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A Course of Study in Aviation Education Including a Survey of Utah High Schools

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A COURSE OF STUDY IN AVIATION EDUCATION

INCLUDING

A SURVEY OF UTAH HIGH SCHOOLS

by

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INTRODUCTION

<u>The increasing importance of the airplane in present day civilization</u>

Throughout the ages, after each development in speed of communications and transportation, man has made noteworthy changes in his way of living. Indications are that the gradual development of the airplane to a safe and rapid means of transportation has had a great effect upon society by pushing back the frontiers of the world both geographically and scientifically. The impact of this speed has influenced almost every home and certainly every school in America.

<u>Aviation Education in the nation's schools</u>

Because of the growing importance the airplane is playing in our daily lives and the importance it is assuming in transportation, agriculture, business, law enforcement, and the affect it is having in foreign affairs and international relations it has become increasingly evident that more education about aviation and its many related fields should be presented in as many of our nation's schools as possible.

In a nation that produces the majority of the transport planes used by the airlines of the world, and produces the world's leading military aircraft, it is essential that the students learn more about the greatest advancement made by man to conquer time and distance.

The technological advancements in aviation during the past ten years have been phenomenal; yet the number of courses in Aviation Education in our high schools has diminished rapidly from the high number taught during World War II.

This fact is pointed out in the following statement in an editorial in Flying magazine:

> Of seven million high school students now in classrooms in the United States, less than one-half of one per cent are exposed to accredited aviation subjects in any category--scientific, vocational, cultural.
>
> Can aviation industry draw an increasingly necessary volume of engineering talent from such a background?
>
> Can air commerce man the ramparts of world trade from such a lack-lustre horizon?
>
> Can military aviation recruit quality youth from this vacuum of motivation?
>
> Can the local air scene be other than a weed-grown relic of a discouraged dream while the lap of the air ocean does not reach the ear of a boy at a desk?
>
> And if air industry and commerce and defense and community progress are bereft of intellectual concept in the origins--what of the nation and its tomorrows?[1]

There appears to be at present a lack of interest in aviation in the United States by the general public and by the high school students who should be the pilots, engineers, mechanics and airline executives of tomorrow.

Today the airlines are having difficulty recruiting pilots to man the planes scheduled for airline operation within the next three years. The Air Force pilot recruiting program is lagging because the young men eligible for military duty are not interested in aviation. The airplane manufacturers are having a difficult time finding enough engineers to man their drafting boards and research laboratories. There is a shortage of aeronautical engineers to do research and design at our governmental research and development centers.

The insufficient number of trained pilots is indicated by the decline in student pilot licenses issued by the Civil Aeronautics

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1. Gill Robb Wilson, "Public School Education--The Bullseye", Flying, Editorial, October, 1955

Administration during the years 1947 to 1942, from a high in 1947 of 192,924 to a low in 1942 of 30,537.[(1)] During this time the pilots of today should have been trained; the pilots of tomorrow should now be in training.

The fact that the United States lags in the training of engineers is shown by the report in Planes, which states that last year Russia graduated 54,000 in comparison to 20,000 for the U. S.[2]

An equally important facet of this picture regards the education of those students who will not be pilots, engineers, mechanics, or enter any one of the many vocations in the field of aviation. They must be directed to a better understanding of aviation in terms of the changes in global geography, changes in civil transportation, changes in agriculture, changes in national defense, and possible changes in governmental policy. Education of this type is needed so that the men and women of tomorrow can visualize the nation's responsibility and their own responsibility in a world that has no barriers.

It is believed by many leaders, both educational and governmental, that if we are to maintain a place of leadership in the world aviation picture, it is necessary that a greater educational effort be put forth to prepare our students of today as air-wise citizens of tomorrow. The need for more aviation education in our schools is stated in the opening paragraph of a report of the American Association of School Administrators:[3]

> Aviation is having a profound effect upon the institutions and peoples of the world. Technology has given

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1. Civil Aeronautics Administration, Statistical Handbook of Civil Aviation, 1955, p. 27
2. Aircraft Industries Association, Planes, February, 1956, p. 1
3. American Association of School Administrators, Aviation Education, 1949, p. 1

> mankind a vehicle capable of transporting men, their goods, and their ideas through aerial pathways at fantastic rates of speed. Frequently in the past, science and invention have speeded ahead of social adjustment, producing dislocations in society. The invention of the airplane and the discovery of atomic energy threaten to produce another period of social lag. Already aviation has influenced events and conditions of life and transformed old patterns of social living. Every objective of education, every social, scientific, and economic area with which education deals, has been affected. Education cannot ignore what is happening; it can help to reduce the social lag.

The high schools of the state of Utah which offer study courses in aviation are very few. It is likely this condition cannot meet the needs of many students who have an intense interest in the field of aviation. As a result, a very valuable learning opportunity may be missed which might have furnished the necessary interest motivation for a resulting career in one of the many phases of aviation.

Purpose of the study

It is the purpose of this study to:

A. Ascertain the present status of Aviation Education in Utah high schools

B. Present a course of study which may meet the needs of those schools now contemplating or who now have a regular class in Aviation Education

Definition of terms

Because some educators, writers, and school administrators refer to classes in airplane subjects as Air Age Education, some have named it Aviation Education, and still others call it Aeronautics or Aeronautical Education, there is some question on the part of the students and educators as to the meaning of each of these terms.

The definition of the terms, Air Age Education, Aeronautics, and Aviation Education, given by Dr. Mervin K. Strickler is, in the opinion of the writer, the best approach to a standard, well solidified definition. Dr. Strickler in his doctoral study,[1] made in 1951, formulated the following definitions of the three terms under discussion:

> Air Age Education: The definition of air age education as stated or implied by the individuals and groups cited in this article does not allow for a distinction between either general and special education or formal and informal education. In addition, by referring to an age one immediately implies other ages. For example, the AASA Committee referred to both the air and atomic ages. Both are honorific labels, and neither term can be clearly defined. Nor can the essence of the one be distinguished from that of the other. Moreover, they coalesce with other terms such as the jet age, the rocket age, and the hydrogen age. These poetic terms--and they are just that--lead to such questions as these: Is the rocket age part of the air age? When will the atomic age become the hydrogen age?
>
> Because of its very nature, the term air age education applies to an era that is overlapped by other eras and will undoubtedly be followed by other eras. Also, it is only one of many similar terms applicable to technological developments and their effect upon a given age. Because of these factors, air age education as a descriptive term is nebulous. For a field of knowledge that requires rigorous thinking one must have clear-cut and operable definitions. On these grounds, the term air age education is not useful for careful thinking.

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1. Mervin K. Strickler, "The Air Center as a Means of Implementing Aviation Education", 1951, pp. 1-2

Aeronautical Education: Aeronautical education has come to mean the educational activities related to the scientific study of flight, Aerodynamics in its most technical and mathematical form is properly a study under the classification of aeronautical education. Properly used, the term aeronautical education is education of a technical nature, that is, in Dr. Durand's words--'technical, professional, vocational education.' It is education of those engaged in rendering aviation services to society. Otherwise expressed, it is special education as distinguished from general education.

Aviation Education: Aviation education is education of a general type. It denotes general education as distinguished from special education, and it may be either formal or informal. Thus with a proper distinction between general and special education and an understanding of the meaning of formal and informal education, the writer proposes the following operational definition of aviation education:

> Aviation education is that branch of general education concerned with communicating knowledge, skills, and attitudes about aviation and its impact upon society. It must be distinguished from that branch of special education known as aeronautical education which is concerned with training specialized aviation workers.

REVIEW OF LITERATURE

Recommendations for Aviation Education course content

Suggested subjects to be taught in various Aviation Education programs are stated briefly by the Congressional Aviation Policy Board:[1]

> An aeronautical educational program should be established throughout the public school system in order that basic problems of the air age--global geography, meteorology, navigation, mechanics, communications, and the rudiments of flight--are well understood by future generations.

The above statement by government congressional leaders indicates the thinking of a council of 35 members who served on the board. The Aviation Policy Board further recommends:

> To provide an air-minded public and a reservoir of technically trained personnel, flight and technical courses should be promoted in colleges and universities with full scholastic credit given; and aviation education courses should be stressed in our primary and secondary schools.
>
> Education has not yet reached full stride in giving our citiznes intellectual preparation for the world as aeronautical science has modified it. Distance must be measured in time; surface route concepts must be abandoned.
>
> Thirty states have adopted aviation education programs. Seventeen others are planning such programs. Several have incorporated provision for flight experiences in their courses, giving valuable understanding of flight principles.
>
> Considerable progress toward this goal has been made, but more is necessary if our citizens are to meet the responsibilities of world leadership. The primary need is properly trained teachers. A program of providing schools with surplus aircraft equipment to assist in development of mechanical skills is highly desirable.[2]

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1. Congressional Aviation Policy Board, National Aviation Policy, Senate Report #949, 80th Congress, 1948, p. 5
2. Ibid., p. 32

The recommendations of the American Council on Education for a basic aviation course are as follows:[1]

> Basic course.--This course is broad and general in its nature so as to give a complete overview of aviation. It may be thought of as a prerequisite for further study and particularly as providing a basic foundation for the better understanding of the "Aviation-skills" courses. In content it should cover the following aspects of aviation:
>
> (a) The effect of aviation on our living; its history, its tremendous growth and probable effect on the future.
> (b) The airplane: its parts, structure, types (including the helicopter and autogyro).
> (c) Theory of flight: air foil studies, forces acting on a plane, axes of rotation, stability, safety measures in flying.
> (d) Power plants and their components; all types of engines, including jets and gas turbines; propellers; carburetion; ignition; lubrication; fuels.
> (e) Flight instruments and their use.
> (f) Weather and the atmosphere: clouds, circulation of the air, winds, storms, weather maps, fronts, forecasts, flight advisory service.
>
> (g) Aerial navigation: latitude and longitude, aeronautical charts, the magnetic compass, dead reckoning, celestial navigation, radio navigation, radar navigation.
> (h) Air traffic control: the Civil Aeronautics Administrtion; Civil Aeronautics Board regulations; at airports; along airways.
> (i) National and international problems of control.
> (j) Airports: classes, runways, airport lighting, administration buildings and terminals, hangars and service facilities, refueling facilities, fire and crash emergency equipment. Federal aid to airports program.
> (k) Vocational opportunities in aviation.
>
> Since this course is more or less technical, it should require special teacher qualifications. It should meet five days a week during the school year and be offered in the upper years of the senior high school. Credit should be given toward graduation.

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1. H. E. Mehrins, Editor. Aviation in School and Community. 1954, pp. 7-8

Mr. Willis C. Brown, Specialist for Aviation Education, in the U. S. Office of Education stated some of the reasons expressed by students going beyond the criteria of a common learnings program are:[1]

1. A desire to specialize in flying as a life's work
2. A desire to specialize in aircraft mechanics
3. Desire to continue in aeronautical engineering
4. Desire to have a military career in aviation
5. Desire to use aviation as a hobby

Such aims may be served by offering one or more elective courses in high schools. Some suggested course titles or units follow:

1. Airplane Model Building, Testing and Competition Flying--School Sponsored Club
2. Air Transportation
3. Fundamentals of Aeronautics
4. Mathematics of Aviation
5. Science of Aeronautics

These courses are usually offered in the 11th or 12th year, although numbers 1and 2 have been successfully offered in the 9th year.

In a study by Paul A. Burns,[2] several subjects were suggested as a program of study in Aviation Education; however, no attempt was made to develop these subjects into a course of study.

Some national aspects of Aviation Education

If Aviation Education is to be taught in the high schools, the question arises as to the year or grade in which the subject should be taught. This will have to be determined by the individual school planning the course and will be modified by conditions prevailing within the school or district.

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1. Willis C. Brown, "Aviation Education for Modern Living," Aviation Education Series reprint, pp. 6-7
2. Paul A. Burns, The Aspects of Aviation Adaptable to Ohio Secondary Schools, 1949, pp. 50-76

In a national survey made by Kermit B. Anderson,[1] of a selected group of high schools, it was found that those schools now teaching Aviation Education, 95 percent taught the subject in the twelfth grade; five percent of the schools said scheduling difficulties had interfered with twelfth grade enrollment.

It was further shown that of the 84 high schools included in the survey, 76 schools, or 90 percent, offered Aviation Education as a regular course; the remaining schools offered the course as an extra-class activity; seven schools teach a one-semester course; 67 schools a two-semester course; one school a three-semester course; and one school a four-semester course.

Subjects presently taught in Aviation Education

As a result of his survey on Aviation Education, Mr. Anderson was able to list in order of importance the selected activities which the instructors felt contributed most to the interest and needs of the students:[2]

Why the Airplane Flies	Ranked	First
Class orientation rides	"	Second
Weather	"	Third
Powerplants	"	Fourth
Navigation	"	Fifth
Our Air Age	"	Sixth
Vocational Opportunities	"	Seventh
Model airplane building	"	Eighth
Air Traffic control	"	Ninth

The above result was obtained from the returns of 66 high schools.

1. Kermit B. Anderson, A Survey of Certain Aspects of Aviation Education in Selected Schools in the United States. 1955, p. 39
2. Ibid., p. 83

STATUS OF AVIATION EDUCATION IN UTAH HIGH SCHOOLS TODAY

Purpose

In order to ascertain the number of high schools in the state of Utah now teaching a course in Aviation Education, a questionaire type information form was developed and mailed to each high school listed in the official school directory published by the Utah State Department of Public Instruction. Two all-girl private schools were not contacted.

The information form was prepared in such a way as to obtain additional information about the school and pertinent information about the Aviation Education course being taught, or reasons for not offering this subject. Additional questions were asked which may help establish the trend that Aviation Education may take within the next two years.

Scope in area

A total of 79 information forms were mailed to Utah high schools, with a total of 77 being returned. This gives a return percentage of 97.5 percent. The information form used will be found in the appendix of this thesis.

Scope in time

That part of the information form that was answered only by the schools presently teaching Aviation Education asked for definite school and class enrollment figures for the school years 1953-to 1956, and the school year in which the program was first started.

Those high schools not teaching Aviation Education were asked about their plans with regard to this course for the next two years.

Tabulation of survey returns

School grouping. During a preliminary examination of the returns, a very wide range was noted in the total school enrollment for the 1955-56 school year. This ranged from a low of 44 in the smallest high school to a high of 2344 in one of the Salt Lake City schools.

In order to make a closer analysis of the returned information forms, the schools were divided into the following groups according to the 1955-56 total school enrollment. This grouping is used a number of times in subsequent tables.

Table 1. Grouping of high schools according to 1955-56 enrollment

Group Number	Enrollment	Number of Schools
One	300 or less	39
Two	301 to 600	19
Three	601 to 900	8
Four	901 to 1200	2
Five	1201 to 1500	5
Six	1501 to 1800	1
Seven	More than 1800	3
		77

From enrollment figures obtained recently from the Utah High School Activity Association report it was found that the two schools not returning the information form fall within group one. This gives a total of 41 in this group.

Results of the survey

One of the primary purposes of the survey was to determine the number of high schools in the state presently teaching a class or classes in Aviation Education.

From question number three of the information form, "Does your school now offer a class in Aviation Education as defined in the accompanying letter?", the following answers were tabulated:

Table 2. The present teaching status of Aviation Education in Utah high schools

Group number	Enrollment	Teaching Course	Not Teaching Course
One	300 or less	2	37
Two	301 to 600	1	18
Three	601 to 900	3	5
Four	901 to 1200	1	1
Five	1201 to 1500	5	0
Six	1501 to 1800	1	0
Seven	More than 1800	0	3
		13	64

By using the total figures from the above table, it is found that 16.5 percent of the high schools in Utah are now teaching Aviation Education.

