that it is the same as in a shallow-banked turn. Remember, we must keep the nose in its usual position during the turn.

As in our previous turns, we release our rudder and aileron pressure as soon as the turn is established, then apply slight opposite aileron pressure.

Recover. When we wish to recover from the turn, we coordinate our controls so as to stop the turn and the bank. At the same time we adjust the back pressure so that by the time we are flying straight we are back in a normal climb. O. K., now you take over and execute a climbing turn to the left.

Exhibit 5

SAMPLE PAGE FROM "PATTER FOR ELEMENTARY FLIGHT MANEUVERS" (Civil Aeronautics Bulletin No. 31)

These findings led first to the development of two training aids of fundamental importance for elementary instruction: (1) Patter for Elementary Flight Maneuvers, and (2) Fundamentals of Basic Flight Maneuvers.

Patter provides a model presentation of air instructions in basic maneuvers. As pointed out by E. L. Kelly, Project Director at Purdue University, who was largely responsible for the basic work on these and on a number of other aids considered in this report (86):

> "Behind the preparation of 'Patter' was a very strong feeling that a student deserved at least one simple and complete description of each maneuver while in the air, preferably during the first time it was demonstrated to him. Analysis of actual recordings of flight instruction convinced us that such descriptions were not available in the spontaneous instruction given by instructors in the air. It was at this point we decided to prepare appropriate 'Patter' for each of the maneuvers."

In the Fundamentals were outlined the basic facts which should be understood by the student pilot before going up for instruction in the various maneuvers. These, as in the case of Patter, were prepared in light of educational principles, attention being given particularly to the definition of each new term as it was introduced.

Following many revisions and "flight testing" by experienced instructors, these training aids were presented to the Civil Aeronautics Administration and, following additional modifications by the staff of that agency, were published early in 1943 as CAA Bulletins No. 31 (Exhibit 5) and No. 32 (Exhibit 6), with an initial order of 20,000 copies.

The usefulness of such materials in connection with the training of Navy pilots by the CAA is acknowledged in a letter dated July 18, 1942, addressed to the Assistant Secretary of Commerce by Capt. (now Admiral) A. W. Radford of the Bureau of Aeronautics, U. S. Navy:

> "We are very appreciative of this effort to standardize CPT students and to bring their training in line with ours. The Flight Maneuver booklets have been unanimously accepted and praised, and it is felt that they will go a long way towards increasing the efficiency of flight training."

Even before the publication of these materials by CAA, special revisions were prepared by the U. S. Navy with the aid of personnel provided by the Committee on Selection and Training of Aircraft Pilots. Acknowledgment of the manuals prepared for the use of the U. S. Navy by the training staff of the Bureau of Aeronautics, in cooperation with research personnel supplied by the Committee on Selection and Training of Aircraft Pilots, is found in a letter dated July 28, 1942, addressed to the Chairman of the Committee by Capt. (now Admiral) A. W. Radford which states in part:

> "The flight manual, originally written under the auspices of the National Research Council, has met with unanimous approval by flight personnel who have read the booklet, and it is felt that it will be of inestimable value in furthering flight training."

Among other practical outcomes in this area was a translation of the Elementary Patter into Chinese, prepared through the Division of Research, CAA. A preliminary edition of Patter and Fundamentals for secondary training was also prepared and submitted to the CAA, but this, so far as the records of the Committee show, has not led to CAA publication or use.

Development of Air-borne Model Magnetic Wire Recorder. The Committee deserves considerable credit in connection with the development and promotion of the Air-borne Model Magnetic Wire Recorder in aviation. This instrument was developed largely through the initiative of the Director of Research, CAA, and of the Project Director at Purdue University (1942), the latter serving as a consultant to the Armour Institute of Technology in the design and manufacture of the first model of this instrument (88). Mass production of the Air-borne Model Magnetic Wire Recorder was further stimulated through the efforts of the Division of Research, CAA, working in close cooperation with the Committee.

The Air-borne Model Magnetic Wire Recorder has proven of great value in research by the Committee and, in addition, is used in training activities by the U. S. Navy and the Army Air Forces. It has also become an extremely useful tool in Army and Navy operations through other applications which have apparently very advantageously affected the war effort. In view of the latter it is perhaps significant to note, as apparent from correspondence quoted below, that the Air-borne Model Magnetic Wire Recorder

and the possibilities inherent in the instrument were first brought to the attention of the military services by the Committee on Selection and Training of Aircraft Pilots through the Civil Aeronautics Administration. A letter dated October 8, 1942, from M. S. Viteles, Chairman, Committee on Selection and Training of Aircraft Pilots, to Dean R. Brimhall, Director of Research, Civil Aeronautics Administration, stated:

> "During recent months, facilities for recording instruction have been tremendously improved by the development of a new instrument.
>
> "This instrument, described in the attached memorandum, represents one of the most important outcomes of the research program sponsored by the Civil Aeronautics Administration through the National Research Council Committee on Selection and Training of Aircraft Pilots. The recorder has enormous possibilities, not only for the improvement of training practices, but also for use by test pilots in maintaining an operations log; for recording conversation between the tower and planes, etc.
>
> "The magnetic wire recorder as designed for use in aeronautical research and operations is now ready for mass production. There is every reason to believe that great immediate benefit would ensue if a unit were made available at every center where instructors are being trained by CPT. It is strongly urged that steps be taken to obtain these instruments for such use, and also for use in connection with other CPT activities.
>
> "The aircraft model of the magnetic wire recorder can be beneficially employed not only by CPT, but also by the Armed Forces. It is suggested that the Civil Aeronautics Administration bring to the attention of the Bureau of Aeronautics, U. S. Navy, and of the Army Air Forces, the usefulness and availability of this instrument."

A letter dated October 14, 1942, from William A. M. Burden, Special Aviation Assistant to the Secretary of Commerce, to Artemus L. Gates, Assistant Secretary of Navy for Air, and to Robert A. Lovett, Assistant Secretary of War for Air, pointed out that:

> "The Civil Aeronautics Administration has received a communication from the National Research Council Committee on Selection and Training of Aircraft Pilots. The Committee advises this agency that it has been able to adapt a light and efficient recording device to the improvement of aircraft pilot instruction. The Committee has also suggested that the Civil Aeronautics Administration bring to the attention of the Armed Services the usefulness and availability of this instrument. We are acting upon its recommendation by sending you a copy of the letter and a copy of a statement on the instrument itself."

In responses to the above letter, M. P. Aldrich, Lt. Cdr., U.S.N.R. (October 17, 1942), and Robert A. Lovett, Asst. Secretary of War for Air (October 20, 1942), indicated an early interest on the part of the Services in the instrument, which has since been produced in large quantities for the military services.

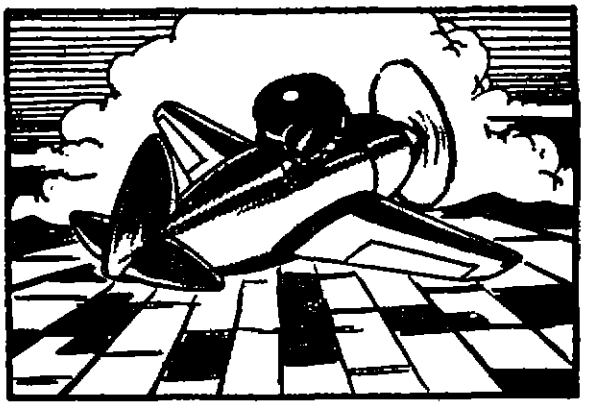
Development of the WTS Methods Training Course. Analysis of flight instruction supported the conclusion that flight instructors should be good teachers, as well as good flyers, and that existing requirements for instructors, which placed almost complete emphasis on flying ability, were incomplete. The CAA War Training Service, becoming aware of this fact, requested the Committee, early in 1943, to develop a 30-hour course on the theory and techniques of flight instruction as a basic unit in the CAA Controlled Secondary Instructor Course and, in addition, to train selected personnel to give this course at training centers.

Such a course (89) was developed by Committee personnel. It represented an application to flight instruction of the outcomes of educational and industrial research on the learning and teaching processes (90), and of the results of findings from pilot training research conducted by the Committee on Selection and Training of Aircraft Pilots. It undertook to achieve an integration and organization of these established principles and research findings in such a manner as to furnish practical and effective guidance to flight instructors. This was done with a minimum of technical terminology, and with repeated and specific references to the flight situation.

Applying standards formulated by the Committee on Selection and Training of Aircraft Pilots, the Civil Aeronautics Administration selected a group of seven men known as "methods instructors" to take this course at an Institute conducted by Committee personnel at the University of Minnesota in April, 1943. These methods instructors were then assigned to CAA Instructor Training Centers to give instruction in teaching methods to those undergoing training as flight instructors. A second Institute, involving a group

10. CLIMBING TURNS

Civil Aeronautics Bulletin No. 23; second edition. P. 183–184.



A shallow climbing turn is simply a gentle turn made while the airplane is climbing. Thus, in making a climbing turn, combine the principles you learned when you practiced normal climbs and normal turns.

As in all turns, coordination of your controls is important. You will find it necessary to hold more back pressure in a climbing turn than in a normal turn, since the nose is already held in a climbing position.

Remember: In a *climb,* the air speed of the plane decreases. In a *turn* your minimum safe flying speed becomes greater. Thus, in a **climbing turn,** your margin of safety above this minimum flying speed is less than during either a normal climb or a normal turn.

Therefore: With the same amount of power, the same degree of climb cannot be maintained in a climbing turn as in a straight climb.

Decrease the angle of climb before starting the turn.

Make a shallow banked turn.

Coordinate your controls. If you don't use enough rudder for your angle of bank you will climb with one wing low and "slip." Too much rudder for your angle of bank results in a skid, and a resultant loss of air speed.

A skid in a climbing turn is dangerous. It may develop into a spin.

To recover from a climbing turn, coordinate opposite rudder and aileron pressure. At the same time ease off your additional back pressure so that, by the time the plane is flying straight, you are back in a normal climb.

A maximum climbing turn is executed similarly to a shallow climbing turn, except that it is done at full throttle so that your angle of climb can be slightly steeper. In maximum climbing turns, your bank should be less than in a shallow climbing turn. In general, the steeper the climb, the shallower should be your bank in a turn.

The recovery is the same as from a normal climbing turn, except that when you come out of the turn you should be back in a maximum climb.

Exhibit 6

SAMPLE PAGE FROM "FUNDAMENTALS OF ELEMENTARY FLIGHT MANEUVERS" (Civil Aeronautics Bulletin No. 32)

of 30 men assigned by CAA, was held at Ohio State University in the fall of 1943. Each man undergoing such instruction was provided with a comprehensive manual entitled Lesson Plans for Training Methods Unit, CAA-WTS Controlled Secondary Instructor Course and an Instructor's Kit which was then used as a guide in conducting training and teaching methods at Instructor Training Centers.

The materials for this course were turned over to the Army Air Forces and the U. S. Navy for use in developing similar instructor training programs. Copies have also been made available to the air forces of allied nations. There has been established in this course, and through the experience at the Institute, the basis for important postwar activity in improving the quality of flight instruction of civilian pilots. These materials represent a basic step in raising the level of professional skills, and such a course might well be established as a prerequisite in the licensing of pilot instructors as we move into the extended training of civilian pilots in the postwar era.

Compilation of Instructional "Tricks." Investigations of flight instruction showed the need for eliminating certain inadequacies in the procedures employed. These investigations also revealed that many special teaching techniques actually used by individual instructors in the field were of great value. It therefore seemed desirable to compile those special teaching methods which individual flight instructors had found by experience to be effective in dealing with specific problems of individual trainees and in teaching specific maneuvers. It also seemed well to make provisions for circulating such ideas to instructors throughout the country. For these reasons, a questionnaire was sent (1943-44) to 1000 flight instructors in the WTS Army and Navy programs, requesting each to describe methods he had found particularly useful in overcoming student pilot difficulties. Over 300 techniques were compiled from replies to the questionnaire (91, 92) returned by approximately 100 flight instructors. These techniques are now being evaluated by civilian and Navy instructors. Upon completion of this evaluation it is intended to prepare a manual which may well become a valuable supplement to available flight instruction manuals. In the meantime a compilation of instructor "tricks," in preliminary form, has been made available to the U. S. Navy, the Army Air Forces, and the Royal Air Force.

The outcomes of the major studies discussed above can be considered positive contributions in the area of pilot training. Equally significant results may be expected from training studies now in progress.

One of the major difficulties encountered in conducting research in training lies in controlling conditions, e.g., selection of student pilots and rigorous control of types of instruction. The establishment of the Institute of Aviation Psychology at the University of Tennessee (1943), through the cooperation of the Committee on Selection and Training of Aircraft Pilots, the Civil Aeronautics Administration, and the State of Tennessee Bureau of Aeronautics, was intended, in part, to overcome this difficulty. Here use is being made of the tools and techniques developed in Committee research described above in the investigation of specific problems in training, such as the relative effectiveness of training with and without instruments, variations among age groups in learning to fly, and factors involved in learning to land a plane. Such studies are directed primarily towards problems of civilian aviation, and the findings should be of particular significance for postwar aviation.

In addition to field research on general problems of pilot training, attention has been directed towards basic perceptual processes involved in learning to fly. In this connection, an extensive investigation of peripheral vision has been undertaken at the University of North Carolina (1942-44), centered on the development and evaluation of procedures for the improvement of peripheral visual acuity (93, 94). Another investigation at Brooklyn College (1943-44) has involved the study of methods for training subjects in perception of position, through use of the Stability of Orientation apparatus (67).

Certain other investigations in the area of training, while not resulting in major contributions or immediate practical outcomes, have had some value as exploratory research. Such studies are described below:

Eye Movements and Visual Cues in Landing. The attention of the Committee was early directed by the Director of Research, CAA, to the importance of investigating the role of visual cues in landing a plane. Exploratory work in this area was begun in 1939 at the University of Rochester. This resulted in the development of a photographic instrument suitable for such research and in certain preliminary findings on the patterns of eye movements of experienced and inexperienced pilots, respectively. Research under this project was not completed and no final report is available, but the investigation has served as a stimulus for similar investigations by other groups.

In an investigation at Brown University (1940), provision was made for a detailed introspective account of visual cues used both during flight and in landing, supplemented by an analysis of introspective accounts by other observers (95, Supplement). Initial steps were also taken for the development of

photographic equipment and in planning further extended objective studies in this area. These studies were interrupted by the entry of the Investigator into the Navy, where he has since conducted similar research. An exploratory study initiated in 1941 at Purdue University, involving the use of photographic equipment, indicated that there were no patterns of eye movements during landing (Exhibit 7) which clearly differentiated experienced from inexperienced pilots although lack of adequate criteria prevented determination of the relationship between eye movements and excellence of landing (95). On the basis of the rather small sample of pilots studied it was suggested that the procedure of instructing the student to look at some specific place, and nowhere else, during landing was inadvisable, particularly since a few experienced pilots, who insisted that there was a proper place to look, actually did not maintain fixation on this suggested area during their own landings.

Studies in Peripheral Vision. An early study at the University of Minnesota (1939-40) attempted to determine the relationships between skill in landing and disjunctive reaction time to peripherally presented visual stimuli (96). Lack of a clear criterion of landing proficiency represented the major limitation of this report, but the study has merit as an exploratory research.

Air-Ground Time. Early in the work of the Committee on Selection and Training of Aircraft Pilots attention was drawn to the amount of time spent on the ground and in the air, respectively, during flight periods as a possible source of significant variation in the training of aircraft pilots. As a result, in 1940, observations were made of the proportion of flight time spent on the ground and in the air as an incidental feature of larger investigations conducted at the University of Maryland and at Tulane University (97). Subsequently (1941-42), through projects at Kansas City University, Purdue University, and the University of Utah, the Committee initiated a major study (97), designed to provide through the use of a modified Servis Recorder (Exhibit 8) extensive data on differences in the amount of time spent on the ground and in the air and on the influence of such factors as type of airport, instructor, student attitudes, etc. upon such variability.

Perhaps the most immediately important finding of this series of studies was that students undergoing instruction in relatively small private fields, used solely for civilian trainees, spent a significantly greater proportion of time during Stages C and D actually flying than did student pilots training at the large commercial airports. In general, the findings suggested the desirability of making instructors and operators aware of the need for considering special local situations which may result in excessively extending the amount of time spent on the ground during flight training.

In addition to providing such preliminary finding, the studies served to indicate the necessity of more exacting design and of larger samplings of airports, instructors, and students, if it seems desirable to do further work in order to answer with a greater degree of definitiveness the questions asked in initiating these studies on air-ground time.

Analysis of Movements in Handling Controls. In an investigation conducted at the University of Pennsylvania (1939-40) steps were taken to obtain objective data on coordinated patterns of limb and body movements employed in controlling the flight of a plane. Both direct observation and motion photography were employed for analyzing the details of limb and body movements and for determining differences in patterns of movements characterizing "superior" and "inferior" pilots. While this evaluation of flying habits in relation to plane performance was preliminary in character, it nevertheless represents an example of the application of the techniques of motion study to pilot performance and a source of data relevant to problems of training (98).

Although designed as major investigations in the area of training, the two projects described below yielded no definitive outcomes.

Investigation of Form ACA 342A and of the Ohio State Flight Inventory as Training Aids. This investigation, conducted as part of the Midwest-Navy Project (1942-44), yielded no meaningful results on training due to the practical impossibility of adequately controlling the instructional procedures at the several flight centers where the project was administered (99, 100, 101, 102). [5]

The Link Trainer as a Synthetic Training Device. While there have been some indications that training on the Link Trainer (Contact) might be substituted for a limited number of hours of instruction in the air, experimental investigations in this area at the University of Mighigan (1939-41) have so suffered from inadequate design and treatment and from ambiguous data as to render them of little or no practical value (78).

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[5] Other findings of this project, involving the comparison of inspector ratings, are, however, of practical value, and are described in the section on the evaluation of pilot performance.

A B

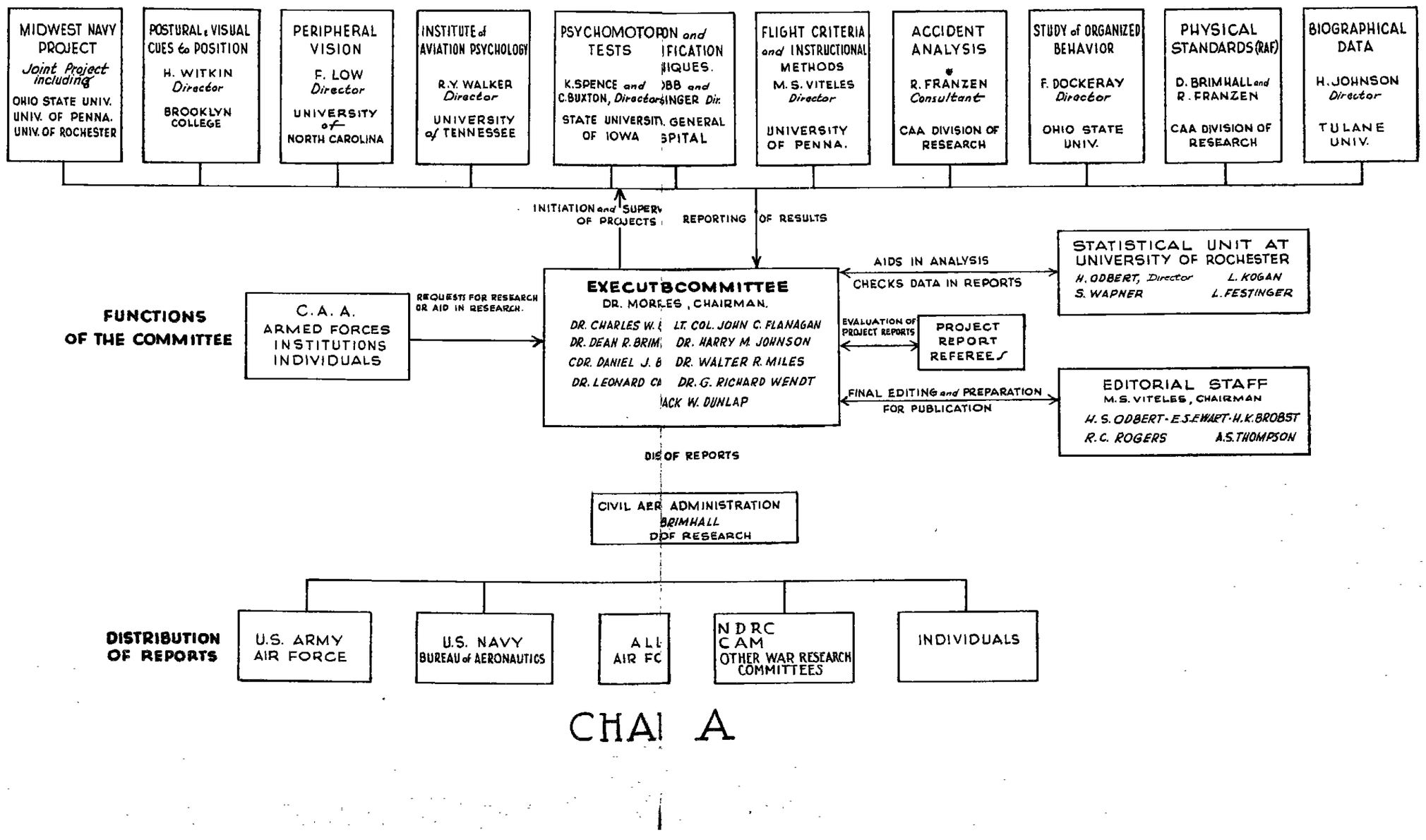
Exhibit 7

ENLARGEMENTS FROM MOTION PICTURES TAKEN DURING LANDING

In "A" the pilot is looking out the front of the cabin.
In "B" the pilot is looking out the area to the left of front.