High schools presently teaching Aviation Education

The information form was prepared so that all schools answered questions one through three. Those schools now teaching a course in Aviation Education answered in addition questions four through ten, and those high schools not offering this course answered questions eleven through fifteen.

The following table lists the names of the high schools in Utah now teaching Aviation Education, the group into which the high school is tabulated, the number of teachers in each school teaching this course, and the number of classes taught per day.

Table 3. Names of high schools now teaching Aviation Education

Name of School	Group Number	Number of Teachers in Aviation Education	Number of Classes Taught per Day
Altamont	1	1	1
Richfield	1	1	1
Murray	2	1	2
Cyprus	3	1	4
Ben Lomond	3	1	1
Lincoln	3	1	3
Box Elder	4	1	1
Weber	5	1	3
Jordan	5	1	3
Olympus	5	1	5
Davis	5	1	2
Granite	5	1	4
Ogden	6	1	1
		13	31

Table 4 on the following page is tabulated from the returns of the thirteen high schools now teaching Aviation Education.

This table gives the name of the high school, the year the program first started and total school enrollments as compared with Aviation Education enrollment for the school years 1953-56. The percent columns show the percentage of the total student body enrolled in Aviation Education in each of the school years 1953 to 1956.

Table 4. Total school enrollment as compared with Aviation class enrollment in Utah high schools for the years 1953-56

Name	Year Program Started	1953-54 Total School Enrollment	1953-54 Aviation Class Enrollment	1953-54 %	1954-55 Total School Enrollment	1954-55 Aviation Class Enrollment	1954-55 %	1955-56 Total School Enrollment	1955-56 Aviation Class Enrollment	1955-56 %
Altamont	1955-56	-	-	-	-	-	-	270	14	5.2
Richfield	1955-56	-	-	-	-	-	-	291	20	6.9
Murray	1947-48	438	60	13.7	470	65	13.8	536	70	13.0
Cyprus	1943-44	714	50	7.0	701	50	7.1	795	80	10.1
Ben Lomond	1955-56	-	-	-	-	-	-	788	19	2.4
Lincoln	1950-51	567	60	10.5	612	69	11.3	693	83	12.0
Box Elder*	1936-37	1140	40	3.5	1160	19	1.6	1150	21	1.8
Weber	1946-47	1258	169	13.4	1329	108	8.3	1332	104	7.8
Jordan	1952-53	1205	51	4.2	1276	52	4.1	1316	46	4.3
Olympus	1953-54	1075	226	21.0	1250	255	20.4	1426	285	20.0
Granite	1951-52	1151	106	9.2	1229	95	7.7	1238	112	9.1
Davis	1952-53	1285	46	3.8	1350	49	3.6	1484	55	3.7
Ogden	1946-47	1549	21	1.4	1560	25	1.6	1530	24	1.6
		10,382	829		10,937	787		12,849	943	

* Average class size since the class started has been about 20. Cause of increase in 1953 not known.

The following table was prepared by using the figures obtained from the information form:

Table 5. Average percentage of students enrolled in Aviation courses in those schools teaching Aviation Education for the school years 1953-1956

1953-54	1954-55	1955-56
8.0%	7.2%	7.35%

Students enrolled in Aviation Education

During the 1955-56 school year 2.91 per cent of all the senior high school students in Utah were enrolled in a class in Aviation Education. This figure was obtained by using the total Aviation Education class enrollment of 943 and the total school enrollment of 32,410 for grades 10, 11, and 12 of the schools contacted.

Total school increase compared with Aviation Education class increase

Total school enrollment for six high schools selected at random from the survey indicates a steady growth during the past three years:

Table 6. Total school enrollment of six selected Utah high schools now teaching Aviation Education, for the school years 1953-1956[1]

School year	Total school enrollment
1953-54	7,629
1954-55	8,101
1955-56	8,671

1. Schools selected from groups 2, 3, 4, 5, and 6

From table 6 an increase in total student body enrollment in six selected high schools of 13.7 per cent is noted between the 1953-54 school year and the 1955-56 school year. Aviation Education classes show an increase of 13.7 per cent between the 1953-54 school year and 1955-56 school year. The six schools were selected because they all have Aviation Education programs in operation during each of the school years between 1953-56.

<u>Activities of the Aviation Education program</u>

The last three questions of the information form, answered by those schools now teaching Aviation Education, related to the activities of their particular program:

8. Does your school sponsor a Civil Air Patrol student cadet program? (Eight schools answered "yes", Five answered "no".)

9. Is your school a member of the National Aviation Education Council? (One school answered "yes", Twelve answered "no".)

10. Do you have model plane building activity as part of the Aviation Education program? (Eight schools answered "yes", Five answered "no".)

High schools not presently teaching Aviation Education

Page two of the information form was prepared to find out some of the reasons why the majority of the high schools of this state do not teach Aviation Education, and also to obtain information that may show the trend of thought about this course.

In answer to question number 11, "During the next two years is it possible your school may be offering a class in Aviation Education as defined in the accompanying letter?", the following answers were received:

Schools answering "yes"	9
Schools answering "no"	26
Schools "undecided"	29

In answer to the question, "Would your school be interested in offering a program in Aviation Education if help were offered from the State Department of Public Instruction?", the following answers were received:

Schools answering "yes"	28
Schools answering "no"	8
Schools answering "Questionable"	22
Schools not answering	6

Item number 13 of the information form asked, "Please check one or more of the following reasons why your school does not offer a class in Aviation Education at the present time." The factors below were then listed and are referred to in the same order in table 7:

a. Insufficient student interest
b. Insufficient funds
c. Course of study not available
d. Trained teachers not available
e. School administration not interested
f. Other reasons (Write in)

Table 7. Factors listed for not teaching Aviation Education in Utah high schools

Factors	High School Group Numbers 1	2	3	4	5	6	7	Total
a	12	10	2	0	*	**	2	26
b	22	11	1	0	*	**	3	37
c	11	3	0	0	*	**	0	14
d	28	11	2	0	*	**	1	42
e	5	1	0	0	*	**	1	7
f[1]	10	7	1	1	*	**	1	20

* Five schools in this group. All teach Aviation Education
** One school in this group, teaching Aviation Education.
1. Under item f, "other reasons", the following answers were written in by various schools:

Inadequate classroom space	10
All teachers teaching a full load . . .	6
Insufficient instructor interest	2

Several schools offered opinions or comments with regard to Aviation Education, of which the following are typical:

"Have had a Civil Air Patrol program in our school. Past three years students have not registered for this class."

"We tried to conduct one for three years using an outside instructor and also one from the cadet training program at the local college. Very few were interested and it was not successful."

"Schedule in small schools too full to add additional classes."

"Was given a few years ago. Students lost interest because they were quite far removed from airports and airplanes."

"A small student body is limited in the number of non-required courses it might offer."

"With a small student body I'm afraid not enough would want it to warrant a class. We could survey the situation, however, and determine exactly."

"Insufficient facilities which may be helped when we move into new quarters next fall."

"Would be interested to check into the program."

"Plans for aviation class now at State Department of Education for approval. We plan to teach during second semester of this year using local CAP personnel, if State Department will approve.

"This field is new to us and this course hasn't been thought of."

"Our school has only 101 students in grades 7-12. Our schedule is so tight there is little possibility of getting in another course."

The question, "Would your school be interested in establishing a Civil Air Patrol student cadet program?", received the following response:

Schools answering "yes"	. . .	15
Schools answering "no"	. . .	24
Schools not answering	. . .	25

The "yes" answers to this question would indicate an interest in an aviation program. This group includes the nine high schools that indicated they might possibly start a program within the next two years.

To the last question of the information form, "Would you like to receive full information about the Civil Air Patrol student cadet program?", the following answers were tabulated:

Schools answering "yes"	. . .	45
Schools answering "no"	. . .	13
Schools not answering	. . .	6

SUMMARY OF SURVEY

1. The greatest majority, 41 schools, or 52 percent of Utah high schools, have a total 1955-56 enrollment of less than 300 students.

2. Of the 77 schools surveyed, a total of 13, or 16.5 percent are presently teaching Aviation Education. There are 13 teachers teaching a total of 31 class periods daily.

3. The 1955-56 enrollment in Aviation Education classes shows an increase of 156, or 19.8 percent, above the 1954-55 school year and an increase of 114, or 13.7 percent above the 1953-54 school year.

4. Total enrollment in Aviation Education classes in all Utah high schools during the 1955-56 school year was 943 students.

5. The average percentage of students enrolled in Aviation Education in the high schools that are teaching Aviation Education during 1955-56 is 7.35 percent.

6. During the 1955-56 school year 2.91 percent of all Utah high school students were enrolled in Aviation Education.

7. An increase of 13.7 percent in total student body enrollment in those schools teaching Aviation Education occurred between the 1953-54 and 1955-56 school years.

8. An increase of 13.7 percent in Aviation Education enrollment occurred between the 1953-54 and 1955-56 school years.

9. Eight Utah high schools sponsor a Civil Air Patrol student cadet program.

10. One Utah high school is a member of the National Aviation Education Council.

11. Eight Utah high schools have model plane building activity as part of the Aviation curriculum.

12. Nine Utah high schools indicated they may be offering a class in Aviation Education during the next two years, 26 said they would not be offering the class and 29 schools were "undecided."

13. Twenty-eight Utah high schools said they would be interested in offering Aviation Education if help were offered from the State Department of Public Instruction.

14. The factors most frequently indicated for not teaching Aviation Education were:

a.	Trained teachers not available	42
b.	Insufficient funds	37
c.	Insufficient student interest	26
d.	Course of study not available	14
e.	Inadequate class room space	10
f.	School administration not interested . .	7
g.	All teachers teaching a full load . . .	6
h.	Insufficient instructor interest . . .	2

15. The number of schools interested in establishing a Civil Air Patrol program was 15. Twenty-four schools were not interested and 25 schools did not answer the question.

16. Schools interested in obtaining full information about the Civil Air Patrol student cadet program numbered 45. Thirteen were not interested, and six schools did not answer the question.

COURSE OF STUDY IN AVIATION EDUCATION

Introduction

This course of study was prepared to aid high school teachers now teaching Aviation Education and teachers who are preparing to teach Aviation Education for the first time.

The course is prepared for use on the high school level, preferably during the eleventh or twelfth grade.

Seven main basic units

The course of study is divided into seven main basic units as follows:

1. Commercial Air Transportation
2. Know Your Airplane
3. Theory of Flight
4. Model Building
5. Aircraft Powerplants
6. Meteorology
7. Navigation

Units divided into sections

Each of the main units is divided into sections which cover an important area of the total unit being studied. The time required to present each section is left to the discretion of the teacher. Some sections are short and will possibly be presented in one or two class periods; however, some sections are quite lengthy and may require five or six class periods to complete.

Informational outline method used

The informational outline method of preparing and organizing the course of study was used because it furnishes a quick reference to the significant points to be covered, together with some concise information about the topic. This method was felt to be more flexible than the rigid daily lesson plan style. Proper use of the informational outline by the teacher can be made only by a thorough study of the text reference given at the beginning of each section.

Things to do

At the end of each section is a suggested list of "Things to do". These consist of classroom demonstrations to be made, reports to be assigned, problems to be assigned, field trips, and other material that can be discussed about the lesson. This is not an all-inclusive list, but it is suggestive of the class activity which may be undertaken.

Films

An annotated list of films pertaining to the subject covered, the type of film (16 mm. 35 mm. movie or filmstrip), and the source of the film is also presented at the end of each section.

Books

In the introduction to each main unit is listed a group of books which were used and which are recommended as texts to formulate that particular unit of work. At the beginning of each section is a list of texts used, together with the pages or chapter in the text where the material can be found.

The text references at the beginning of each section were chosen after careful consideration of several books and are, in the writer's opinion, the best presently available for use in Aviation Education.

Additional units

The course of study as herein presented contains only the basic units in Aviation Education deemed essential by the writer. A few of the many units that could be covered are:

1. The role of the airport in the cummunity
2. Vocational opportunities in Aviation
3. Air traffic control
4. Political and international problems created by the airplane

Sources of aid in starting an Aviation Education program

There are two national non-profit organizations that are active in Aviation Education and are ready at any time to aid in the formulation of an Aviation Education program. They are the Civil Air Patrol, a branch of the United States Air Force, and the National Aviation Education Council.

The Civil Air Patrol

The following are the aims of the Coordinated Civil Air Patrol--High School Aviation Course:

a. To inform American youth of aviation's effect upon the world in which he lives

b. To reveal the career opportunities aviation offers

c. To help youth develop general understandings of aircraft and aviation

d. To help youth develop the general aviation skills and attitudes required by an aviation age

e. To enable the cooperation of the schools and the Civil Air Patrol to the end that the Aviation Education goal defined in the Nation's Air Policy Statements can best be achieved

<u>The National Aviation Education Council</u>

A school membership in the National Aviation Education Council will provide many publications of current material on aviation.

The principle aims and objectives of the National Aviation Education Council are as follows:

a. Curriculum enrichment of Aviation Education

b. The evaluation, recommendation, publishing and distribution of educationally suitable Aviation Education materials and the dissemination of these resource materials to educational groups and agencies.

UNIT I.

AIR TRANSPORTATION

Introduction

The impact of the air age upon today's society is felt around the world. Air transportation has shortened the great time consuming distances of twenty years ago until extensive travel has become a pleasant, comfortable experience enjoyed daily by thousands of people. Today, air travel to New York, London, Tokyo, Calcutta, Buenos Aires, and Sidney is a daily occurrence, and air travel within the United States is as commonplace as taking the bus to town or school.

Purpose of this unit of study

The purpose of this unit of study is to present to the student enrolled in Aviation Education a picture of the major air routes of the United States and the commercial air carriers that fly along these routes. It is not the intent of this unit to advertise the merits or capabilities of one airline over another, but to present as an overall picture the great contribution that is being made to our daily living by those companies engaged in air transportation. This unit of study is placed at the beginning of the course to encourage class participation and to stimulate interest.

Scope of this unit

The section dealing with the domestic air lines does not represent all the air carriers of the United States, but only those that are permanently certificated by the Civil Aeronautics Board. This limits the presentation to the thirteen large trunk line companies that furnish the majority of available air transportation in the United States. Many smaller air lines known as "local service carriers", provide air transportation between many of our smaller cities. It is recommended that an additional amount of study be given to any local service carrier that may serve the area in which this unit of study is given.

All the typical flight schedules and fares shown are correct as of January, 1956. Such material will change and will need revising periodically by the teacher. This part of the unit is presented to make the student aware of the comparatively small amount of time and money required to travel great distances, and to give the student a better understanding of global geography by a comprehensive study of the maps necessary to present properly the air transportation unit.

It is recommended that two or three good maps, preferably showing the air routes, be available for use, particularly a polar projection map that is now available from many map making companies.

The advent of jet propelled craft in air transportation is covered in Section IV. Although this service has not yet started, the various airline companies have indicated mid-1959 as the approximate date for opening the new era of high speed commercial jet transportation.

Books and Periodicals

The following books have been used as text references in the preparation of this unit:

Basic Aeronautics, M. E. Tower

Official Airline Guide, Wayne W. Parrish

The ABC World Airways Guide, Muirhead Johnston

Section IV, "Jet Transports of Tomorrow" was prepared from press releases from Boeing Airplane Company and Douglas Aircraft Company and the following periodicals:

Boeing Magazine, December 1955

Aviation Week, March 12, 1956

Aviation Age, December 1955

Airline companies

The following U. S. air carriers will furnish free to the schools many pieces of printed educational material. Several also have motion pictures on air travel and airplanes that can be borrowed for school showings.