NATIONAL RESEARCH UNCIL COMMITTEE...
on selection and training of rcraft Pilots.

FLOW CHART OF 1944 PROJECTS



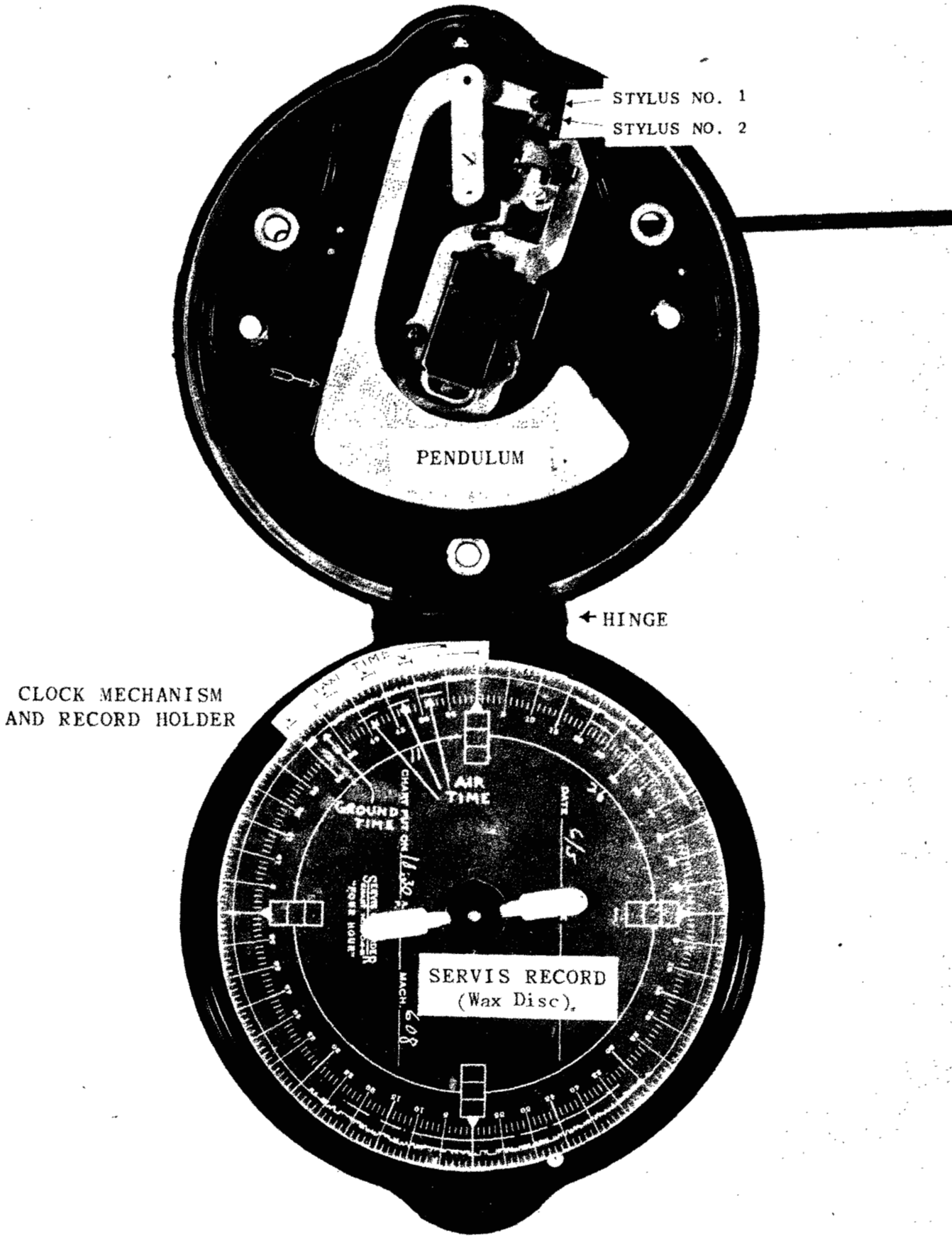


Exhibit 8
SERVIS RECORDER

EVALUATION OF PILOT PERFORMANCE

The Committee research program, from its very beginning, included the investigation of criteria of pilot proficiency. Studies have been devoted both to the evaluation of rating and grading methods actually used by instructors and inspectors and to the development of improved measures of pilot performance. The impact of this activity is apparent not only in the Civil Aeronautics Administration operating program but also in the work done on criteria by the military services.

Research on criteria has led to practical outcomes, detailed below, in:

1. the development and evaluation of new instruments and techniques for the analysis of pilot performance both for research purposes and for field use;

2. the evaluation and improvement of commonly used methods for assessing pilot proficiency.

Development of New Techniques

Standard Flights. One major practical outcome of Committee research on criteria has been the application of the concept of standardized test situations to aviation through research at the University of Pennsylvania (1939-43). Through this project, the Committee research program has provided, for use in the air, standard patterns of maneuvers analogous to the standard series of driving operations used both by civilian agencies and by the military services in measuring proficiency in the operation of a motor vehicle.

Standard flights (Exhibit 9) have been developed for various stages of the Civilian Pilot Training and War Training Service courses. Such standard flights have been used extensively in research conducted by the Committee on Selection and Training of Aircraft Pilots (98, 99, 102, 103). It is difficult to evaluate directly the influence which the concept of standard flights has had upon the operating program of the Civil Aeronautics Administration. However, the following facts may be of interest in this connection:

1. Standard flights have been prepared in descriptive and graphic form for nearly a score of airports at which CAA pilot training programs have been in operation. The use of standard flights was discussed with the personnel of the Civil Aeronautics Administration, General Inspection Division, as early as January, 1941 (104), and with personnel of the CAA Standardization Center at Houston, Texas, in 1942.

2. A manual, in the form of a bulletin, entitled Standard Check Flight Procedures (105), prepared in 1942, by the Committee on Selection and Training of Aircraft Pilots, was distributed by the CAA to flight supervisors throughout the country. It was also used in connection with the course in training methods given to personnel in the CAA-WTS Secondary Instructor Course described on page 16 of this report.

So far as is known, the Committee research program was the first to develop and make field use of the standard flight as a fundamental technique in pilot evaluation. There is every reason to believe that the concept and techniques of standard flights as developed in Committee research have filtered into the research and operating activities of the military services in the United States. Particular interest in this development has been expressed by the research personnel of the Royal Air Force which has made considerable use of standard flights in evaluating pilot performance as one basis for the classification of aircrew personnel. The "standard flight" represents an instrument of great potential value in connection with formulation of plans for the training of civilian pilots in the post-war era.

Ohio State Flight Inventory. Prior to the initiation of research by the Committee on Selection and Training of Aircraft Pilots, evaluation of pilot performance was limited largely to the assignment of ratings on individual maneuvers and grades on over-all flight performance without detailed or controlled reference to specific aspects of the performance. Beginning in 1939, research at Ohio State University was directed towards the development of a rating technique, including a standardized procedure for recording observations on specific items of pilot performance and an objective method of scoring such observations.