American Airlines, Inc.
Office of Public Relations
100 Park Avenue
New York City, N. Y.

Braniff International Airways Inc.
Department of Public Relations
Love Field, Dallas, Texas

Capital Airlines, Inc.
Department of Public Relations
Washington National Airport
Washington, D. C.

Colonial Airlines, Inc.
Office of Public Relations
230 Park Avenue
New York City, N. Y.

Continental Airlines, Inc.
Traffic and Sales Manager
Stapelton Airfield
Denver, Colorado

Delta Air Lines, Inc.
Director of Information Services
Atlanta Airport
Atlanta, Georgia

Eastern Air Lines, Inc.
Office of Public Relations
Eastern Air Lines Building
10 Rockefeller Plaza, New York City, N. Y.

National Airlines, Inc.
Office of Public Relations
Aviation Building
3240 N. W. 27th Ave.
Miami 42, Florida

Northeast Airlines, Inc.
Department of Public Relations,
Logan International Airport
239 Prescott St., East Boston, Mass.

Pan American World Airways
Educational Director
P. O. Box 1111
New York City 17, N. Y.

Pan American-Grace Airways, Inc.
Office of Publicity
135 East 42nd Street
New York City 17, N. Y.

Trans World Airlines, Inc.
Director of Air World Education
380 Madison Ave.
New York City 17, N. Y.

United Air Lines, Inc.
School and College Services
5959 South Cicero Ave.
Chicago 38, Ill.

Western Air Lines, Inc.
Office of Public Relations
6060 Avion Drive, P. O. Box 45,005
Airport Station
Los Angeles, Calif.

COMMERCIAL AIR TRANSPORTATION

Section I. Today's Transportation

Text reference: Basic Aeronautics, pp. 215-224

I. The world of yesterday

   A. Modes of travel

      1. Walking
      2. Horses or horsedrawn vehicles
      3. Sailing ship
      4. Steam ship
      5. Steam locomotive

   B. Barriers to travel

      1. Deserts
      2. Oceans
      3. Mountains
      4. Polar regions
      5. Jungles
      6. Swamps

II. The world of today

   A. Modes of travel

      1. Automobile
      2. Train
      3. Steamship
      4. Airplane

   B. Overcoming barriers to travel
      (The physical barriers are still present, but because of the airplane they offer minimum resistance to today's transportation.)

1. Daily flights across both Pacific and Atlantic oceans
2. Daily flights across the Rocky Mountains
3. Daily flights across the jungles of South and Central America
4. Daily flights across the Andes Mountains of South America
5. Daily flights to Alaska
6. Twice weekly flights across the Polar region to Sweden
7. Daily flights across the desert and jungles of Africa
8. Daily flights to many islands of the south seas
9. Hundreds of flights daily between major U. S. cities
10. Hundreds of flights daily serving various European cities

III. Travel time comparisons

A. Salt Lake City to New York, by train 56 hours; by plane, 9 hours

B. Salt Lake City to San Francisco, by train, 18 hours; by plane 3 hours and 20 minutes

C. San Francisco to Honolulu, by ship, 3 days; by plane, 8 hours

D. San Francisco to New York, by train, 74 hours; by plane, 7 hours and 30 minutes (nonstop)

E. Salt Lake City to Chicago, by train, 36 hours; by plane, 4 hours and 35 minutes

<u>Things to do</u>:

1. Assign a report entitled "Travel from New York City to San Francisco Fifty Years Ago."
2. Compare travel time requirements for the airplane and train to other U. S. cities.

<u>Films</u>:

"Airport America" (16 mm. sound, color, 15 minutes. The role of the airplane in today's living. Loaned by Utah State Aeronautics Commission, Salt Lake City, Utah)

"Flying Businessman" (16 mm. sound, color, 15 minutes. The story of how and why businessmen fly. Shows good shots of many different airplanes. Loaned by Utah State Aeronautics Commission.)

"The Double-Decked Strato Clipper" (16 mm. sound, color, 24 min. A history of commercial aircraft from the first overseas flight in 1927, to the world circling operations of the industry today. Rare shots of old type planes--some of them will seem very strange--making history as they take off on some epoch-making flight. Illustrates how the great Double-Decked Strato Clipper was developed from its predecessors, how years of meticulous engineering made it possible, how it was built, tested and finally, after many grueling months of rigorous flights, accepted for passenger service. Rent from Ideal Pictures Corporation, 54 Post Office Place, Salt Lake City 1, Utah)

COMMERCIAL AIR TRANSPORTATION

Section II. The Major Domestic Trunk Lines

Text references: Air Transport Facts and Figures, 16th Edition
Official Airline Guide
ABC World Airways Guide

I. American Airlines

A. Headquarters: New York City, N. Y.

B. Area of operation

1. The majority of the cities served are located within an area described by a parallelogram with the four corners at Washington, D. C., Tulsa, Chicago, and Boston.

2. Extensive routes run across the south central U. S. to Los Angeles.

3. Nonstop flights from New York to Los Angeles, Los Angeles to Chicago, and Los Angeles to Washington, D. C.

C. Types of aircraft used

1. Convair 340

2. Douglas DC-6, DC-6B, DC-7

D. Typical flight schedules and fares

1.	New York to Los Angeles (nonstop)	8 hrs. 45 min.	$158.85
2.	Chicago to El Paso (nonstop)	6 hrs.	80.05
3.	Fort Worth to Washington, D. C.	6 hrs. 35 min.	78.10
4.	New York to Chicago (every hour)	2 hrs. 45 min.	45.10

II. Braniff Airways

A. Headquarters: Dallas, Texas

B. Area of operation

1. The domestic routes serve the central states and extend from Bismark, North Dakota south to Brownsville, Texas. The eastern terminus is Chicago and the western terminus is Denver.

2. Braniff also has international flights

C. Types of aircraft used

1. Convair 340

2. Douglas DC-3, DC-6

3. Lockheed Constellation

D. Typical flight schedules and fares

1. Minneapolis to Houston	7 hrs.	$73.00
2. Des Moines to Dallas	3 hrs. 50 min.	45.75
3. Tulsa to New Orleans	4 hrs. 20 min.	39.50
4. Denver to San Antonio	6 hrs.	62.10

III. Capital Airlines

A. Headquarters: Washington, D. C.

B. Area of operation

1. Capital airlines routes at present are confined to the heavy industrial areas of the Great Lake Region, bounded by the cities of New York, Washington, D. C., Chicago, and Rochester.

2. Additional routes extend southward from Pittsburgh to Knoxville, Atlanta, and New Orleans.

C. Types of aircraft used

1. Lockheed Constellation

2. Douglas DC-3, DC-4

3. Vickers Viscount

D. Typical flight schedules and fares

1. New York to Minneapolis	6 hrs.	$61.60
2. Burmingham to New York	4 hrs. 10 min.	56.55
3. Washington, D. C. to Chicago (4 flights daily)	1 hr. 30 min.	37.80

IV. Colonial Airlines

A. Headquarters: New York City, N. Y.

B. Area of operation

1. Colonial operations are confined to the northeastern U. S. and southeastern Canada. They are best described by a parallelogram with corners at Ottawa, Montreal, Washington, D. C., and New York.

2. Additional routes are Washington, D. C. to Burmuda, and New York to Bermuda.

C. Types of aircraft used

1. Douglas DC-3

2. Douglas DC-4

D. Typical flight schedules and fares

1. Washington, D. C. to Montreal	5 hrs. 20 min.	$70.40
2. New York to Bermuda	3 hrs. 35 min.	99.00
3. New York to Ottawa	3 hrs.	28.00

V. Continental Airlines

A. Headquarters: Denver, Colorado

B. Area of operation

1. Continental Airlines operates routes in the south central section of the U. S., located within a triangle bounded by Denver, Wichita, and El Paso, with an extended route from Albuquerque to San Antonio.

2. Through-plane service with American, Braniff, and United to Chicago, Seattle, and Los Angeles

C. Types of aircraft used

1. Super Convair 340

2. Douglas DC-3, DC-6, DC-6B

D. Typical flight schedules and fares

1. Denver to Kansas City	2 hrs. 40 min	$39.40
2. Tulsa to El Paso	5 hrs. 20 min.	42.70
3. Denver to Tulsa	2 hrs. 45 min.	39.45
4. El Paso to Denver	3 hrs. 20 min.	55.60

VI. Delta Airlines

A. Headquarters: Atlanta, Georgia

B. Area of operation

1. Delta Airlines routes are best described as being within a triangle with Houston, Miami, and Chicago as the corner cities.

2. Additional routes extend from Atlanta to New York, and Atlanta to Dallas; number of cities served is 55.

C. Types of aircraft used

1. Super Convair 340

2. Martin 404

3. Douglas DC-3, DC-6, DC-7

D. Typical flight schedules and fares

1. Houston to New York	9 hrs. 45 min.	$97.35
2. Chicago to Miami	3 hrs. 50 min.	80.20
3. Dallas to Atlanta	3 hrs. 50 min.	40.40

VII. Eastern Air Lines

A. Headquarters: New York City, N. Y.

B. Area of operation

1. Eastern Air Lines serves the heavily populated and industrialized east coast section of the U. S.

2. The majority of its 12,756 miles of routes are within a quadrangle area bounded by Houston, Chicago, New York, and Miami.

3. Additional routes extend to Mexico City on the west and San Juan, Puerto Rico, on the east.

4. Eastern Air Lines is famous for its New York to Miami flight, which is the most heavily traveled route in the world.

C. Types of aircraft used

1. Convair 340

2. Martin 404

3. Douglas DC-4, DC-6, DC-6B, DC-7B

4. Lockheed Super C Constellation

D. Typical flight schedules and fares
(all listed are nonstop)

1.	New York to Miami	3 hrs. 30 min.	$76.70
2.	Miami to Chicago	4 hrs. 5 min.	80.20
3.	Miami to Cleveland	3 hrs. 58 min.	75.00
4.	Detroit to Miami	4 hrs.	78.60
5.	Atlanta to Chicago	2 hrs. 14 min.	41.10

VIII. National Airlines

A. Headquarters: Miami, Florida

B. Area of operation

1. National Airlines is the eastern seaboard carrier

2. The routes of this company are from New York, Washington, Miami, and Havana, with extensions to New Orleans from Tampa and Jacksonville.

3. These routes are in the most highly travelled business and vacation area in the world.

C. Types of aircraft used

1. Convair 340

2. Lockheed Constellation and Lodestar

3. Douglas DC-6, DC-6B, DC-7, DC-7B

D. Typical flight schedules and fares

1.	New York to Jacksonville	4 hrs.	$54.80
2.	New York to Havana	6 hrs.	95.80
3.	Washington to Miami	3 hrs. 25 min.	63.30
4.	Miami to Havana	1 hr. 5 min.	20.00

IX. Northeast Airlines

A. Headquarters: Boston, Mass.

B. Area of operation

1. This company serves the New England States.

2. The routes extend from Presque Isle on the north to New York City on the south, and from Boston to Montreal and Nantucket.

C. Types of aircraft

1. Convair 240

2. Douglas DC-3

D. Typical flight schedules and fares

1.	New York to Bangor	2 hrs. 52 min.	$27.65
2.	Boston to Montreal	1 hr. 48 min.	18.00

X. Northwest Airlines

A. Headquarters: St. Paul, Minnesota

B. Area of operation

1. Northwest Airlines is one of the largest air carriers in the U. S.

2. Domestic routes extend from New York and Washington, D.C., across the northern section of the United States to Seattle, and from Seattle to Honolulu

3. Northwest also operates international routes which are discussed in Section III.

C. Types of aircraft

1. Boeing Stratocruiser B-377

2. Douglas DC-3, DC-4, DC-6B

3. Lockheed Turbo Constellation L-1049G

D. Typical flight schedules and fares

1.	Seattle to New York	11 hrs. 35 min.	$158.85
2.	Portland to Chicago	7 hrs. 37 min.	114.75
3.	Seattle to Honolulu	13 hrs. 20 min.	125.00

XI. Trans World Airlines

A. Headquarters: New York City, N.Y.

B. Area of domestic operation

1. Many routes extend across the entire U. S., from San Francisco to Chicago to New York, and from Los Angeles to New York.

2. The routes can best be described as a parallelogram bounded by San Francisco, Phoenix, Washington, D. C., and Boston.

C. Types of aircraft used

1. Martin 404

2. Lockheed Constellation, Super Constellation, and Super G Constellation

D. Typical domestic flight schedules and fares (all fares tourist)

1. New York to San Francisco	12 hrs.	$99.00
2. Kansas City to Los Angeles	5 hrs. 37 min.	68.00
3. Pittsburgh to St. Louis	2 hrs. 34 min.	27.00
4. San Francisco to Chicago	6 hrs. 41 min.	76.00

XII. United Airlines

A. Headquarters: Chicago, Ill.

B. Area of operation

1. Officially listed as one of the "big four" air carriers in the United States

2. United's routes extend from Boston, New York, Washington area on the east coast through Denver and Salt Lake City to San Francisco and Los Angeles on the west coast.

3. Additional routes are from Salt Lake City to Seattle, San Francisco and Los Angeles to Hawaii, and routes extending the full length of the west coast.

C. Types of aircraft used

1. Convair 340

2. Douglas DC-3, DC-4, DC-6, DC-6B, DC-7

D. Typical domestic flight schedules and fares

1.	Salt Lake City to Chicago	4 hrs. 35 min.	$85.15
2.	Salt Lake City to Seattle	4 hrs. 15 min.	50.90
3.	Salt Lake City to San Francisco	3 hrs. 20 min.	41.65
4.	San Francisco to New York	7 hrs. 30 min.	158.85
5.	Salt Lake City to Denver	2 hrs.	28.05
6.	Salt Lake City to Washington, D. C. (tourist)	7 hrs.	88.00

XIII. Western Air Lines

A. Headquarters: Los Angeles, Calif.

B. Area of operation

1. Routes of Western Air Lines extend from San Diego northward along the Pacific coast to Seattle, and from Los Angeles to Salt Lake City, to Edmonton, Canada

2. Additional routes extend from Great Falls to Denver, from Salt Lake City to Denver to Minneapolis, and from Salt Lake City to San Francisco.

3. Western also serves many cities in Wyoming, Nebraska, South Dakota, and Minnesota.

C. Types of aircraft used

1. Convair 340

2. Douglas DC-3, DC-4, DC-6B

D. Typical flight schedules and fares

1.	Salt Lake City to Los Angeles	3 hrs. 10 min.	$43.25
2.	Salt Lake City to Edmonton	8 hrs.	64.80
3.	Salt Lake City to Minneapolis	3 hrs. 40 min.	68.50
4.	Salt Lake City to Great Falls	4 hrs.	34.55

Things to do:

1. Divide the class into groups of three or four students and have each group write to one of the airline companies for free educational material. (See Introduction to Air Transportation unit for addresses)

2. Have each group report on the material received and the area of the United States in which the airline operates.

3. Have each student plan a flight within the United States and write a report about the airplane, the service offered, the time required and cost.