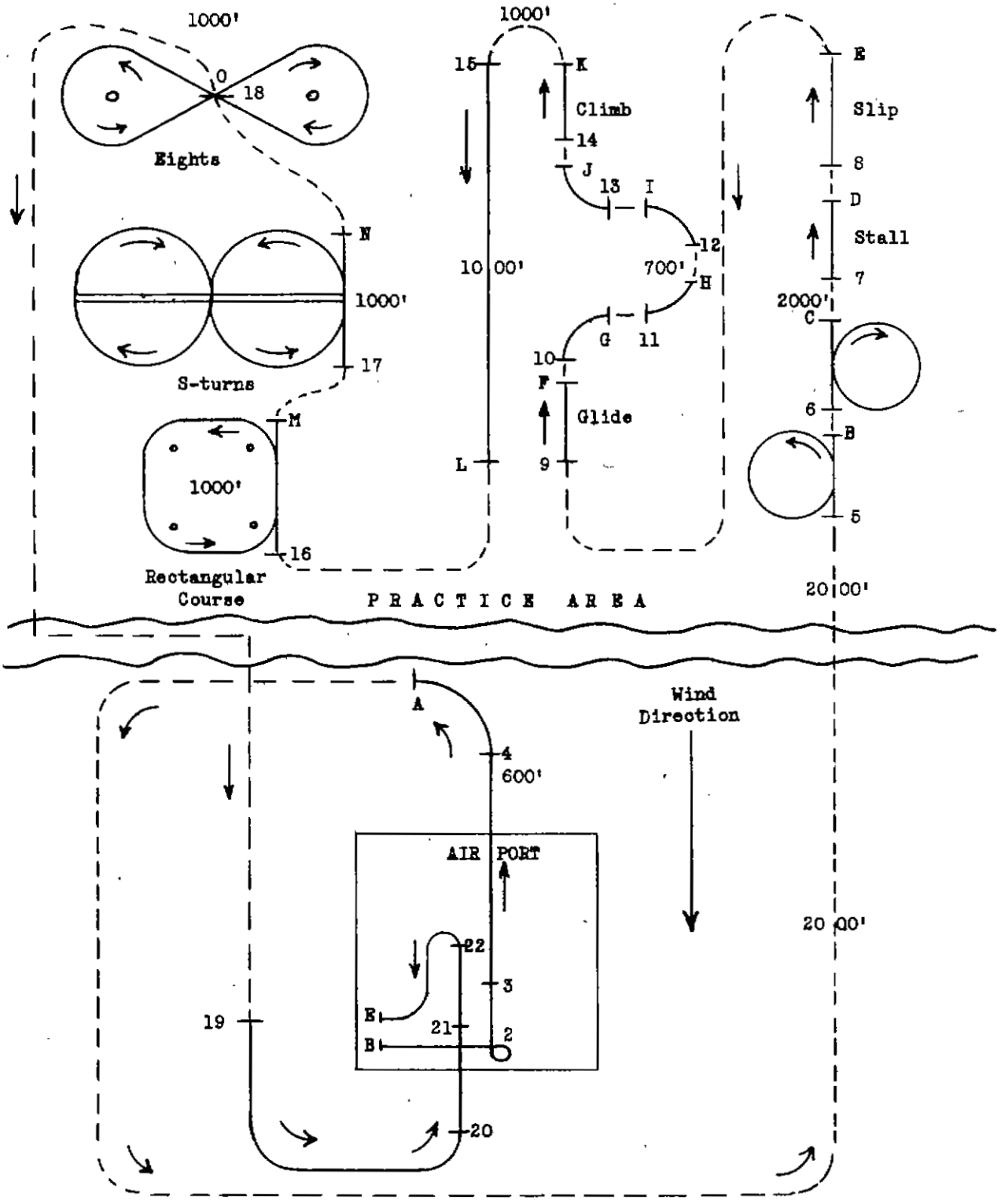


Exhibit 9

STANDARD FLIGHT D

(For use at Boston Metropolitan Airport, Norwood, Mass. and Muller Field, Revere, Mass.)

November 20, 1941

This research has led to the preparation of the Ohio State Flight Inventory, which is a comprehensive and standardized check list of items descriptive of a pilot's performance during flight. Check sheets are available for each maneuver taught in the CAA elementary course. Items are grouped, whenever possible, according to the portion of the maneuver being observed, as for example, entry, turn proper, and recovery in turns. When used in conjunction with standard flights, the Inventory provides for standardized observation and recording of the details of pilot performance during each maneuver. In addition, methods have been devised to yield maneuver scores and flight scores.

The Ohio State Flight Inventory has undergone several revisions based upon research and on field use of the instrument (106). For the form currently in use (Exhibit 10) there has been provided a detailed manual giving specific instructions for its use (107).

The Ohio State Flight Inventory has served as a valuable source of criterion data in Committee research, such as in the 1942 Midwest Project (108) and in more recent studies at the Institute of Aviation Psychology, University of Tennessee (109, 110). It has become familiar to many CAA flight instructors and inspectors both through its use in field research and through the course on training methods given at the institutes held at the University of Minnesota and at Ohio State University, in 1943, referred to on page 16. Copies of the current version have been supplied to the CAA Division of Research for use in research at Stephens College, Columbia, Missouri.

In general, the principle of standardized observation and recording of specific items of flight performance has found wide application in pilot evaluation. Copies of Ohio State Flight Inventory sheets and manual were requested in 1943 by the Army Air Forces for try-out on an experimental basis. CAA Form ACA-342Z, issued by the Civil Aeronautics Administration in 1943, embodies principles for observing and recording flight performance earlier used in the Ohio State Flight Inventory.

Purdue Scale for Rating Pilot Competency. This scale (Exhibit 11) was developed at Purdue University (1940) on the basis of preliminary research during which several other scales were constructed and the best points of each combined into a 14-item scale for experimental study. A factor analysis (111) showed that the items in the scale were, in general, measuring three factors, tentatively identified as "skill," "judgment," and "emotional stability." Experiment also indicated that ratings on this scale differentiated between criterion groups represented by the "best" and the "poorest" students of each of 91 instructors in a large number of flight training centers.

The rating scale has an important advantage in terms of ease of administration. It has been employed as a criterion measure in the Midwest Project (1942) and in connection with other research sponsored by the Committee on Selection and Training of Aircraft Pilots. The scale has been adapted for use in Navy pilot training and by the Northeast Airlines.

Objective Recording of Pilot Performance. An important outcome of Committee research on criteria has been the development of apparatus and techniques for recording in objective and permanent form the actual performance of the pilot and of the plane during flight. Two recording methods, graphic and photographic, have been investigated.

Research on the graphic method involved, first of all, the evaluation at Tulane University (1939-40) and at the University of Pennsylvania (1940-41) of commercial recorders, including the Friez Flight Record Analyzer and the Redhed Ride Recorder. Experimental trial of these instruments at Tulane University (112), at the University of Maryland (113), and at Harvard University (114, 115) early revealed basic limitations in these instruments. A detailed quantitative and qualitative analysis (112, 116) of graphic records, in research conducted at the University of Pennsylvania, has led to important conclusions concerning the possible use of such instruments in field work and in quantitative research. On the basis of these studies the Committee drew up specifications for a recorder particularly suitable for field use. A model of this instrument (Exhibit 12), known as the CAA-NRC Flight Recorder (117), was constructed at the Massachusetts Institute of Technology (1942-43). Further investigation with this apparatus is necessary in order to provide information as to its practical value and techniques for the analysis of the records. Although loaned to the U. S. Navy for field trial, little has been done with the recorder since its construction in 1943.

Research on photographic techniques has resulted in the development of installations useful in recording flight and control movement data descriptive of pilot performance. Problems of photographic recording were attacked independently at the University of Rochester (1939-40) and at the University of Pennsylvania (1939-44). While the Rochester project, with the cooperation of the Director of Research, CAA, proceeded immediately to the development of a concealed photographic unit, including an instrument panel and control movement indicator (118), the Pennsylvania group, in its earlier studies, photographed directly the plane instrument panel and the actual manipulation of controls by the pilot (98).

S T E E P T U R N S

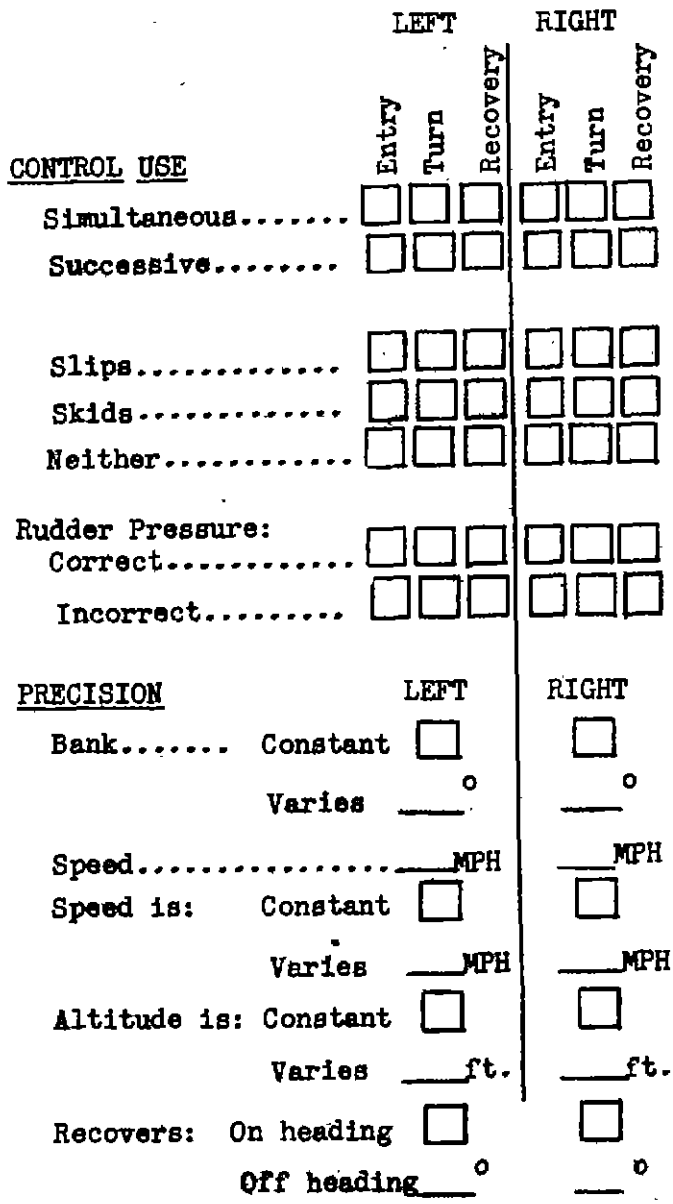


Exhibit 10

SAMPLE PAGE FROM "OHIO STATE FLIGHT INVENTORY"