4. Start a bulletin board picture collection of the different air transport planes used by the air lines.

Films:

The following films and filmstrips may be obtained from United Airlines on a free loan bas is:

"Modern Flight" (32 frames)

"Coast to Coast Geography from the Air" (34 frames)

"An Airplane Trip" (11 minutes)

"Of Men and Wings" (18 minutes)

"United 6534" (30 minutes)

"Flying Colors" (28 minutes)

"A World in a Week--California" (30 minutes)

"Highway to Hawaii" (30 minutes)

"The Sky if for Everyone" (30 minutes)

"Points East" (29 minutes)

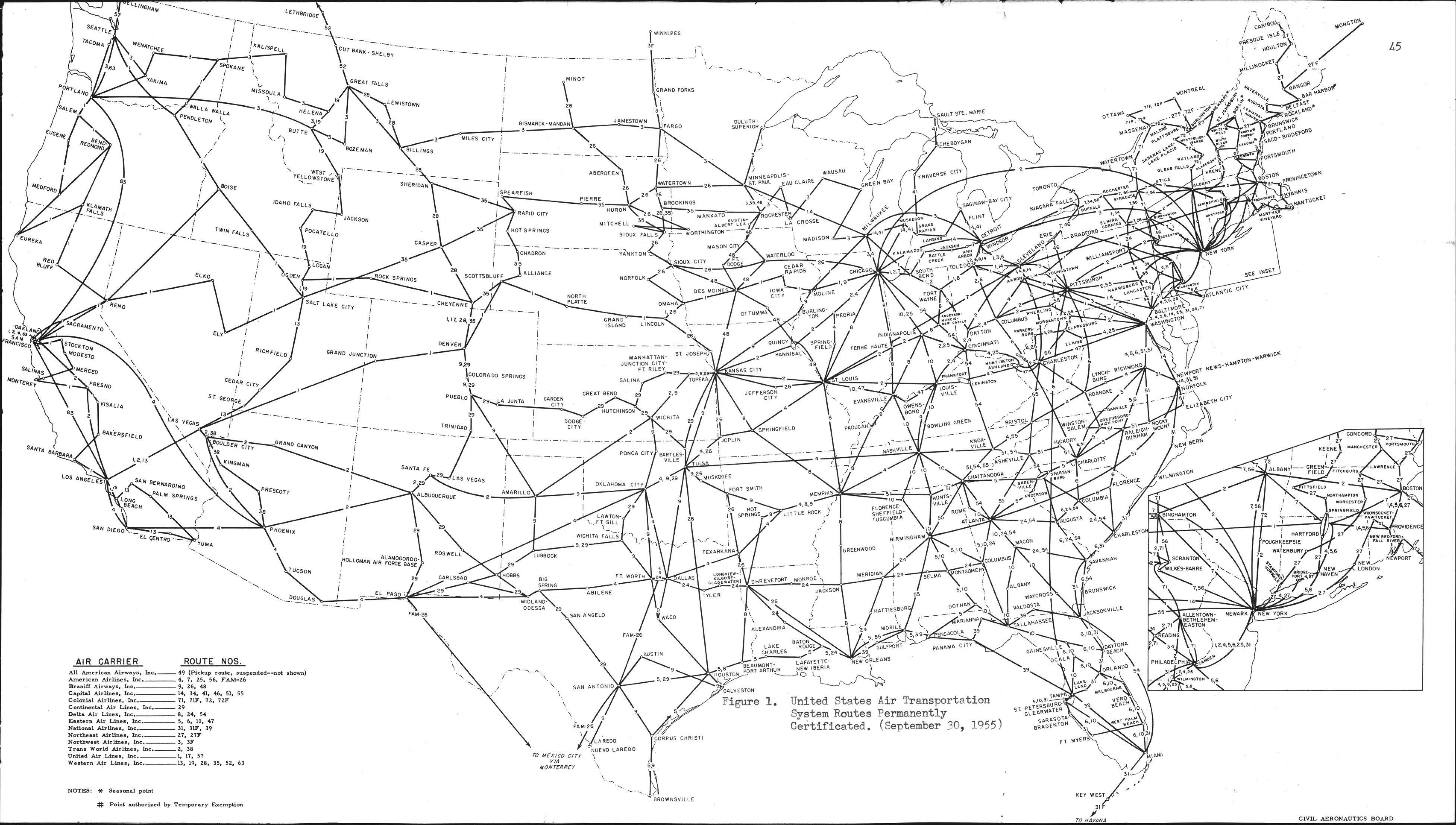

Figure 1. United States Air Transportation System Routes Permanently Certificated. (September 30, 1955)

Table 8. AIR-LINE DISTANCES BETWEEN CITIES IN THE UNITED STATES

	ALBUQUERQUE, N. M.	AMARILLO, TEXAS	ATLANTA, GA.	BILLINGS, MONT.	BIRMINGHAM, ALA.	BOSTON, MASS.	BUFFALO, N. Y.	BURLINGTON, VT.	CHARLESTON, S. C.	CHARLOTTE, N. C.	CHEYENNE, WYO.	CHICAGO, ILL.	CINCINNATI, OHIO	CLEVELAND, OHIO	DALLAS, TEXAS	DENVER, COLO.	DES MOINES, IOWA	DETROIT, MICH.	EL PASO, TEXAS	FARGO, N. D.	HOUSTON, TEXAS	INDIANAPOLIS, IND.	JACKSONVILLE, FLA.	KANSAS CITY, MO.	KNOXVILLE, TENN.	LITTLE ROCK, ARK.	LOS ANGELES, CALIF.	LOUISVILLE, KY.	MEMPHIS, TENN.	MIAMI, FLA.	MINNEAPOLIS, MINN.	NASHVILLE, TENN.	NEW ORLEANS, LA.	NEW YORK, N. Y.	OMAHA, NEBR.	PHILADELPHIA, PA.	PHOENIX, ARIZ.	PITTSBURGH, PA.	PORTLAND, ORE.	RALEIGH, N. C.	ST. LOUIS, MO.	SALT LAKE CITY, UTAH	SAN ANTONIO, TEXAS	SAN FRANCISCO, CALIF.	SEATTLE, WASH.	SPOKANE, WASH.	SYRACUSE, N. Y.	TULSA, OKLA.	WASHINGTON, D. C.	WICHITA, KANS.
ALBUQUERQUE, N. M.	X	273	1272	744	1138	1972	1580	1878	1539	1457	429	1129	1251	1421	588	334	837	1364	229	961	754	1169	1488	720	1280	816	664	1178	939	1698	983	1119	1029	1815	721	1753	330	1499	1107	1576	942	484	617	896	1184	1030	1718	604	1653	549
AMARILLO, TEXAS	273	X	999	809	866	1722	1338	1640	1266	1185	440	894	992	1173	334	358	626	1124	358	847	533	915	1219	481	1009	543	937	915	667	1441	812	848	776	1560	526	1494	598	1244	1304	1306	685	668	444	1157	1359	1176	1475	335	1391	304
ATLANTA, GA.	1272	999	X	1519	140	937	697	951	267	227	1229	587	369	554	721	1212	739	596	1291	1114	701	426	285	676	155	456	1936	319	337	604	907	214	424	748	817	666	1592	521	2172	356	467	1583	882	2139	2182	1961	781	678	543	776
BILLINGS, MONT.	744	809	1519	X	1425	1861	1473	1713	1761	1617	370	1073	1304	1369	1092	453	798	1283	973	565	1315	1204	1796	846	1447	1143	959	1275	1213	2085	742	1309	1479	1760	703	1727	872	1479	686	1698	1057	387	1252	904	668	443	1600	930	1669	801
BIRMINGHAM, ALA.	1138	866	140	1425	X	1052	776	1049	402	361	1119	578	406	618	581	1095	670	641	1152	1060	567	433	374	579	235	325	1802	331	217	665	862	182	312	864	732	783	1456	608	2066	491	400	1466	744	2013	2082	1865	875	552	661	658
BOSTON, MASS.	1972	1722	937	1861	1052	X	400	182	820	721	1735	851	740	551	1551	1769	1159	613	2072	1300	1605	807	1017	1251	818	1259	2596	826	1137	1255	1123	943	1359	188	1282	271	2300	483	2540	609	1038	2099	1766	2699	2493	2266	264	1398	393	1424
BUFFALO, N. Y.	1580	1338	697	1473	776	400	X	304	699	538	1335	454	393	173	1198	1370	760	216	1692	919	1286	435	879	861	548	913	2198	483	803	1181	731	627	1086	292	883	279	1906	178	2156	490	662	1699	1430	2300	2117	1888	138	1023	292	1036
BURLINGTON, VT.	1878	1640	951	1713	1049	182	304	X	884	755	1612	749	690	476	1501	1684	1049	516	1995	1149	1580	739	1079	1161	815	1214	2485	780	1100	1347	985	916	1361	260	1171	328	2202	445	2385	665	966	1969	1729	2568	2333	2108	177	1327	432	1337
CHARLESTON, S. C.	1539	1266	267	1761	402	820	699	884	X	177	1486	757	506	609	981	1474	967	681	1552	1317	936	594	197	928	316	723	2203	500	604	482	1104	455	630	641	1058	562	1857	528	2425	220	704	1845	1122	2405	2428	2204	738	945	453	1039
CHARLOTTE, N. C.	1457	1185	227	1617	361	721	538	755	177	X	1362	587	335	435	930	1358	819	504	1496	1153	927	428	341	803	180	649	2119	343	521	652	939	340	649	533	918	451	1783	362	2290	130	568	1727	1105	2301	2285	2059	595	853	330	933
CHEYENNE, WYO.	429	440	1229	370	1119	1735	1335	1612	1486	1362	X	891	1082	1199	726	96	583	1125	653	563	947	986	1493	560	1183	813	882	1033	902	1763	642	1032	1131	1604	463	1556	663	1298	947	1461	795	371	882	967	973	768	1472	588	1477	465
CHICAGO, ILL.	1129	894	587	1073	578	851	454	749	757	587	891	X	252	308	803	920	309	238	1252	569	940	165	863	414	454	552	1745	269	482	1188	355	397	833	713	432	666	1453	410	1758	642	262	1260	1051	1858	1737	1508	592	598	597	591
CINCINNATI, OHIO	1251	992	369	1304	406	740	393	690	506	335	1082	252	X	222	814	1094	510	235	1335	820	892	100	626	541	219	524	1897	90	410	952	605	238	706	570	622	503	1581	257	1985	396	309	1453	1039	2043	1972	1744	514	661	404	702
CLEVELAND, OHIO	1421	1173	554	1369	618	551	173	476	609	435	1199	308	222	X	1025	1227	617	90	1525	835	1114	263	770	700	400	740	2049	311	630	1087	630	459	924	405	739	360	1749	115	2055	428	492	1568	1256	2166	2026	1796	303	853	306	873
DALLAS, TEXAS	588	334	721	1092	581	1551	1198	1501	981	930	726	803	814	1025	X	663	632	999	572	972	225	763	908	451	767	293	1240	726	420	1111	862	617	443	1374	586	1299	887	1070	1633	1057	547	999	252	1483	1681	1489	1326	236	1185	340
DENVER, COLO.	334	358	1212	453	1095	1769	1370	1654	1474	1358	96	920	1094	1227	663	X	610	1156	557	642	879	1000	1467	558	1178	780	831	1038	879	1726	700	1023	1082	1631	488	1579	586	1320	982	1463	796	371	802	949	1021	826	1508	550	1494	437
DES MOINES, IOWA	837	626	739	798	670	1159	760	1049	967	819	583	309	510	617	632	610	X	546	983	397	821	411	1023	180	651	478	1438	476	485	1333	235	525	827	1022	123	973	1155	715	1475	902	273	953	882	1550	1467	1240	898	396	896	334
DETROIT, MICH.	1364	1124	596	1283	641	613	216	516	681	504	1125	238	235	90	999	1156	546	X	1479	745	1105	240	831	645	442	723	1983	316	623	1152	543	470	939	482	669	443	1690	205	1969	510	455	1492	1238	2091	1938	1709	354	813	396	821
EL PASO, TEXAS	229	358	1291	973	1152	2072	1692	1995	1552	1496	653	1252	1335	1525	572	557	983	1479	X	1163	676	1264	1473	839	1326	847	701	1254	976	1643	1157	1169	983	1905	878	1836	346	1590	1286	1621	1034	689	503	995	1376	1239	1828	674	1728	661
FARGO, N. D.	961	847	1114	565	1060	1300	919	1149	1317	1153	563	569	820	835	972	642	397	745	1163	X	1183	725	1399	549	1004	869	1427	818	882	1716	214	902	1222	1210	390	1184	1225	949	1239	1210	660	863	1207	1446	1197	969	1042	741	1140	634
HOUSTON, TEXAS	754	533	701	1315	567	1605	1286	1580	936	927	947	940	892	1114	225	879	821	1105	676	1183	X	865	821	644	790	388	1374	803	484	968	1056	665	318	1420	794	1341	1017	1137	1836	1056	679	1200	189	1645	1891	1704	1403	442	1220	559
INDIANAPOLIS, IND.	1169	915	426	1204	433	807	435	739	594	428	986	165	100	263	763	1000	411	240	1264	725	865	X	699	453	290	483	1809	107	384	1024	511	251	712	646	525	585	1499	330	1885	495	231	1356	999	1949	1872	1644	567	591	494	620
JACKSONVILLE, FLA.	1488	1219	285	1796	374	1017	879	1079	197	341	1493	863	626	770	908	1467	1023	831	1473	1399	821	699	X	950	410	690	2147	594	590	326	1191	499	504	838	1098	758	1794	703	2439	414	751	1837	1011	2374	2455	2237	928	921	647	1031
KANSAS CITY, MO.	720	481	676	846	579	1251	861	1161	928	803	560	414	541	700	451	558	180	645	839	549	644	453	950	X	624	325	1356	480	369	1241	413	473	680	1097	166	1038	1049	781	1497	905	238	925	702	1506	1506	1287	998	216	945	177
KNOXVILLE, TENN.	1280	1009	155	1447	235	818	548	815	316	180	1183	454	219	400	767	1178	651	442	1326	1004	790	290	410	624	X	479	1941	188	350	736	792	161	547	632	745	552	1607	375	2115	296	392	1547	959	2121	2114	1890	641	676	430	753
LITTLE ROCK, ARK.	816	543	456	1143	325	1259	913	1214	723	649	813	552	524	740	293	780	478	723	847	869	388	483	690	325	479	X	1480	435	129	949	708	325	355	1081	492	1007	1137	779	1759	774	291	1148	516	1688	1785	1573	1038	231	892	348
LOS ANGELES, CALIF.	664	937	1936	959	1802	2596	2198	2485	2203	2119	882	1745	1897	2049	1240	831	1438	1983	701	1427	1374	1809	2147	1356	1941	1480	X	1829	1603	2339	1524	1780	1673	2451	1315	2394	357	2136	825	2237	1589	579	1204	347	959	940	2336	1266	2300	1197
LOUISVILLE, KY.	1178	915	319	1275	331	826	483	780	500	343	1033	269	90	311	726	1038	476	316	1254	818	803	107	594	480	188	435	1829	X	320	919	605	154	623	652	580	582	1508	344	1950	429	242	1402	949	1986	1943	1717	603	582	476	633
MEMPHIS, TENN.	939	667	337	1213	217	1137	803	1100	604	521	902	482	410	630	420	879	485	623	976	882	484	384	590	369	350	129	1603	320	X	872	699	197	358	957	529	881	1263	660	1849	645	240	1250	631	1802	1867	1650	923	341	765	442
MIAMI, FLA.	1698	1441	604	2085	665	1255	1181	1347	482	652	1763	1188	952	1087	1111	1726	1333	1152	1643	1716	968	1024	326	1241	736	949	2339	919	872	X	1511	815	669	1092	1397	1019	1982	1010	2708	695	1061	2089	1148	2594	2734	2520	1212	1176	923	1297
MINNEAPOLIS, MINN.	983	812	907	742	862	1123	731	985	1104	939	642	355	605	630	862	700	235	543	1157	214	1056	511	1191	413	792	708	1524	605	699	1511	X	697	1051	1018	290	985	1280	743	1427	996	466	987	1110	1584	1395	1166	861	626	934	546
NASHVILLE, TENN.	1119	848	214	1309	182	943	627	916	455	340	1032	397	238	469	617	1023	525	470	1169	902	665	251	499	473	161	325	1780	154	197	815	697	X	469	761	607	685	1446	472	1969	457	254	1393	823	1963	1975	1752	739	515	569	594
NEW ORLEANS, LA.	1029	776	424	1479	312	1359	1086	1361	630	649	1131	833	706	924	443	1082	827	939	983	1222	318	712	504	680	547	355	1673	623	358	669	1051	469	X	1171	847	1089	1316	919	2063	776	598	1434	507	1926	2101	1898	1187	548	966	677
NEW YORK, N. Y.	1815	1560	748	1760	864	188	292	260	641	533	1604	713	570	405	1374	1631	1022	482	1905	1210	1420	646	838	1097	632	1081	2421	652	957	1092	1018	761	1171	X	1144	83	2145	317	2445	426	875	1972	1584	2571	2408	2179	194	1231	205	1266
OMAHA, NEBR.	721	526	817	703	732	1282	883	1171	1058	918	463	432	622	739	586	488	123	669	878	390	794	525	1098	166	745	492	1315	580	529	1397	290	607	847	1144	X	1094	1036	836	1371	1008	354	833	828	1429	1369	1146	1021	352	1014	257
PHILADELPHIA, PA.	1753	1494	666	1727	783	271	279	328	562	451	1556	666	503	360	1299	1579	973	443	1836	1184	1341	585	758	1038	552	1007	2394	582	881	1019	985	685	1089	83	1094	X	2083	259	2412	345	811	1925	1507	2523	2380	2151	220	1163	123	1204
PHOENIX, ARIZ.	330	598	1592	872	1456	2300	1906	2202	1857	1783	663	1453	1581	1749	887	586	1155	1690	346	1225	1017	1499	1794	1049	1607	1137	357	1508	1263	1982	1280	1446	1316	2145	1036	2083	X	1828	1005	1903	1272	504	849	653	1114	1019	2044	932	1983	879
PITTSBURGH, PA.	1499	1244	521	1479	608	483	178	445	528	362	1298	410	257	115	1070	1320	715	205	1590	949	1137	330	703	781	375	779	2136	344	660	1010	743	472	919	317	836	259	1828	X	2165	330	559	1668	1291	2264	2138	1908	268	917	192	950
PORTLAND, ORE.	1107	1304	2172	686	2066	2540	2156	2385	2425	2290	947	1758	1985	2055	1633	982	1475	1969	1286	1239	1836	1885	2439	1497	2115	1759	825	1950	1849	2708	1427	1969	2063	2445	1371	2412	1005	2165	X	2377	1723	636	1720	534	145	290	2281	1531	2354	1411
RALEIGH, N. C.	1576	1306	356	1698	491	609	409	665	220	130	1461	642	396	428	1057	1463	902	510	1621	1210	1056	495	414	905	296	774	2237	429	645	695	996	457	776	426	1008	345	1903	330	2377	X	667	1829	1235	2410	2367	2139	519	972	233	1044
ST. LOUIS, MO.	942	685	467	1057	400	1038	662	966	704	568	795	262	309	492	547	796	273	455	1034	660	679	231	751	238	392	291	1589	242	240	1061	466	254	598	875	354	811	1272	559	1723	667	X	1162	792	1744	1724	1500	796	361	712	394
SALT LAKE CITY, UTAH	484	668	1583	387	1466	2099	1699	1969	1845	1727	371	1260	1453	1568	999	371	953	1492	689	863	1200	1356	1837	925	1547	1148	579	1402	1250	2089	987	1393	1434	1972	833	1925	504	1668	636	1829	1162	X	1087	600	701	550	1835	917	1848	808
SAN ANTONIO, TEXAS	617	444	882	1252	744	1766	1430	1729	1122	1105	882	1051	1039	1256	252	802	882	1238	503	1207	189	999	1011	702	959	516	1204	949	631	1148	1110	823	507	1584	828	1507	849	1291	1720	1235	792	1087	X	1490	1787	1614	1553	486	1388	573
SAN FRANCISCO, CALIF.	896	1157	2139	904	2013	2699	2300	2568	2405	2301	967	1858	2043	2166	1483	949	1550	2091	995	1446	1645	1949	2374	1506	2121	1688	347	1986	1802	2594	1584	1963	1926	2571	1429	2523	653	2264	534	2410	1744	600	1490	X	678	727	2435	1461	2442	1369
SEATTLE, WASH.	1184	1359	2182	668	2082	2493	2117	2333	2428	2285	973	1737	1972	2026	1681	1021	1467	1938	1376	1197	1891	1872	2455	1506	2114	1785	959	1943	1867	2734	1395	1975	2101	2408	1369	2380	1114	2138	145	2367	1724	701	1787	678	X	229	2238	1560	2329	1437
SPOKANE, WASH.	1030	1176	1961	443	1865	2266	1888	2108	2204	2059	768	1508	1744	1796	1489	826	1240	1709	1239	969	1704	1644	2237	1287	1890	1573	940	1717	1650	2520	1166	1752	1898	2179	1146	2151	1019	1908	290	2139	1500	550	1614	727	229	X	2010	1353	2100	1227
SYRACUSE, N. Y.	1718	1475	781	1600	875	264	138	177	738	595	1472	592	514	303	1326	1508	898	354	1828	1042	1403	567	928	998	641	1038	2336	603	923	1212	861	739	1187	194	1021	220	2044	268	2281	519	796	1835	1553	2435	2238	2010	X	1157	290	1173
TULSA, OKLA.	604	335	678	930	552	1398	1023	1327	945	853	588	598	661	853	236	550	396	813	674	741	442	591	921	216	676	231	1266	582	341	1176	626	515	548	1231	352	1163	932	917	1531	972	361	917	486	1461	1560	1353	1157	X	1058	130
WASHINGTON, D. C.	1653	1391	543	1669	661	393	292	432	453	330	1477	597	404	306	1185	1494	896	396	1728	1140	1220	494	647	945	430	892	2300	476	765	923	934	569	966	205	1014	123	1983	192	2354	233	712	1848	1388	2442	2329	2100	290	1058	X	1106
WICHITA, KANS.	549	304	776	801	658	1424	1036	1337	1039	933	465	591	702	873	340	437	334	821	661	634	559	620	1031	177	753	348	1197	633	442	1297	546	594	677	1266	257	1204	879	950	1411	1044	394	808	573	1369	1437	1227	1173	130	1106	X