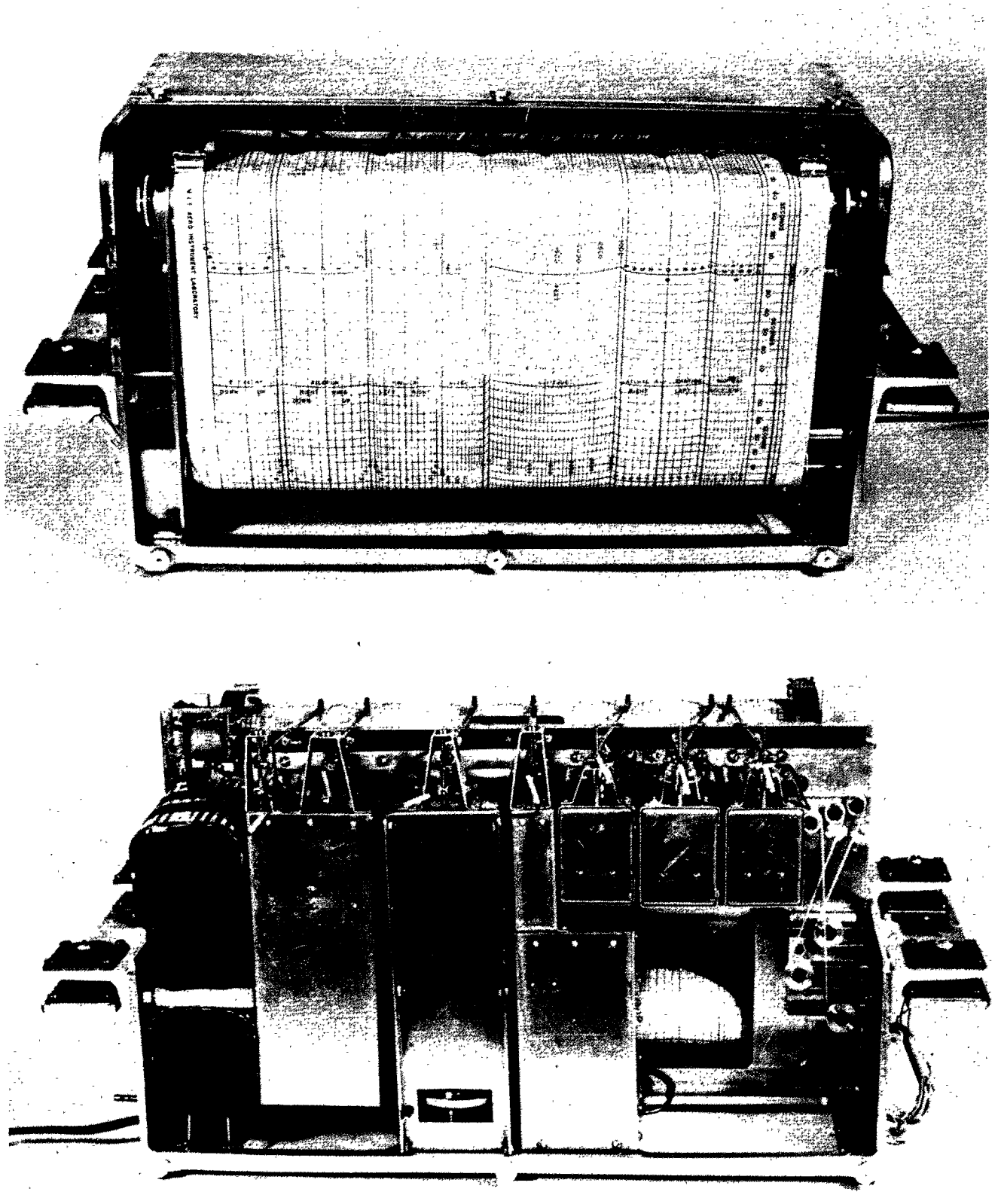


Exhibit 12

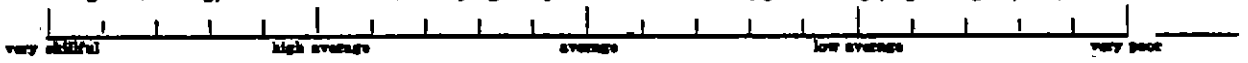
CAA-NRC FLIGHT RECORDER
Upper: Top Front View (cover removed)
Lower: Top Rear View (cover removed)

Student Pilot's Name_____

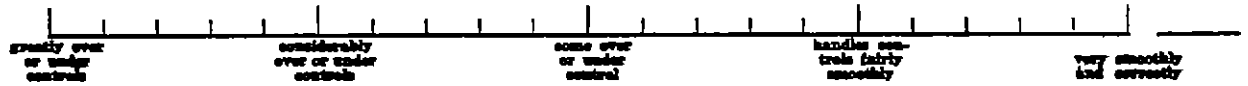
A SCALE FOR RATING PILOT COMPETENCY

No opportunity to observe

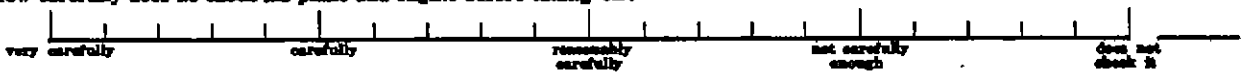
1. Considering his training, how skillful is he in carrying out precision maneuvers (spot landings, figure eights, etc.)?



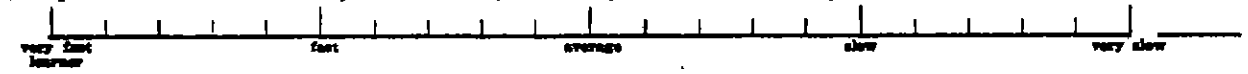
2. How does he handle the controls?



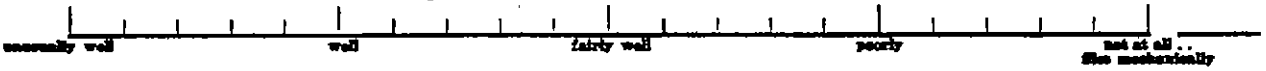
3. How carefully does he check his plane and engine before taking off?



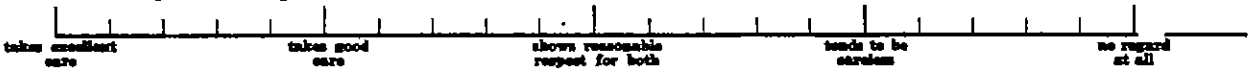
4. As compared with the other students you have trained, how readily does he "catch on" to your instructions?



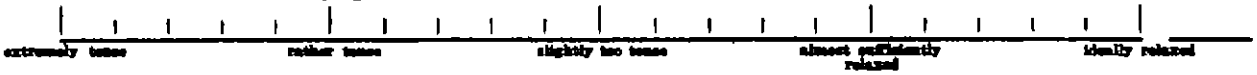
5. To what extent does he have the feel of a ship?



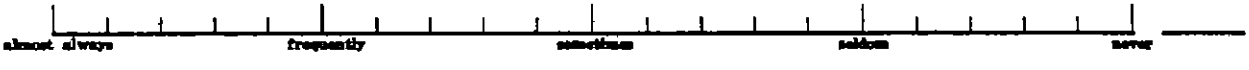
6. Does he show respect for a ship and its motor?



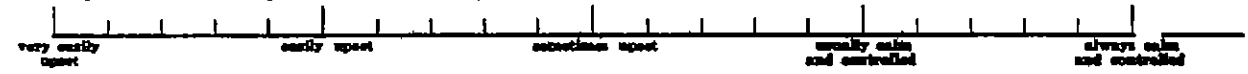
7. How tense or relaxed is he when flying?



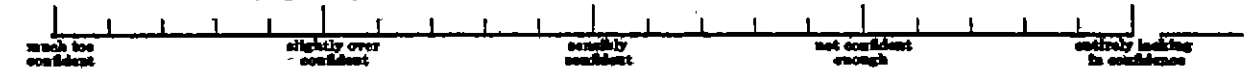
8. Is he inclined to show off while flying a plane?



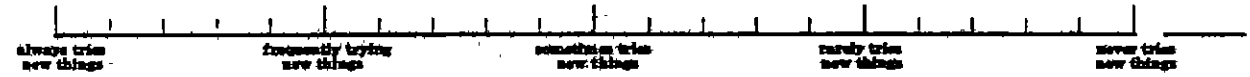
9. How easily does he become upset when something goes wrong, for example, a motor failure?



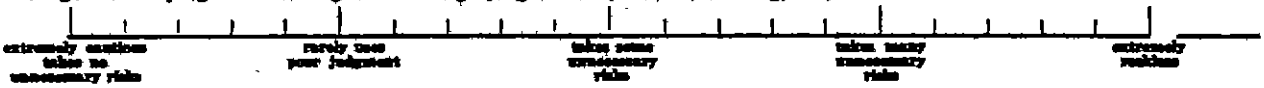
10. How confident is he of his flying ability?



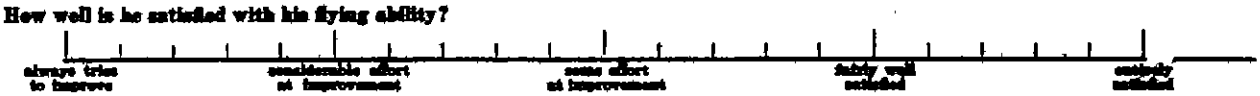
11. Does he like to try out new things, new maneuvers and cross country trips, for example?



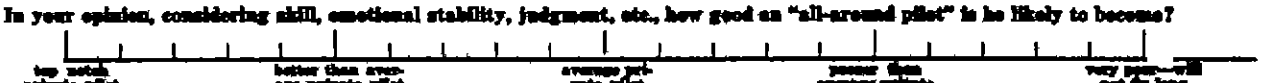
12. How good is his judgment with regard to taking flying risks? (weather, stunting, etc.)



13. How well is he satisfied with his flying ability?



14. In your opinion, considering skill, emotional stability, judgment, etc., how good an "all-around pilot" is he likely to become?