COMMERCIAL AIR TRANSPORTATION

Section III. The International and Overseas Air Carriers (Based Within Continental United States)

Text references: Official Airline Guide
The ABC World Airways Guide

I. American Airlines (international routes)

A. The international route of this company operates from New York City to Mexico City, with intermediate stops at Washington, Memphis, and Dallas.

B. Typical schedule and fare

New York to Mexico City	14 hrs. 20 min.	$145.40

II. Braniff

A. International routes

1. The international route of this company operates from Houston and Miami south to Havana, Panama City, Guayaquil, Lima, La Paz, and Buenos Aires.

2. An additional route extends from Lima to Rio de Janeiro.

B. Typical schedules and fares

1.	Houston to Lima	24 hrs. 50 min.	$340.00 (tourist)
2.	Houston to Panama	8 hrs. 40 min.	129.00 (tourist)
3.	Lima to Sao Paulo	9 hrs.	217.00

III. Delta Airlines

A. International routes

1. Delta operates a route from New Orleans to Havana to Port Au Prince and San Juan.

2. An additional route extends from Havana to Caracas, Venzuela

B. Typical schedules and fares

1.	New Orleans to Havana	2 hrs. 20 min.	$ 60.20
2.	New Orleans to Caracas	7 hrs. 40 min.	186.20
3.	Havana to San Juan	6 hrs.	80.00

IV. Eastern Air Lines

A. International route

1. New York direct to San Juan

2. Miami to San Juan

3. International through-plane agreement with Braniff Airlines to South America

B. Typical schedules and fares

1. New York to San Juan	6 hrs.	$100.00
2. Miami to San Juan	4 hrs.	64.00

V. National Airlines (overseas route)

A. National Airlines' overseas route is limited to routes between New York City and Havana and Miami and Havana.

B. Typical flight schedules and fares

1. New York to Havana	5 hrs.	$70.50
2. Miami to Havana	1 hrs. 5 min.	20.00

VI. Northwest Airlines

A. International routes

1. Northwest Airlines' international routes extend from Seattle north to Alaska, then via the great circle route to Tokyo, Japan.

2. Additional routes in the Far East are best described as being within a triangle bounded by Tokyo, Shanghai, and Manila. Many cities are served within this triangle.

B. Typical flight schedules and fares

1. Seattle to Tokyo	24 hrs.	$650.00
2. Seattle to Anchorage	5 hrs.	75.00 (tourist)

VII. Pan American World Airways

A. International routes

1. Pan American is the only U. S. airline that operates solely on an international basis. This company does not operate any domestic flights within the United States.

2. Pan American routes circle the entire globe; New York, Shannon, London, Brussels, Paris, Lisbon, Barcelona, Rome, Dusseldorf, Frankfurt, Munich, Istanbul, Beirut, Karochi, Calcutta, Rangoon, Bankok, Hong Kong, Manila, Tokyo, Guam, Wake Island, Honolulu, Los Angeles.

3. Additional routes extend from Honolulu to Sidney and Aukland, from Seattle to Fairbanks and Nome, from Lisbon to Johannesburg, and Lisbon to Rio De Janeiro.

4. Extensive routes are flown across the Caribbean Sea and to all parts of South America.

5. Service to all major cities of Europe is provided, including Oslo, Stockholm, and Helsinki.

B. Typical flight schedules and fares

1. New York to Paris (nonstop)	11 hrs. 30 min.	$420.00
2. New York to London (nonstop)	12 hrs.	400.00
3. London to Istanbul	10 hrs. 15 min.	198.10
4. Lisbon to Calcutta	11 hrs. 30 min.	551.60
5. Hong Kong to Wake Island	20 hrs.	302.40
6. Wake Island to Honolulu	9 hrs.	254.00
7. Honolulu to Los Angeles	8 hrs. 45 min.	168.00

VIII. Pan American Grace

A. International routes
(Pan American Grace airlines operates from New York southward to Miami, Panama, Guayaquil, Lima, Santiago, Buenos Aires.)

B. Typical flight schedules and fares

1. New York to Lima	15 hrs. 10 min.	$306.00
2. Lima to Santiago	5 hrs.	126.00
3. Santiago to Buenos Aires	3 hrs. 10 min.	60.00

IX. Trans World Airlines

A. International routes

1. Transworld Airlines operates extensive flights across the Atlantic to Shannon, London, and Paris.

2. The major European cities are served as are Rome, Athens, Cairo, Dhahran, Bombay and terminating routes to Colombo, Ceylon.

B. Typical flight schedules and fares

1. New York to Paris	14 hrs.	$310.00	(tourist)
2. Paris to Geneva	1 hr. 35 min.	19.60	"
3. Paris to Rome	5 hrs. 45 min.	53.20	"
4. Rome to Cairo	5 hrs. 55 min.	155.12	"
5. Cairo to Bombay	9 hrs. 30 min.	249.20	"

X. United Airlines

A. Overseas routes

1. San Francisco to Hawaii

2. Los Angeles to Hawaii

B. Typical flight schedule and fare

San Francisco to Honolulu	8 hrs. 10 min.	$168.00

<u>Things to do</u>:

1. Divide the class into groups and have each group write to one of the international air carriers for free educational material. (See Introduction to this unit for addresses)

2. Plan an international flight and cover the following points:

   a. Obtaining passports

   b. Making reservations

   c. Money exchange rates

   d. Total distance of trip

   e. Time required for flight

   f. Travel fares

   g. Points of interest to visit during your trip.

Films:

Full information about the following films can be obtained from Pan American World Airways. All are 16 mm. sound, color.

"Wings to France" (3 reels, 31 minutes)

"Wings to England and Belgium" (3 reels, 31 minutes)

"Wings to Italy" (3 reels, 30 minutes)

"Wings to Vikingland" (3 reels, 28 minutes)

"Wings to Ireland" (3 reels, 31 minutes)

"Wings to Bermuda" (2 reels, 20 minutes)

"Wings to Hawaii" (3 reels, 31 minutes)

"Round South America" (6 reels, 57 minutes)

"Wings to Mexico and Guatemala" (3 reels, 32 minutes)

"Wings to Cuba and the Carribbean" (3 reels, 30 minutes)

"Wings to Haiti" (2 reels, 22 minutes)

"Wings to Alaska" (2 reels, 22 minutes)

"Wings to New York" (3 reels, 28 minutes)

"New Horizons" (4 reels, 34 minutes)

"Wings to Japan"

"Wings to the U.S.A."

Full information on the following films can be obtained from Northwest Orient Airlines. All films are 16 mm. sound, color.

"Hawaiian Express" (26 minutes)

"High Road to the Orient" (28½ minutes)

"Northwest to Alaska" (27 minutes)

"The Philippines" (18 minutes)

"Japan" (18 minutes)

"Hong Kong" (18 minutes)

"Formosa" (18 minutes)

Table 9. Distances Between Key World Cities

	AUCKLAND	BERLIN	BOMBAY	BUENOS AIRES	CAIRO	CALCUTTA	CAPETOWN	CARACAS	CHICAGO	COLON
AUCKLAND	•	11028	7639	6431	10295	6950	7281	8210	8198	7452
BERLIN	11028	•	3910	7402	1795	4368	5981	5247	4405	5844
BOMBAY	7639	3910	•	9277	2707	1027	5115	9024	8056	9726
BUENOS AIRES	6431	7402	9277	•	7345	10265	4269	3168	5598	3348
CAIRO	10295	1795	2707	7345	•	3539	4500	6338	6129	7139
CALCUTTA	6950	4368	1027	10265	3539	•	6024	9605	7980	10078
CAPETOWN	7281	5981	5115	4269	4500	6024	•	6365	8494	7056
CARACAS	8210	5247	9024	3168	6338	9605	6365	•	2501	884
CHICAGO	8198	4405	8056	5598	6129	7980	8494	2501	•	2292
COLON	7452	5844	9726	3348	7139	10078	7056	884	2292	•
DAKAR	10730	3113	5910	4337	3260	6799	4108	3344	4530	4224
HONG KONG	5676	5440	2675	11472	5061	1648	7375	10167	7793	10052
HONOLULU	4398	7309	8012	7561	8838	7047	11534	6013	4250	5214
ISTANBUL	10586	1078	2992	7611	768	3638	5154	6048	5477	6749
KHABAROVSK	6380	4666	3977	11254	5261	3110	9095	8296	5677	7909
LISBON	12176	1436	4986	5956	2363	5638	5325	4041	3990	4769
LONDON	11393	579	4468	6916	2181	4947	6012	4660	3950	5274
LOS ANGELES	6571	5724	8633	6170	7520	8090	9992	3632	1745	2998
MANILA	4981	6132	3191	11051	5704	2203	7486	10620	8143	10249
MEXICO, D.F.	6806	6047	9731	4592	7688	9492	8517	2232	1691	1463
MIAMI	8049	4969	8850	4399	6484	9009	7658	1366	1188	1134
MONTREAL	8942	3729	7509	5615	5414	7607	7931	2449	744	2524
MOSCOW	10064	1004	3129	8376	1803	3321	6300	6173	4974	6703
NATAL (BRAZIL)	8912	4923	7525	2483	5039	8506	3936	2457	4655	3251
NEW ORLEANS	7652	5173	8929	4858	6816	8869	8300	1968	833	1512
NEW YORK	8823	3965	7794	5297	5602	7918	7764	2132	713	2197
NOVOSIBIRSK	8321	2723	2482	10121	3048	2264	7232	7581	5717	7874
PARIS	11524	545	4359	6870	1995	4883	5807	4736	4134	5373
PERTH	3322	8427	4526	7821	6990	4182	5400	10943	10964	10578
RIO DE JANEIRO	7620	6220	8335	1200	6146	9377	3773	2810	5296	3334
SAN FRANCISCO	6528	5661	8394	6467	7364	7814	10247	3904	1858	3289
SANTIAGO	6009	7782	9980	706	7947	10809	5514	3045	5311	3019
SEATTLE	7006	5045	7744	6908	6823	7228	10209	4093	1737	3612
SHANGHAI	5829	5218	3131	12201	5183	2117	8061	9501	7061	9297
SINGAPORE	5225	6167	2430	9868	5137	1801	6005	11375	9371	11655
STOCKHOLM	10570	504	3875	7808	2111	4195	6444	5420	4278	5941
SYDNEY	1343	10006	6316	7330	8952	5685	6843	9513	9272	8784
TOKYO	5497	5540	4188	11408	5935	3194	9156	8799	6299	8401
WARSAW	10780	320	3597	7662	1630	4048	5958	5517	4667	6161
WASHINGTON	8629	4169	7987	5218	5800	8084	7901	2059	597	2050

	DAKAR	HONG KONG	HONOLULU	ISTANBUL	KHABAROVSK	LISBON	LONDON	LOS ANGELES	MANILA	MEXICO, D.F.
AUCKLAND	10730	5676	4398	10586	6380	12176	11393	6571	4981	6806
BERLIN	3113	5440	7309	1078	4666	1436	579	5724	6132	6047
BOMBAY	5910	2675	8012	2992	3977	4986	4468	8633	3191	9731
BUENOS AIRES	4337	11472	7561	7611	11254	5956	6916	6170	11051	4592
CAIRO	3260	5061	8838	768	5261	2363	2181	7520	5704	7688
CALCUTTA	6799	1648	7047	3638	3110	5638	4947	8090	2203	9492
CAPETOWN	4108	7375	11534	5154	9095	5325	6012	9992	7486	8517
CARACAS	3344	10167	6013	6048	8296	4041	4660	3632	10620	2232
CHICAGO	4530	7793	4250	5477	5677	3990	3950	1745	8143	1691
COLON	4224	10052	5214	6749	7909	4769	5274	2998	10249	1463
DAKAR	•	8285	8777	3314	7730	1737	2719	6229	8951	5358
HONG KONG	8285	•	5549	4984	2145	6853	5982	7195	693	8782
HONOLULU	8777	5549	•	8109	2261	7820	7228	2574	5299	3779
ISTANBUL	3314	4984	8109	•	4792	2012	1552	6783	5664	7110
KHABAROVSK	7730	2145	2261	4792	•	6025	5040	5118	2410	6679
LISBON	1737	6853	7820	2012	6025	•	985	5621	7546	5390
LONDON	2719	5982	7228	1552	5040	985	•	5382	6672	5550
LOS ANGELES	6229	7195	2574	6783	5118	5621	5382	•	7261	1546
MANILA	8951	693	5299	5664	2410	7546	6672	7261	•	8835
MEXICO, D.F.	5358	8782	3779	7110	6679	5390	5550	1546	8835	•
MIAMI	4104	8979	4855	5972	6860	4146	4429	2339	9305	1285
MONTREAL	3872	7729	4910	4789	5716	3246	3282	2427	8186	2318
MOSCOW	4049	4439	7037	1091	3815	2427	1555	6003	5131	6663
NATAL (BRAZIL)	1881	10096	8462	5173	8733	3498	4468	6057	10709	4682
NEW ORLEANS	4695	8540	4216	6225	6397	4541	4674	1673	8778	876
NEW YORK	3815	8054	4964	4975	6024	3364	3458	2451	8498	2094
NOVOSIBIRSK	5789	2750	6070	2598	2182	4159	3231	6082	3456	7288
PARIS	2615	5985	7438	1400	5144	904	213	5588	6677	5716
PERTH	9341	3748	6780	7477	5684	9347	8996	9352	3235	10105
RIO DE JANEIRO	3125	11021	8285	6389	10667	4796	5766	6331	11259	4771
SAN FRANCISCO	6388	6897	2393	6703	4823	5666	5357	347	6967	1887
SANTIAGO	4830	11611	6861	8143	10751	6366	7252	5645	10943	4197
SEATTLE	6140	6475	2680	6068	4348	5197	4786	959	6644	2339
SHANGHAI	8254	764	4941	4962	1390	6654	5715	6438	1150	8022
SINGAPORE	8277	1606	6717	5375	3751	7386	6745	8736	1487	10318
STOCKHOLM	3572	5113	6862	1348	4176	1856	890	5454	5797	5959
SYDNEY	10934	4584	5073	9294	5790	11302	10564	7530	3944	8052
TOKYO	8648	1794	3853	5560	913	6915	5940	5433	1866	7021
WARSAW	3343	5144	7355	863	4475	1715	899	5922	5837	6365
WASHINGTON	3957	8147	4519	5215	6007	3562	3663	2300	8562	1887

	MIAMI	MONTREAL	MOSCOW	NATAL (BRAZIL)	NEW ORLEANS	NEW YORK	NOVOSIBIRSK	PARIS	PERTH	RIO DE JANEIRO
AUCKLAND	8049	8942	10064	8912	7652	8823	8321	11524	3322	7620
BERLIN	4969	3729	1004	4923	5173	3965	2723	545	8427	6220
BOMBAY	8850	7509	3129	7525	8929	7794	2482	4359	4526	8335
BUENOS AIRES	4399	5615	8376	2483	4858	5297	10121	6870	7821	1200
CAIRO	6484	5414	1803	5039	6816	5602	3048	1995	6990	6146
CALCUTTA	9009	7607	3321	8506	8869	7918	2264	4883	4182	9377
CAPETOWN	7658	7931	6300	3936	8300	7764	7232	5807	5400	3773
CARACAS	1366	2449	6173	2457	1968	2132	7581	4736	10943	2810
CHICAGO	1188	744	4974	4655	833	713	5717	4134	10964	5296
COLON	1134	2524	6703	3251	1512	2197	7874	5373	10578	3334
DAKAR	4104	3872	4049	1881	4695	3815	5789	2615	9341	3125
HONG KONG	8979	7729	4439	10098	8540	8054	2750	5985	3748	11021
HONOLULU	4855	4910	7037	8462	4216	4964	6070	7438	6780	8285
ISTANBUL	5972	4789	1091	5173	6225	4975	2598	1400	7477	6389
KHABAROVSK	6860	5716	3815	8733	6397	6024	2182	5144	5684	10667
LISBON	4146	3246	2427	3498	4541	3364	4159	904	9347	4796
LONDON	4429	3282	1555	4468	4674	3458	3231	213	8996	5766
LOS ANGELES	2339	2427	6003	6057	1673	2451	6082	5588	9352	6331
MANILA	9305	8186	5131	10709	8778	8498	3456	6677	3235	11259
MEXICO, D.F.	1285	2318	6663	4682	876	2094	7288	5716	10105	4771
MIAMI	•	1411	5731	3723	669	1092	6761	4572	11377	4179
MONTREAL	1411	•	4386	4260	1449	320	5352	3422	11375	5097
MOSCOW	5731	4386	•	5894	5820	4665	1745	1544	7591	7175
NATAL (BRAZIL)	3723	4260	5894	•	4355	4041	7638	4402	9195	1299
NEW ORLEANS	669	1449	5820	4355	•	1171	6609	4840	10884	4743
NEW YORK	1092	320	4665	4041	1171	•	5678	3624	11626	4817
NOVOSIBIRSK	6761	5352	1745	7638	6609	5678	•	3261	6323	8918
PARIS	4572	3422	1544	4402	4840	3624	3261	•	8870	5699
PERTH	11377	11375	7591	9195	10884	11626	6323	8870	•	8310
RIO DE JANEIRO	4179	5097	7175	1299	4743	4817	8918	5699	8310	•
SAN FRANCISCO	2594	2539	5871	6313	1926	2571	5850	5558	9162	6621
SANTIAGO	4139	5456	8781	2970	4500	5127	10648	7239	7898	1816
SEATTLE	2734	2281	5203	6378	2101	2408	5252	5021	9253	6892
SHANGHAI	8246	7053	4235	10119	7786	7371	2495	5754	4381	11336
SINGAPORE	10546	9200	5238	9598	10146	9530	3898	6671	2429	9774
STOCKHOLM	4979	3667	762	5354	5101	3924	2347	958	8355	6651
SYDNEY	9329	9954	9012	9663	8855	9933	7351	10544	2053	8306
TOKYO	7451	6383	4647	10343	6912	6740	2962	6034	4926	11533
WARSAW	5273	4009	715	5181	5249	4344	2455	849	8121	6467
WASHINGTON	923	488	4858	4082	966	205	5835	3829	11571	4796

	SAN FRANCISCO	SANTIAGO	SEATTLE	SHANGHAI	SINGAPORE	STOCKHOLM	SYDNEY	TOKYO	WARSAW	WASHINGTON
AUCKLAND	6528	6009	7006	5829	5225	10570	1343	5497	10780	8629
BERLIN	5661	7782	5045	5218	6167	504	10006	5540	320	4169
BOMBAY	8394	9980	7744	3131	2430	3875	6316	4188	3597	7987
BUENOS AIRES	6467	706	6908	12201	9868	7808	7330	11408	7662	5218
CAIRO	7364	7947	6823	5183	5137	2111	8952	5935	1630	5800
CALCUTTA	7814	10809	7228	2117	1801	4195	5685	3194	4048	8084
CAPETOWN	10247	5514	10209	8061	6005	6444	6843	9156	5958	7901
CARACAS	3904	3045	4093	9501	11375	5420	9513	8799	5517	2059
CHICAGO	1858	5311	1737	7061	9371	4278	9272	6299	4667	597
COLON	3289	3019	3612	9297	11655	5941	8784	8401	6161	2050
DAKAR	6388	4830	6140	8254	8277	3572	10934	8648	3343	3957
HONG KONG	6897	11611	6475	764	1606	5113	4584	1794	5144	8147
HONOLULU	2393	6861	2680	4941	6717	6862	5073	3853	7355	4519
ISTANBUL	6703	8143	6068	4962	5375	1348	9294	5560	863	5215
KHABAROVSK	4823	10751	4348	1390	3751	4176	5790	913	4475	6007
LISBON	5666	6366	5197	6654	7386	1856	11302	6915	1715	3562
LONDON	5357	7252	4786	5715	6745	890	10564	5940	899	3663
LOS ANGELES	347	5645	959	6438	8736	5454	7530	5433	5922	2300
MANILA	6967	10943	6644	1150	1487	5797	3944	1866	5837	8562
MEXICO, D.F.	1887	4197	2339	8022	10318	5959	8052	7021	6365	1887
MIAMI	2594	4139	2734	8246	10546	4979	9329	7451	5273	923
MONTREAL	2539	5456	2281	7053	9200	3667	9954	6383	4009	488
MOSCOW	5871	8781	5203	4235	5238	762	9012	4647	715	4858
NATAL (BRAZIL)	6313	2970	6378	10119	9598	5354	9663	10343	5181	4082
NEW ORLEANS	1926	4500	2101	7786	10146	5101	8855	6912	5249	1011
NEW YORK	2571	5127	2408	7371	9530	3924	9933	6740	4344	205
NOVOSIBIRSK	5850	10648	5252	2495	3898	2347	7351	2962	2455	5835
PARIS	5558	7239	5021	5754	6671	958	10544	6034	849	3829
PERTH	9162	7898	9253	4381	2429	8355	2053	4926	8121	11571
RIO DE JANEIRO	6621	1816	6892	11336	9774	6651	8306	11533	6467	4796
SAN FRANCISCO	•	5937	678	6140	8440	5361	7416	5135	5841	2442
SANTIAGO	5937	•	6445	11712	10189	8131	7046	10705	8069	5015
SEATTLE	678	6445	•	5713	8068	4719	7745	4781	5207	2329
SHANGHAI	6140	11712	5713	•	2365	4825	4899	1097	4951	7448
SINGAPORE	8440	10189	8068	2365	•	5993	3920	3307	5846	9657
STOCKHOLM	5361	8131	4719	4825	5993	•	9696	5051	501	4123
SYDNEY	7416	7046	7745	4899	3920	9696	•	4866	9696	9758
TOKYO	5135	10705	4781	1097	3307	5051	4866	•	5249	6772
WARSAW	5841	8069	5207	4951	5646	501	9696	5249	•	4457
WASHINGTON	2442	5015	2329	7448	9657	4123	9758	6772	4457	•

GREAT CIRCLE DISTANCES in statute miles

COMMERCIAL AIR TRANSPORTATION

Section IV. Jet Transports of Tomorrow

Text references: Boeing Magazine, Dec. 1955
Aviation Week, March 12, 1956
Aviation Age, Dec. 1955

I. Manufacturers of jet transports

A. Boeing Airplane Company

1. Model 707 Stratoliner (707-120)

a. Dimensions--wing 130' 10", length 134' 6", height 38' 3", Sweepback 35 degrees

b. Gross weight--more than 230,000 pounds

c. Power--four advanced type Pratt & Whitney J57 turbojet engines, rated at more than 10,000 lbs/thrust each

d. Speed--cruising, 550 to 600 mph

e. Cruising altitude--25,000 to 40,000 feet

f. Range--non-stop transcontinental; non-stop transatlantic

g. Payload--more than 31,000 pounds

h. Landing gear--tricycle; main undercarriage units four-wheel, bogie-type trucks; dual nose wheels.

i. Crew--three: pilot, co-pilot, flight engineer

2. Model 707 Stratoliner (707-220)
(Same as above except that a bigger Pratt & Whitney JT4 engine has been installed and gross weight increased to 245,000 pounds)

3. Model Intercontinental (707-320)

a. Dimensions--wing 141' 6", length 146' 8", height 38' 11"

b. Gross weight--more than 280,000 pounds

c. Power--four Pratt & Whitney JT4 turbojet engines

d. Speed-cruising, 550 to 600 mph

e. Cruising altitude--25,000 to 40,000 feet

f. Range--more than 4,000 miles

g. Payload--more than 35,000 pounds

h. Landing gear--tricycle; main undercarriage units four-wheel, bogie-type trucks; dual nose wheels

i. Crew--four: pilot, co-pilot, flight engineer, navigator

B. Douglas Aircraft Company

1. Model DC-8

a. Dimensions--wing 139' 9", length 148' 10", height 42' 4"

b. Gross weight--265,000 pounds for domestic flights, 287,500 for intercontinental flights

c. Power--Pratt & Whitney J57 or JT4

d. Speed--550 to 580 mph

e. Range--6,720 miles for intercontinental model

f. Passengers--first class 120, tourist 144

g. Crew--five

C. Lockheed Aircraft Corporation

1. Model #188 Electra Turboprop

a. Dimensions--wing 99', length 102' 7", height 34'

b. Weight--110,000 pounds

c. Power--four Allison turboprop 501 engines

d. Cruising speed--410 to 452 mph

e. Range--maximum load, 3,000 miles

f. Payload--20,600 pounds

g. Wing design--straight leading edge, tapered trailing edge

h. Passengers--first class, 66; tourist, 91

i. Crew--three to six

II. Airlines now ordering jet transports

A. Pan American World Airways

1. Eight Boeing Stratoliners

2. Twelve Boeing Intercontinentals

3. Twenty-five Douglas DC-8's

B. American Airlines

1. Thirty Boeing Stratoliners (707-120)

2. Thirty-five Lockheed Electra's

C. United Airlines

1. Thirty Douglas DC-8's

D. Eastern Airlines

1. Twenty-one Douglas DC-8's

2. Forty Lockheed Electra's

E. Braniff Airlines

1. Five Boeing Stratoliners (707-220)

F. Continental Air Lines

1. Four Boeing Stratoliners (707-120)

III. Jet transport flight times

A. Continental routes

1. New York to Los Angeles	4 hours 12 minutes
2. New York to Miami	2 hours 10 minutes
3. New York to Seattle	4 hours 12 minutes
4. Seattle to Anchorage	2 hours 42 minutes