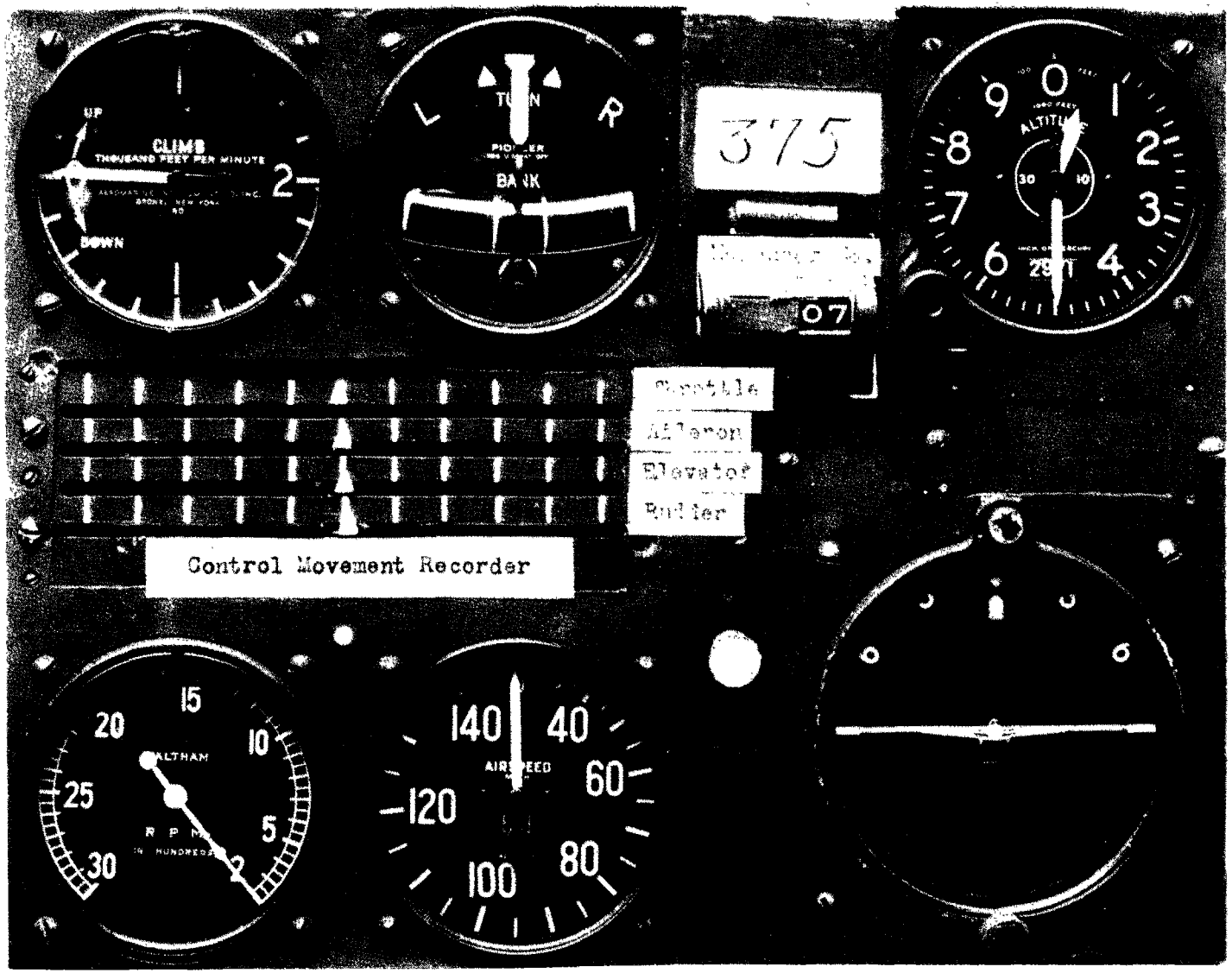


Rated by_____Instructor

Exhibit 11

PURDUE RATING SCALE

Rate of Climb | Turn & Bank | Subject No. | Altimeter



Tachometer | Airspeed | Artificial Horizon

Exhibit 13

CAMERA FIELD -- PHOTOGRAPHIC INSTALLATION

Present installations, adapted with the aid of the staff of the Institute of Aviation Psychology, University of Tennessee, provide for photography of an instrument panel and of a control movement recorder, developed at the University of Pennsylvania, located in the baggage compartment of the plane (Exhibit 13). Both the photographic installation and methods of analyzing photographic records developed in research at the University of Pennsylvania, have been used in obtaining objective criterion data in the 1942 Midwest Project (103), the 1943 Midwest-Navy Project, and in studies currently conducted at the Institute of Aviation Psychology, University of Tennessee. There has been a considerable exchange of information on photographic methods with the Empire Central Flying School, both through the RAF Delegation and through representatives from training activities in Great Britain.

Graphic and photographic records and associated methods of analysis do not yield direct measures of certain aspects of pilot performance, such as observance of safety precautions, use of certain types of judgment, etc. They yield measures primarily of value in analyzing the skill displayed in the execution of maneuvers and are particularly useful in research where detailed and objective information on the level of skill exhibited by the pilot is desired. Because of their objectivity, graphic and photographic records provide basic data for determining the reliability of a single test flight, and in selecting, for pilot assessment, these aspects of flight performance which are relatively stable from flight to flight. It is also possible that graphic and photographic methods could be used for diagnosing specific faults of students who have difficulty in learning to fly, in much the same way as motion photographs are currently employed in the analysis of the faults made by members of football teams during actual play.

Investigations of Commonly Used Techniques for Pilot Evaluation

In addition to developing and evaluating new instruments and techniques, the Committee has conducted research on the evaluation and improvement of procedures commonly used in CAA pilot training programs for the assessment of pilot performance. Following is a discussion of Committee activities in this area.

Analysis of CAA Rating and Grading Methods. In 1939, when the Committee research program was initiated, two methods were used for the evaluation of pilot performance in the CAA Civilian Pilot Training program. One, designed for use by flight instructors, called for log book ratings on a 5-point scale on each maneuver practiced during instruction flights. The other, used by CAA flight inspectors at the time of the final flight test for licensing purposes, called for grades on a per cent basis.

A study at Tulane University (1939), involving an analysis of the records of student pilots trained at 12 CPT centers (119), showed low correlations between instructors' ratings and grades given by flight inspectors, and other serious limitations in the evaluation procedures. Lack of agreement between instructors' ratings and flight inspectors' grades was also reported in a study (6) at Purdue University (1939). Studies at Ohio State University (1939-41) revealed marked disagreements between pairs of instructors and between pairs of inspectors in rating pilots (106, 120). On the whole, research investigations showed that the systems of grading used in the field did not yield adequate criterion data for research purposes or for the accurate field assessment of pilot performance.

Almost every study on the prediction of student pilot success has made use of the "pass-fail" criterion. Although of value in the early stages of Committee research, the "pass-fail" criterion became less and less useful as the incidence of failure was reduced. There has therefore been increasing dependence, in research, upon the more sensitive and more objective methods for assessing pilot proficiency developed in Committee investigations described above.

In general, Committee research has been of extreme importance in pointing to the need for revising and improving methods for evaluating pilot proficiency traditionally employed in civilian pilot training programs. In this connection, there has been direct cooperation with the Division of Safety Regulation, CAA, in analyzing the forms and techniques employed by flight inspectors in arriving at flight grades as a basis for the certification of the private pilot. Such studies (1943-44) have involved the evaluation of Form ACA 342Z (120), a CAA inventory of pilot performance, including the preparation of a detailed manual for the field use of this form (121). Results of investigations which are currently undergoing analysis will yield information on such basic questions (Exhibit 14) as: (a) extent of agreement between inspectors in grading the same student on successive flight tests; (b) extent and nature of inspector differences in emphasizing specific student errors; (c) the reliability of the grade given by the inspector on the basis of a single flight test; (d) the accuracy of inspectors' observations of flight performance during flight tests as recorded in writing on Form ACA 342Z, and verbally, by means of the Air-borne Model Magnetic Wire Recorder (122). It is anticipated that the analysis of inspectors' observations and grades, in comparison with photographic recordings made in the Midwest-Navy study, will point the way towards practical methods of improving techniques employed by inspectors in the assessment of pilot proficiency as a basis for pilot certification.

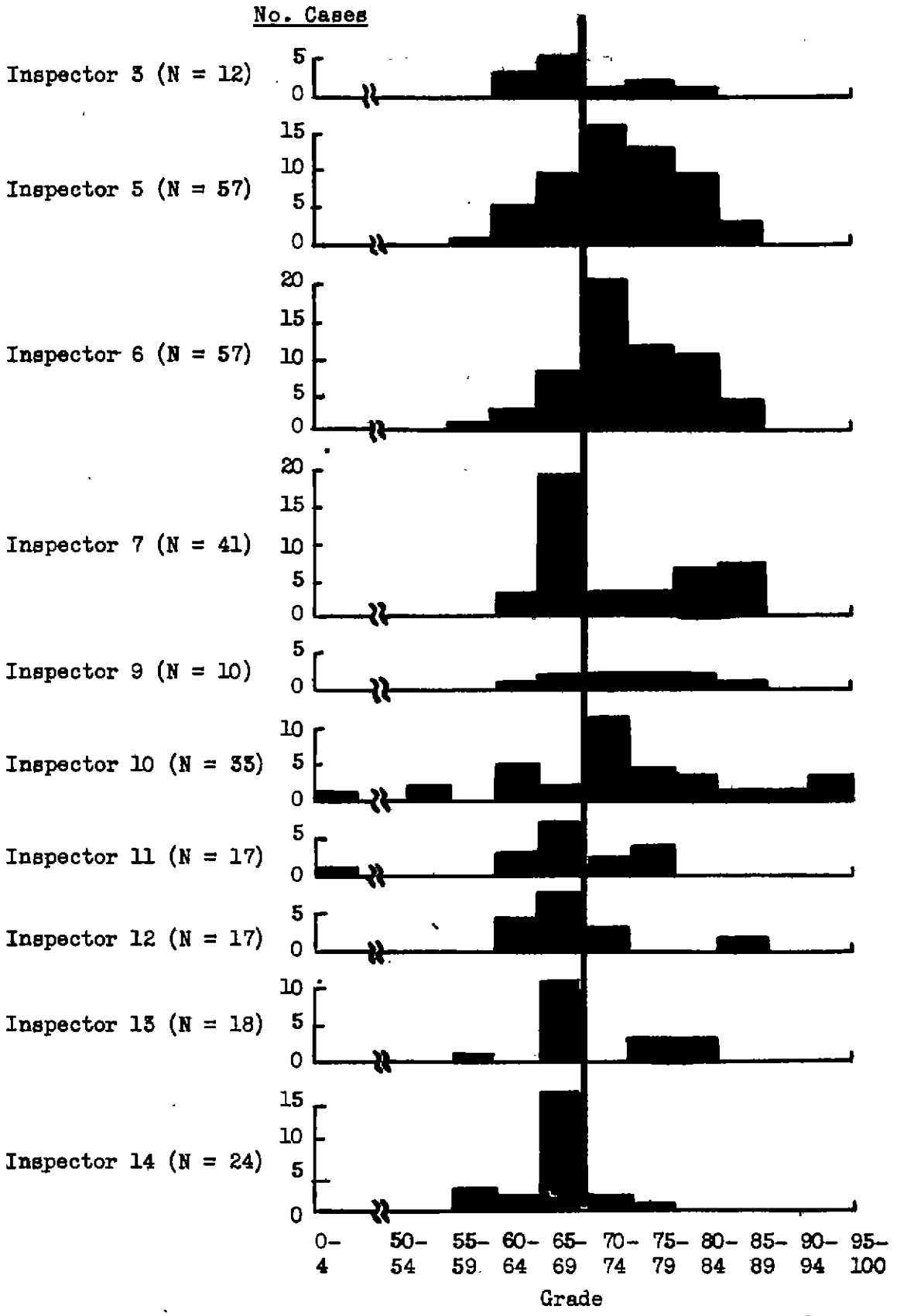


Exhibit 14

DISTRIBUTIONS OF OVER-ALL GRADES ASSIGNED BY TEN INSPECTORS

Additional work on the improvement of instructors' ratings and inspectors' grades has been carried on at the Institute of Aviation Psychology, University of Tennessee, with particular emphasis on methods of grading useful in revealing stages of progress in learning to fly. If current field try-out of this technique yields results comparable to those obtained in preliminary studies, the findings can be of considerable value in improving the practices of instructors and inspectors in the evaluation of flight performance. This is an area which calls for close integration of the Committee research program with the operational activities of the Civil Aeronautics Administration.