B. Intercontinental routes (nonstop)

1. Chicago to Paris	7 hours
2. New York to Rome	7 hours 30 minutes
3. New York to Mexico City	3 hours 46 minutes
4. Los Angeles to Copenhagen	10 hours 38 minutes
5. New York to Rio De Janeiro	9 hours 15 minutes
6. Tokyo to San Francisco	9 hours 27 minutes

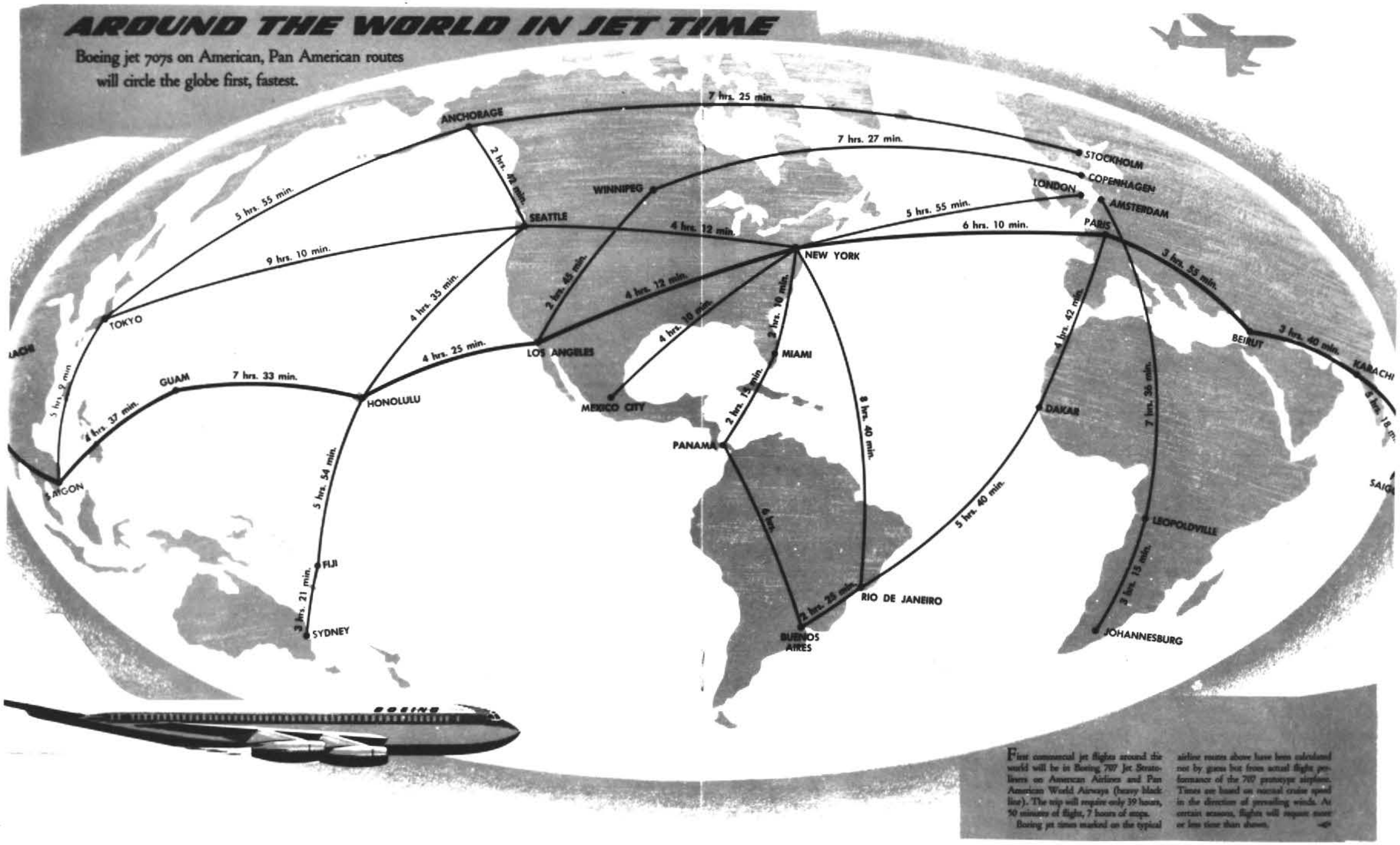

Figure 2. Around the world in jet time

Boeing Magazine

UNIT II.

KNOW YOUR AIRPLANE

Introduction

This unit of study presents the different types of aircraft and methods of classification.

The main classifications are lighter-than air aircraft and heavier-than air aircraft. Further classification under heavier-than-air aircraft may be made according to wing position, wing shape, fuselage shape, and type of engine installation. The purposes for which aircraft are designed and used are also discussed.

A section on the names of the airplane structural parts and control surfaces, as well as the different forces to which they are subjected, is covered. Civilian aircraft international markings and the numbering systems used by the United States military forces are covered in Section III. The final section, "Aircraft Identification in Flight", puts to use as much material as possible that is covered in the first three sections.

Books

The following books are recommended for this unit of study: (See bibliography)

Aviation Study Manual, Volume 1, Book II

The Observers Book of Aircraft, Wm. Green and Gerald Pollinger

Basic Aeronautics, M. E. Tower

Pilots Airplane Manual, N. O. Anderson

Aircraft Recognition for the Ground Observer, U. S. Air Force

The How of the Helicopter, Alfred H. Stevens, Jr.

KNOW YOUR AIRPLANE

Section I. Types of Aircraft

Text references: Aviation Study Manual, Unit 2, pp. 1-5
The Observer's Book of Aircraft

I. Aircraft primary classification

A. Lighter-than air craft
(Require a lighter-than-air gas to support the craft. Helium is used for this purpose.)

1. Blimps

a. Non-rigid

b. Has very little practical use

2. Dirigibles

a. Constructed around a rigid metal framework

b. Dirigibles are steerable and can be controlled.

c. Dirigibles use reciprocating engines for propulsion.

B. Heavier-than-air craft

1. Rotary-wing aircraft (Helicopter)

a. The helicopter rotating blades are powered by the engine.

b. The rotating airfoils produce all lift.

c. Tilting the rotating blades produces directional control.

(1) Blades tilted forward produce a forward motion.

(2) Blades tilted to either side produce a sideways motion.

(3) Blades tilted to the rear produce motion to the rear.

d. Torque effect is offset by a small rotating propeller at the rear of the boom, or by dual contra-rotating blades.

2. Fixed-wing aircraft

   a. Landplanes

      (1) Planes operating only from land airports, or naval aircraft carriers

   b. Seaplanes

      (1) Planes operating only from a body of water

      (2) Seaplanes are equipped with hulls or floats in place of landing gears and wheels.

   c. Amphibians

      (1) Planes designed to operate from either land bases or water bases

      (2) Landing gear wheels retract into the hull or floats when a water landing is made.

II. Aircraft secondary classification

A. Wing position--front view

1. High-wing monoplane
(One wing, located topside of the fuselage)

   a. Aeronca

   b. Piper Tri-Pacer

   c. Cessna 140, 170, 180, 190, 195

   d. PB4Y

   e. B-36

   f. B-52

   g. C-123

   h. Aero Commander

2. Mid-wing monoplane
(One wing, located half-way down on the fuselage)

   a. Curtis C-46

   b. Navy P4M

   c. Boeing C-96

d. Boeing B-29, B-50

e. F-102

f. F-84

g. F-89

3. Low-wing monoplane
(One wing, located on the underside of the fuselage)

a. Beech Bonanza

b. North American T-6

c. Bellanca

d. Navion

e. Beechcraft C-45

f. Douglas DC-3, DC-4, DC-6

4. Parasol wing (Navy PBY)
(A high-wing monoplane with the wing attached one to two feet above the fuselage)

5. Gull-wing monoplane
(Essentially a high-wing monoplane, with the wing shape resembling a sea gull wing)

a. Stinson Reliant

b. North American B-25

6. Inverted gull wing

a. A wing shaped so as to raise the fuselage, yet have a positive dihedral

(1) Fairchild C-119

(2) Corsair F4U

B. Wing shape--top view

1. Rectangular shape
(Most light personal aircraft use this wing)

a. Cessna 120, 140

b. Aeronca Sedan

2. Tapered leading edge
   (Straight trailing edge)

   a. Douglas DC-2, C-47

   b. Convair B-36

   c. Boeing C-97

3. Double-tapered wing
   (Both leading edge and trailing edge taper toward the tip.)

   a. Douglas DC-6, DC-7

   b. Convairliner

   c. F-84

   d. Globemaster

4. Tapered trailing edge wing
   (Straight leading edge)

   a. Aero Commander

   b. Cessna 170, 180, 310

   c. Beech Bonanza

   d. Martin 202, 404

5. Elliptical wing
   (Not many used)

   a. Republic F-47

   b. English Spitfire

6. Double-tapered sweepback
   (Used in many fighters and high-speed aircraft)

   a. Boeing 707 Jetliner

   b. F-86, F-84

   c. Douglas DC-8 (Jet transport)

7. Inverse-tapered sweepback (Republic F-91)
   (The wing becomes wider as the tip is approached.)

8. Delta-wing design

   a. Wing shaped like a triangle

   b. Used on very high speed aircraft

(1) F-92

(2) F-102

(3) F-4D

(4) English Vulcan and Javelin

C. Fuselage shape

1. Dart shape

a. Boeing B-47

2. Cigar shape

a. Douglas DC-4, DC-6, DC-7

b. Convair 340

c. Martin 202, 404

3. Carrot shape

a. F-47

b. F-94

4. Tubular shape

a. B-29

b. B-50

D. Engine installation

1. Propeller aircraft

a. Reciprocating engine

(1) Radial--air-cooled

(2) Inline--liquid and air-cooled

b. Turbo-prop engines
(This installation sometimes uses two contra-rotating propellers.)

2. Jet aircraft

a. Gas-turbine engine

b. Thrust produced by jet exhaust action

c. Installed singly or in pairs

III. Classification as to purpose

A. Civilian aircraft

1. Light personal planes

a. Used for transportation

b. Used for pleasure flying

2. Executive aircraft

a. Used for transportation

b. Usually four to ten passenger

3. Large transport aircraft

a. Used by commercial airlines

b. Seating capacity 20 to 90 passengers

4. Cargo carrying aircraft

a. Used for air freight

b. Passengers cannot be carried on this type airplane.

5. Utility aircraft

a. Ambulance service

b. Aerial mapping service

c. Aerial prospecting

d. Agricultural crop dusters and sprayers

e. Advertising service

f. Patrol service

g. Engineering service

Things to do:

1. Have each student choose an airplane in which he is interested and gather as much information as possible on it.

2. Assign days for the student to report to the class on his findings.

3. Have students report on new airplane designs.

Films:

"Smokejumpers" (16 mm. sound, 10 minutes. Contrasts forest fire fighting methods of the past with those of today. Points out that time and distance are important in fire fighting and shows how through the use of the airplane and "smokejumpers." it has been possible to attack forest fires when they are small and more easily extinguished. Loan by CAA)

"Rescue Squadron (16 mm. sound, 17 minutes. Depicts the operation of the Air Rescue Service in the salvage of human life, both military and civilian, in times of disaster. Loan by CAA)

"Know Your Air Force Better" (16 mm. sound, 15 minutes. A family watching a television program at home take the suggestion offered by an animated figure to visit their nearest Air Force base on Air Force Day. At a typical installation, they see all kinds of demonstrations and types of airplanes. Also, the narrator takes the audience to other localities where more spectacular demonstrations have taken place. Loan by Air Force)

"Latest North American Aircraft" (16 mm. sound, color, 13 minutes. Depicts the external physical characteristics of the Air Force B-45 Tornado Four jet bomber; the Air Force F-86 Sabre jet fighter; the Navy FJ-1 Fury, carrier-based jet fighter; and the Navy AJ-1 carrier-based bomber. Also explains some of the operational features of each plane and includes scenes of the first carrier landing made by a jet fighter. Loan by CAA)

"Uses of Aircraft for Insect Control--Mosquito Control" (16 mm. sound, 14 minutes. Shows how the airplane has been effectively used for mosquito control in the Tennessee River area. Illustrates two common types of airplane installations for this type of work and then proceeds to demonstrate proper operational techniques devised for thermal aerosol spraying. Loan by CAA)

"Wings of Mercy" (16 mm. sound, 20 minutes) Depicts Saskatchewan's air ambulance service. Through this service, every one in Saskatchewan is now within three hours of a hospital--at the very most. This is an excellent film to show how aviation can bring new hope and new security to those who live in outlying districts. Loan by CAA)

KNOW YOUR AIRPLANE

Section II. Aircraft Structure

Text references: Aviation Study Manual, Unit 2, p. 6
Basic Aeronautics, Chap. 3
Pilot's Airplane Manual, Chapter 1 and 5

I. Aircraft nomenclature

A. Fuselage group

1. Cabin
2. Cockpit
3. Baggage compartment

B. Wing group

1. Leading edge
2. Trailing edge
3. Ailerons
4. Flaps

C. Empennage or tail group

1. Vertical stabilizer
2. Rudder and rudder-trim tab
3. Horizontal stabilizer
4. Elevators and elevator-trim tab

D. Powerplant group

1. Propellers
2. Engine
3. Cowling
4. Cowl flap
5. Engine nacelle

E. Landing gear group

1. Fixed
2. Retractable

II. Stresses applied to the structure during flight

A. Tension or tensile stress
(This stress is produced in a member by two forces acting upon it in the same line but in opposite directions.)

1. Control cables

2. Lower side of wing and wing spar

3. A bending beam has tension one one side and compression on the loaded side.

B. Compression
(This stress is produced by two forces, acting upon a member in the same line and same direction and is the squeezing effect produced by the two forces.)

1. The top side of a wing is under compression during flight.

2. The top side of the wing spar is under compression during flight.

3. The landing gear is under compression when the aircraft is on the ground.

C. Shear
(The tendency of an external force to move or slide one portion of the member past another portion, a cutting action similar to scissor action)

1. Rivets used in aircraft construction are subject to shear.

2. Landing gear wheel axles develop severe shear stress during landing.

3. Wing spar attaching belts are under shear at all times.

D. Torsion
(The deflection of any member by a twisting motion about its longitudinal axis--the term torsion is sometimes used synonymously with torque or torsional moment.)

1. Probably the greatest torsion stress on an airplane is the twisting of the fuselage section by the action of the tail group.

E. Bending
(A force which tends to cause bending of a member, a combination of tension stress on the side opposite the applied force and compression stress on the same side as the applied force)

1. Upward bending of wing in flight

2. Forward bending of propeller when turning at high speeds

III. Wing construction

A. Wing spars
(The main supporting structure of the wing, essentially two or more beams, either wood or metal, running longitudinally outward toward the wing tip)

B. Wing ribs

1. Wing ribs produce the curved shape of the wing.

2. Nose ribs provide the shape for the leading edge of the wing.

3. Ribs are constructed of wood for some airplanes, and stamped out of aluminum sheet for others.

C. Wing bracing

1. Internally braced wings

a. Drag wire

b. Anti-drag wire

c. Compression ribs

d. Cloth covering

(1) Grade A cotton fabric

(2) Irish linen

2. Externally braced or stressed-skin wings

a. Longitudinal stringers

b. Corrugated sub-covering

c. Most of this bracing is accomplished by solid covering.