Relation of Maneuver Ratings to Total Flight Performance. One of the by-products of the RAF study referred to on page 7 was the development of a criterion measure based on the ratio of successful to unsuccessful flights during flight training, which may well deserve serious consideration in the development of practical field criteria for CAA use (46). Also of possible value in planning for the improvement of flight assessment are data on the relationship between ratings on specific maneuvers and success or failure in flight training gathered in the same investigation (123).

Analysis of Training Time as a Criterion. A practical question for both civilian and military training is the extent to which student performance in the early stages of training is associated with or predictive of final performance. There is evidence from research (1941-42) conducted at the University of Rochester (124), the University of North Carolina (125, 126), and the Midwest Project (1942) that there is no close or consistent relationship between the number of hours spent in early stages of flight training and later success or failure in the course (103, 127). These findings, if confirmed in other studies, can be of particular importance in the training of civilian pilots where it may be unnecessary or even inadvisable to place marked emphasis on time to solo in evaluating pilot performance as a preliminary to wash out. Consideration of such findings might well lead to a revision of the civilian pilot training curriculum involving the removal of time limits for various stages of the training course.

In the investigation of criteria, as in other areas, there are studies which have failed to yield practical outcomes or promising results for reasons enumerated in the Introduction to this report. So, for example, early studies at Pensacola (1940-41), designed to devise a flight score based on the number of possible check flights and re-checks (10), failed to produce results useful to Committee research or to the CAA operating program. Preliminary experiments with a pilot-response recorder (128), developed at Indiana University in 1940, have not led to further use of this instrument either in the research program of the Committee or in connection with the pilot training and assessment program of the CAA and military services.

Many critical problems with respect to criteria are not yet fully solved, such as (a) the establishment of cut-off points (for example, for washing out student pilots) on the Purdue Scale for Rating Pilot Competency or the Ohio State Flight Inventory, (b) the grading of graphic or photographic records on a scale of excellence of performance, (c) the determination of the relative value of various criterion measures and a means of combining them into an optimum criterion battery, and (d) the measurement of the "judgment" and "emotional stability" aspects of over-all pilot performance. Nevertheless, the over-all picture, as in the case of research on selection and training, is one of significant and practical achievement.

EMOTIONAL DISTURBANCES ASSOCIATED WITH LEARNING TO FLY

Several studies, conducted chiefly in the earlier years of research, have been concerned with emotional and physiological reactions associated with flight. While several of these studies yielded results of theoretical interest, this group as a whole has perhaps produced the smallest returns in the way of practical findings directly applicable to flight. However, such studies were of value in indicating the areas of research upon which emphasis could be most profitably placed in the over-all program of the Committee on Selection and Training of Aircraft Pilots.

Sleep Motility. A study at the University of Virginia (1939-40), concerned with sleep motility of student pilots undergoing flight training (129), directed attention to motility during sleep following flight lessons. Correlations with success in flight training were not obtained and the study had no direct useful outcomes.

Salivary Secretions and Respiratory Changes. Laboratory tests on salivary secretion of students receiving flight training were made at Cornell University (1940), where investigators also obtained records of respiration and pulse rate during actual flight lessons (130). Limitations in experimental design and in the presentation and discussion of results make this study of questionable practical value.

Muscle Potentials. At the New York Psychiatric Institute (1940-41) a Myo-Voltmeter was designed to measure the electrical output of muscles during flight. Records from this instrument are visually apparent to both instructor and student during flight and the proposal was made that the instructor call the attention of the student to the level of tension associated with the performance of particular maneuvers. The apparatus also served to provide a cardio-tachometer record.

The use of the instrument is limited to the extent that absolute measurements cannot be obtained for comparing individuals. Exploratory studies were reported (131, 132), but no evidence is available on the trial of the instrument in connection with flight training, although provisions were included for its use in the University of Maryland study of "tension".

Tension. No final report providing statistical data and conclusions has been submitted on extended studies of "tension" during flight training conducted at the University of Maryland (1939-43). In preliminary and informal reports (133), attention has been called to the difficulties and ambiguity in applying the term "tension" to the flight situation. Instruments for measuring and recording muscle tension and associated physiological functions are available from these studies.

Skin Temperature and Perspiration. At Yale University (1940) an improved instrument was developed for measuring skin temperature and sweating in airplane pilots (134). This instrument, small enough to be attached to the palm of the pilot's hand, is known as the CAA-NRC Micro-Recorder. Preliminary tests showed appreciable changes in temperature and in humidity associated with flight experience. Efforts to obtain adequate ratings by instructors on tension and emotional stress during flight were unsuccessful. Twenty-five units of the instrument are available for further studies of response during flight.

Muscular Set. At New York University (1939-43) an elaborate polygraph was constructed for experimental work in the measurement of "muscular set". Findings are available on subjects examined in a laboratory situation (135), but no use has been made of the instrument in studies of pilot reaction and performance. The instrument was recently loaned to the National Defense Research Committee for special investigations being conducted by one division of this war research agency.

Noise and Vibration. Studies at the State University of Iowa (1940-43) indicated that noise and vibration conditions, similar to those encountered in military aircraft during flight, showed no significant effect upon performance on the Mashburn Serial Action Test, even when continued for four and one-half hours (136). No measures were obtained of increased physiological cost. The study led to no specific proposals for action.

STUDIES OF AIR SICKNESS

Considerable work in the study of airsickness has been carried on at Wesleyan University (1939-43) and at the University of California (1940-43). These were largely exploratory studies designed to test hypotheses concerning psychological and physiological determinants of airsickness (137, 138, 139).

One practical outcome of this work is a popular pamphlet, entitled How to Prevent Airsickness, which has been widely distributed by the Civil Aeronautics Administration (140). Studies of airsickness have also yielded a number of research tools, particularly a motion sickness questionnaire which has been adapted for use in an extension of studies of motion sickness under the auspices of the Committee on Aviation Medicine, Committee of Medical Research, Office of Scientific Research and Development. In addition, the studies have contributed to the effectiveness of the work of other organizations, such as the Canadian Associate Committee on Seasickness, particularly in avoiding wasted effort in the exploitation of unprofitable leads in research.

More recently (1943-44), use has been made of the Stability of Orientation Test, developed at Brooklyn College (67), in the further examination of determinants of visually-induced airsickness as a supplementary feature of research being conducted at that institution.

AVIATION ACCIDENTS

In a current study (1943-44) the causes of civil aviation accidents, and the maneuvers most closely related to these accidents (Exhibit 15), are being investigated. The frequency with which fatal accidents are associated with stalls, particularly those growing out of turns at low altitudes, has suggested the necessity of important basic changes in the training program. A practical outcome of such research findings and conclusions would be a shift in emphasis during training from precision entries and execution of stalls and spins to training in the avoidance of and immediate recovery from the stall condition, possibly through extended practice in slow flying.

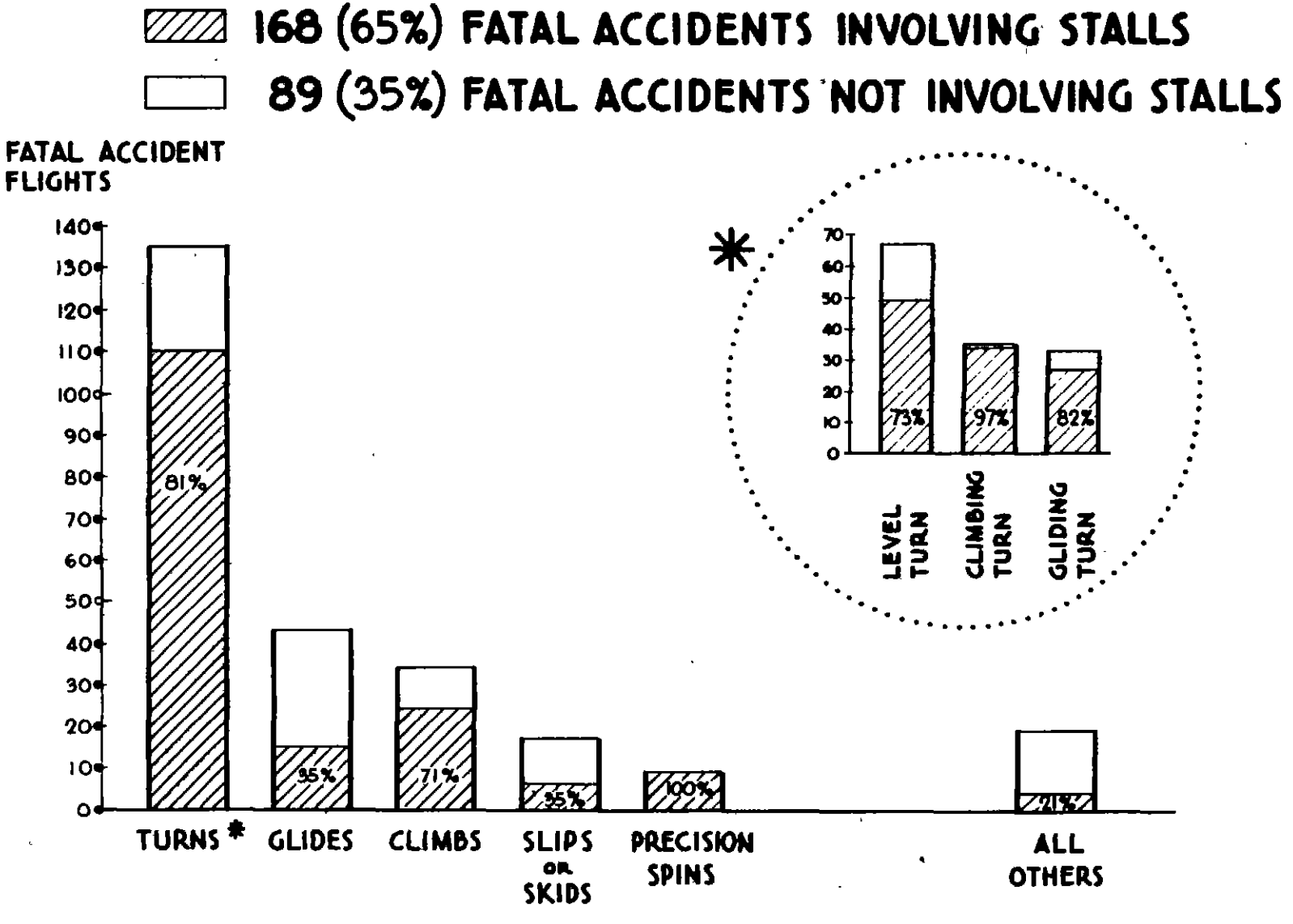


Exhibit 15

LEAD MANEUVERS IN 257 FATAL ACCIDENTS WITH NO STRUCTURAL DEFECT

GENERAL OUTCOMES

In addition to the specific outcomes summarized on the preceding pages, there have been important by-products from the operation of the Committee on Selection and Training of Aircraft Pilots.

Committee meetings have served as a forum for the exchange of ideas among civilian and military agencies and personnel concerned with the problems of aviation psychology. This was particularly true in the early years, since the Committee on Selection and Training of Aircraft Pilots was functioning actively before the military services had established units for psychological research in aviation. The Committee continues to serve as a medium for the exchange of experience, for formulating objectives, and for facilitating the application of such research. Committee membership and liaison include representatives from the military services of the United States and foreign countries, as well as from the civilian agencies concerned with problems of aviation personnel. This fact has contributed considerably to the effectiveness of the Committee in these respects.

Numerous universities and research centers throughout the country have been drawn into research in aviation psychology through participation in the work of the Committee on Selection and Training of Aircraft Pilots, including the universities and laboratories which have conducted basic research under grants from the Committee on Selection and Training of Aircraft Pilots, and approximately 550 additional centers involved in the administration of aviation selection tests through the Standard Testing Program and the CAA-National Testing Service (Appendix I). Such activities have served to arouse interest in aviation psychology research and to establish a core around which an extensive and effective program of post-war research in aviation psychology can be developed.

In cooperation with the Civil Aeronautics Administration and the Tennessee Bureau of Aeronautics, the Committee on Selection and Training of Aircraft Pilots has already taken steps towards the assurance of post-war research through the establishment of an Institute of Aviation Psychology at the University of Tennessee. The Committee program has led to the organization of a similar center at Ohio State University. In this way, the work of the Committee on Selection and Training of Aircraft Pilots is serving to avoid the cessation of research in aviation psychology which occurred at the end of World War I.

Through the work of the Committee a considerable number of professional men and women has become actively engaged in research in aviation psychology. In an address made in 1943, Commander (then Lt. Cdr.) John G. Jenkins, Aviation Psychology Branch, Division of Aviation Medicine, Bureau of Medicine and Surgery, U. S. Navy, expressed gratitude to the Committee for turning over to that section approximately one-quarter of the section's trained personnel. In the Army Air Forces, as well as in the U. S. Navy, there are men engaged in research in aviation psychology who are applying training and experience acquired in programs supported by the Committee on Selection and Training of Aircraft Pilots. These, as well as those still engaged in work with the Committee at various universities, are in a position to utilize such training and experience in research in aviation psychology in the post-war world.

Publications of the Civil Aeronautics Administration have stressed its goal as that of insuring "airworthy aircraft flown by competent pilots". In contrast to other groups, which have emphasized the development of airworthy aircraft, the National Research Council Committee on Selection and Training of Aircraft Pilots has centered attention on the human aspects of aviation with the view of achieving maximum competency, and the highest possible level of performance and safety on the part of the aircraft pilot. By doing so, the Committee has served to establish a firm foundation for a sound structure of research and practice in the attainment of the goal of the Civil Aeronautics Administration.

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APPENDIX I

COOPERATING RESEARCH CENTERS AND PROJECT DIRECTORS

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COOPERATING RESEARCH CENTERS AND PROJECT DIRECTORS

Research centers and project directors in charge of research projects are listed below:

Research Centers	Location	Project Directors
University of Alabama	University, Ala.	C. P. Seitz
Brooklyn College	Brooklyn, N. Y.	H. A. Witkin
Brown University	Providence, R. I.	Carl Pfaffmann
University of California	Berkeley, Calif.	E. E. Ghiselli
University of California	Los Angeles, Calif.	R. M. Dorcus
University of Colorado	Boulder, Colo.	T. W. Howells
Cornell University	Ithaca, N. Y.	H. S. Liddell
		Richard Parmenter
		A. L. Winsor
George Washington University	Washington, D. C.	J. P. Foley
		Thelma Hunt
Harvard University	Cambridge, Mass.	R. A. McFarland
University of Illinois	Urbana, Ill.	T. W. Harrell
University of Indiana	Bloomington, Ind.	W. N. Kellogg
Iowa State College	Ames, Iowa	J. E. Evans
State University of Iowa	Iowa City, Iowa	C. E. Buxton
		K. W. Spence
		Don Lewis
University of Kansas City	Kansas City, Mo.	Lorenz Misbach
University of Maryland	College Park, Md.	R. M. Bellows
		J. G. Jenkins
		J. W. Macmillan
		A. C. Williams
Massachusetts General Hospital	Boston, Mass.	Stanley Cobb
		J. E. Finesinger
Massachusetts Institute of Technology	Boston, Mass.	C. S. Draper
		Walter McKay
University of Michigan	Ann Arbor, Mich.	E. B. Greene
University of Minnesota	Minneapolis, Minn.	M. A. Tinker
Naval Air Station	Pensacola, Fla.	R. A. McFarland
New York University	New York, N. Y.	Raymond Franzen
		D. H. Fryer
New York Psychiatric Institute	New York, N. Y.	Carney Landis
University of North Carolina	Chapel Hill, N. C.	F. N. Low
		Dorothy Rethlingshafer
		R. J. Wherry
Northwestern University	Evanston, Ill.	A. R. Gilliland
Ohio State University	Columbus, Ohio	H. A. Edgerton
		R. Y. Walker
Pennsylvania State College	State College, Pa.	W. M. Lepley
University of Pennsylvania	Philadelphia, Pa.	M. S. Viteles
Purdue University	Lafayette, Ind.	E. L. Kelly
		Joseph Tiffin
University of Rochester	Rochester, N. Y.	J. W. Dunlap
		Brian O'Brien
		H. S. Odbert
		J. D. Page
		M. J. Wantman
Springfield College	Springfield, Mass.	Leonard Larson
Stanford University	Stanford University, Calif.	J. K. Lewis
		Eric Liljencrantz
		E. K. Strong
		Craig Taylor
University of Tennessee	Knoxville, Tenn.	R. Y. Walker
Tulane University	New Orleans, La.	H. M. Johnson

University of Utah	Salt Lake City, Utah	M. W. Lund
Vanderbilt University	Nashville, Tenn.	N. L. Munn
University of Virginia	University, Va.	F. A. Geldard
Wesleyan University	Middletown, Conn.	G. R. Wendt
Williams College	Williamstown, Mass.	Stanley Cobb
		J. E. Finesinger
Yale University	New Haven, Conn.	W. R. Miles

The Standard Testing Program (1942) involved the voluntary cooperation of 46 psychologists in various parts of the country listed below:

Name	Institution	Location
Adams, Donald K.	Duke University	Durham, N. C.
Allen, Clinton M.	Liberal Arts College	Oklahoma City, Okla.
Atkinson, Ernst A.	Montana State University	Missoula, Mont.
Bathurst, James E.	Birmingham-Southern College	Birmingham, Ala.
Beaumont, Henry	Kentucky University	Lexington, Ky.
Berrien, F. K.	Colgate University	Hamilton, N. Y.
Bills, Arthur G.	University of Cincinnati	Cincinnati, Ohio
Bruce, Robert H.	University of Wyoming	Laramie, Wyo.
Caldwell, V. V.	General Extension Division, Oregon State System of Higher Education	Portland, Oreg.
Crannell, Clark W.	University of Michigan	Ann Arbor, Mich.
Davis, Robert A.	University of Colorado	Boulder, Colo.
Ellson, Douglas G.	University of Mississippi	University, Miss.
Gaskill, Harold V.	Iowa State College	Ames, Iowa
Gilmer, B. von Haller	Carnegie Institute of Technology	Pittsburgh, Pa.
Gilliland, A. R.	Northwestern University	Evanston Ill.
Graham, James L.	Lehigh University	Bethlehem, Pa.
Grant, David A.	University of Wisconsin	Madison, Wis.
Hayes, George L.	University of Akron	Akron, Ohio
Hildreth, Harold M.	Syracuse University	Syracuse, N. Y.
Hinckley, Elmer D.	University of Florida	Gainesville, Fla.
Horton, Clark W.	Dartmouth College	Hanover, N. H.
Johnson, H. M.	Tulane University	New Orleans, La.
Jones, Edward S.	University of Buffalo	Buffalo, N. Y.
Kellogg, W. N.	Indiana University	Bloomington, Ind.
Koch, Adolph M.	Essex Junior College	Newark, N. J.
Kreezer, George L.	Cornell University	Ithaca, N. Y.
Ligon, Ernest M.	Union College	Schenectady, N. Y.
Lund, Max W.	University of Utah	Salt Lake City, Utah
Madden, William F.	Middlebury College	Middlebury, Vt.
Manuel, H. T.	University of Texas	Austin, Texas
Miller, Lawrence W.	University of Denver	Denver, Colo.
Miller, Vernon L.	Bowdoin College	Brunswick, Me.
Misbach, Lorenz	University of Kansas City	Kansas City, Mo.
Munn, Norman L.	Vanderbilt University	Nashville, Tenn.
Page, James D.	Temple University	Philadelphia, Pa.
Peterson, John C.	Kansas State College	Manhattan, Kans.
Sanderson, Sidney	Rutgers University	New Brunswick, N. J.
Seashore, Harold C.	Springfield College	Springfield, Mass.
Sisson, E. Donald	Louisiana State University	University, La.
Terry, Paul W.	University of Alabama	University, Ala.
Tinker, Miles A.	University of Minnesota	Minneapolis, Minn.
Willey, Clarence F.	Norwich University	Northfield, Vt.
Williams, Alexander C.	University of Maryland	College Park, Md.
Wingfield, Robert C.	Converse College	Spartanburg, S. C.
Wantman, Morey J.	University of Rochester	Rochester, N. Y.
Yarborough, Joseph U.	Merit System Council, Texas Unemployment Compensation Commission	Austin, Texas

In connection with the CAA-National Testing Service (1942), the selection test battery was administered by 809 Chief Examiners who reported the results to 571 Coordinators distributed throughout the country.