(1) Plywood

(2) Sheet aluminum

D. Wing attachment

1. Full-cantilever style

a. Very strong construction

b. No external wing bracing is used.

c. Cessna 190 and 195 are very good examples of cantilever construction.

2. Semi-cantilever style

   a. Internal wing structure not as strong as cantilever

   b. Strength and rigidity helped by small streamlined tie rods from wing to fuselage

   c. The Stearman biplane is a good example.

3. Full externally braced wing

   a. Lighter than either of above types

   b. Streamlined lift struts brace the wing to the fuselage.

   c. Piper Tri-Pacer and Cessna 120, 140, 170, and 180 are good examples of this construction.

IV. Fuselage construction

A. Semi-monocoque

1. Stress carried by the outer skin and internally bracing of bulkheads and stringers

2. Aluminum sheets used for covering

3. Shapes of fuselage

   a. Round

   b. Oval

   c. Square

   d. Figure eight

B. Truss-type fuselage

1. Pratt truss

   a. Fuselage formed into squares by welded steel tubing

   b. Bracing furnished by tie rods or brace wires

   c. Cloth covered on airplane

2. Warren truss

   a. Fuselage struts form many triangles which take all tension, compression and torsion stresses.

   b. They are light in weight and very strong.

   c. Cloth covered on airplane

V. Stabilizing devices

A. Vertical stabilizer

1. Fixed or adjustable airfoil attached to an aircraft to afford directional stability.

2. Can be semi-monocoque or truss type construction

3. Can be internally braced or externally braced

B. Horizontal stabilizers

1. A fixed or adjustable horizontal airfoil, on the empennage or tail section, that provides longitudinal stability.

2. Can be stressed-skin construction or external and internally braced construction.

VI. Control surfaces

A. Ailerons

1. Small movable airfoils attached to the trailing edge of the wings

2. Controlled by movement to the right or left of the control stick by cables or tubular linkage

B. Elevators

1. Small movable airfoils attached to the trailing edge of the horizontal stabilizers

2. Controlled by movement of control stick forward and rearward, by cable or tubular linkage

C. Rudder

1. A movable airoil attached to the rear of the vertical stabilizer

2. Controlled by movement by a cable linkage system of pedals located on the cockpit floor

VII. Landing gear

A. Spring steel type

1. Landing shock absorbed by spring action of the landing gear strut

B. Fixed-shock-cord type

2. Landing shock absorbed by large rubber bands

C. Oleo-strut type

1. Absorbs shock by a combination of air and oil being compressed upon landing

Things to do:

1. Visit an airport and have someone point out and name all the parts of an airplane.

2. During your first flight note the change in attitude of the airplane with relation to various control movements.

Films:

"The Airplane and Its Parts" (16 mm. sound, 30 minutes. This film explains the functions of various parts of an airplane and why an airplane flies. Rent from Tradefilms, Inc., 666 North Robertson Blvd., Hollywood 46, Calif.)

"NACA Research" (16 mm. sound, color, 20 minutes. This film offers a general overview of research work carried on by personnel of the National Advisory Committee for Aeronautics and shows some of the NACA facilities which are utilized in its research programs. Loan by CAA, Washington office)

KNOW YOUR AIRPLANE

Section III. Aircraft Identification Markings

Text reference: Aviation Study Manual, Unit 2, pp. 16-18

I. Civilian aircraft

A. International aircraft prefix letter symbols

Argentina	LV	Ireland	EI, EJ
Australia	VH	Italy	I
Austria	OE	Japan	None
Belgium	OO	Mexico	XA, XB, XC
Brazil	PP, TT	Netherlands	PH, PK, PJ
Burma	XY, XZ	New Zealand	ZK, ZL, ZM
Canada	CF	Norway	LN
China	B	Pakistan	AP
Columbia	HK	Paraguay	ZP
Czechoslavakia	OK	Peru	OB
Dominican Republic	HI	Switzerland	HB
Finland	OH	Thailand	HS
France	F	Union of South Africa	ZS, ZT, ZU
Germany	D	United Kingdom (Britain)	G
Iceland	TF	U. K. Colonies	VP, VQ, VR
India	VT	United States	N
Iraq	YI		

B. Placing of registration numbers on U. S. aircraft

1. Wing numbers

a. Must be at least 20 inches in height

b. Registration number must be on top of the upper right wing and on the under side of the lower left wing.

2. Tail numbers

a. Must be between two and six inches in height

b. Must be located in the upper half of both sides of the vertical stabilizer

3. Additional markings

a. The aircraft category classifications of "Restricted," "Limited," and "Experimental," must be displayed near the door to the cabin or cockpit.

b. Additional markings must be two inches in height.

II. U. S. Air Force aircraft designations

A. United States Air Force basic letter designations

Purpose	Designation
Amphibious	A
Bomber	B
Cargo and transport	C
Fighter	F
Glider	G
Helicopter	H
Liaison	L
Target and drone	Q
Reconnaissance	R
Search and rescue	S
Trainer (all types)	T
Special research	X

B. United States Air Force special prefix letter

D--Modified aircraft which function as "mother" airplane for radio controlled aircraft or missiles

E--Aircraft on bailment contract to commercial organizations

M--Aircraft to be used as guided missiles

R--Standard aircraft of a different basic type modified for reconnaisance (example: RB-29)

T--Standard aircraft of a different basic type which have been modified for training (example: TF-80)

V--Standard aircraft modified as staff administrative transports

U--To be used with aircraft which are not considered to be entirely suitable to perform their design missions (Example: UC-45)

Y--To be used for aircraft undergoing service testing Example: YF-101)

Z--Indicates obsolete aircraft of which no further procurement will be made

C. United States Air Force numeral and suffix designation

1. Numeral designation appears after the basic letter designation

2. Numeral designation refers to the number of that particular

class of aircraft that has been designed and planned for Air Force use. Not all numbers appear in Air Force planes because some designs have not met Air Force specifications and/or approval.

a. Examples of numberal designation

(1) B-29

(2) B-52

(3) F-94

(4) C-119

3. Suffix designation
(Alphabetical letter after the numerical designation indicates a model change or modification.)

III. United States Naval aircraft designations

A. Class designation

1. Fixed wing

Designation	Class
VA	Attack
VF	Fighter
VF (M)	Fighter, two-engine
VFB	Fighter bomber
VSB	Scout bomber
VTB	Torpedo bomber
VOS	Observation scout
VPB (M)	Patrol bomber, two-engine
VPB (H)	Patrol bomber, four-engine
VR (H)	Transport, four-engine
VR (M)	Transport, two-engine
VJ	Utility, single-engine
VJ (M)	Utility, two-engine
VSN	Trainer
VSN (M)	Trainer, two-engine
VLR	Transport glider
VLN	Training glider

2. Rotary wing

HT	Training helicopter
HR	Transport helicopter
HU	Utility helicopter
HO	Observation helicopter

3. Lighter than air

ZP	Training airship, nonrigid
ZT	Patrol airship, nonrigid
ZT	Free balloon
ZK	Barrage balloon

B. Manufacturer's designation

Identification	Manufacturer
B	Boeing Aircraft Company
C	Curtiss-Wright Corporation
D	Douglas Aircraft Company
E	Edo Aircraft Corporation
F	Grumman Aircraft Engineering Company
H	McDonnell Aircraft Corporation
J	North American Aviation, Inc.
M	Glenn L. Martin Company
N	Naval Aircraft Factory
O	Lockheed Aircraft Corp. (Factory "B")
Q	Fairchild Engine & Airplane Corp.
R	Ryan Aeronautical Company
U	Chance Vought Aircraft
V	Lockheed Aircraft Corp. (Factory "A")
Y	Consolidated-Vultee Aircraft Corp.
L	Bell Aircraft Corporation
P	Piasecki Helicopter Corporation
S	Sikorsky Aircraft Division (United Aircraft)

C. Suffix letter designation

Suffix	Purpose
A	Amphibian
B	Special armament
C	Carrier version of a non-carrier type
D	Drone
E	Special electronic test
G	Search and rescue
H	Hospital
J	Tow target
K	Target drone
L	Searchlight plane
M	Weather reconnaissance
N	Night operation
P	Photographic
Q	Countermeasure
R	Transport version of non-transport type
S	Anti-submarine
T	Training version of non-training type
U	Utility
W	Special search
Z	Administrative flying

Things to do:

1. Collect a series of photographs of all types of aircraft for classroom display.

2. Classify all the above aircraft into groups as presented in this lesson outline.

3. Attach a legend to each photograph.

4. Identify and classify any aircraft you see in flight.

5. Visit an air terminal and determine types and designations of aircraft seen.

Films:

"Achievement in the Air" (16 mm. sound, 11 minutes. Depicts the latest British aircraft developments, both military and civilian, displayed at the Farnborough Air Show.) Loan by CAA

"The Guardian Angel" (16 mm. sound, 13 minutes. Depicts the great variety of uses to which the helicopter is being put in Korea--new tasks are found for it almost daily.)

"Sky Giant" (16 mm. sound, 9 minutes. Shows the building, testing, and flying of the Avro Lancaster Loan by CAA)

KNOW YOUR AIRPLANE

Section IV. Aircraft Identification in Flight

Text references: Aviation Study Manual, Unit 2, pp. 18, 19
Aircraft Recognition for the Ground Observer

I. Basic identifying view

A. Side view

1. Shows fuselage shape

2. Shows vertical stabilizer and rudder shape

B. Front view

1. Shows the number, position and character of the wings

2. Shows the number, position, and type of the engines

a. Radial--air-cooled

b. In-line

c. Jet

3. Shows the type of tail

4. Shows the number and position of the vertical fins

C. Plan view

1. Shows the shape of the fuselage

2. Shows the shape of the horizontal stabilizer

3. Shows the shape of the wings

a. Straight

b. Single taper

c. Double taper

d. Sweptback

e. Delta wing

4. Shows the shape of the wing tip

   a. Round

   b. Square

   c. Straight

II. Basic identifying sounds

   A. Reciprocating engines with propeller

   B. Gas turbine engine with propeller

   C. Gas turbine engine without propeller

      1. Jet engines

      2. Jet engines with afterburner

<u>Things to do</u>:

1. Obtain for the class a set of wall chart type identification posters from the U. S. Air Force.

2. Invite a speaker from the U. S. Air Force Ground Observer Corps to address your school.

3. Organize a Ground Observer group.

4. Have a contest and give a prize for the greatest number of logged aircraft identification in a 24-hour period.

<u>Films</u>:

"Air Defense" (16 mm. sound, 27 minutes. Shows the vital role played by volunteers of the ground Observer Corps who work together with the U. S. Air Force Air Defense Command to defend our nation against sudden destruction from the air. Loan by CAA)

"Strategic Air Power" (16 mm. sound, 25 minutes. Dramatic documentary presenting the mission of the Strategic Air Command and explaining the role played by the men and planes of SAC in carrying out that mission. Highlighted in the film is a B-36D training flight. Loan by CAA)

UNIT III

THEORY OF FLIGHT

Introduction

This unit of study presents to the student the facts underlying the flight of a heavier-than-air aircraft. "Why an airplane flies" is one of the main points that must be covered in a course in Aviation Education.

By careful organizing of the classroom demonstrations, this unit of study can be made very effective and interesting. The teacher should make use of as many teaching aids as possible to present the scientific principles of airflow and Bernoulli's theory. The success or failure of this unit is dependent on the presentation of these principles.

Books

The following books are recommended for this unit of study: (See bibliography)

Basic Aeronautics, M. E. Tower

A Student Guide for Aeronautics, M. E. Tower

A Student Handbook for use in The Theory of Flight Kit, M. E. Tower

Aviation Study Manual, Volume 1, Book II, Civil Air Patrol

Civil Pilot Training Manual, Bulletin #23, Civil Aeronautics Administration

Pilots Airplane Manual, N. O. Anderson

Aerodynamics for Pilots, Bradly Jones

Equipment

It is recommended that a classroom demonstration unit be obtained to aid in presenting this unit. Such a demonstration unit is the "Theory of Flight Kit" (available from Ero Publishers, Inc.)

THEORY OF FLIGHT

Section I. The Airplane Wing and Airfoil

Text references: Aviation Study Manual, Unit 2, p. 11; Unit 3, pp. 1-4
Basic Aeronautics, Chapter 1
Civil Pilot Training Manual, pp. 1-5

I. Airplane wing

A. The wing supports the airplane in flight.

B. Sufficient wing area must be present to lift the airplane and load at the desired speed.

1. The greater the wing area the greater will be the lifting ability.

2. The greater the speed the greater will be the lifting ability.

C. Airplane wing strength

1. The wing must be strong enough to withstand six times the weight of the aircraft.

2. The wing must be light in weight.

II. The airfoil section

A. The wing is a long airfoil.

B. A cross section of a wing is the airfoil shape, or section.

C. The shape of the airfoil determines its lifting ability at a given speed.

D. Hundreds of different shapes have been designed.

E. The National Advisory Committee for Aeronautics has catalogued, designed, and tested hundreds of airfoils in a wind tunnel.

F. Airfoil nomenclature

1. Leading edge

2. Trailing edge

3. Airfoil thickness

4. Upper camber

5. Lower camber

6. Chord line

7. Chord distance

III. Forces acting on an airplane

A. Lift
(Produced by the wings)

B. Drag
(Caused by air resistance on all parts of the plane)

C. Thrust
(The forward motion of the aircraft produced by the propeller.)

D. Gravity
(The earth's pull on the airplane; closely associated with weight)

Things to do:

1. Draw a large airfoil on the blackboard and label all parts.

2. Explain direction of lift, drag, thrust, and gravity forces.

3. Have several students in the industrial arts class construct different shapes of airfoils.

4. Test the airfoils as explained at the end of Section III.

Films:

"Airplane Structures--Wing Construction" (16 mm. sound, 10 minutes. Construction and functions of wings are shown. Forces of thrust and drag and utilization of interior bracing and skin bracing to withstand them are shown and defined. Loan by CAA)

THEORY OF FLIGHT

Section II. How the Airfoil Produces Lift

Text references: Aviation Study Manual, Unit 3, pp. 4,5
Basic Aeronautics, Chapter 1

I. Airflow around an airfoil

A. Meets and passes same quantity of air above and below the wing

B. Leading edge separates or divides the air

C. Air flowing across the top camber moves very fast.

D. Air flowing across lower camber moves slower.

E. Air reunites at trailing edge of wing.

II. Bernoulli's theorem

A. A theory of fluid flow which states that fluid pressure is inversely proportional to its velocity squared; that is, increase the speed of a fluid in a tube and the pressure decreases, or decrease the speed and the pressure increases.

B. Airflow is identical to fluid flow and is treated the same as fluid flow.

III. Airfoil lifting action

A. Airfoil is a streamlined device

1. Distance is greater from leading edge across the top camber to the trailing edge than the distance across the lower camber to the trailing edge.

2. The velocity (speed) of the air across the top of the wing is greater than across the bottom.

3. A low-pressure area exists on top of the wing because of this high speed air flow. (Application of Bernoulli's theorem)

4. The airfoil deflects some air downward, thus resulting in a lifting action.

B. Areas of lifting action

1. Area above the airfoil is a low pressure area.

2. Area below the airfoil is a high pressure area.

3. The greater the difference in pressure between these two areas the greater will be the lifting action.

4. Lift is measured in pounds per square foot of wing area.

Things to do:

From the Student Handbook for use in the Theory of Flight Kit and with the aid of the "Theory of Flight Kit", perform the following experiments:

1. Steam tube--Bernoulli's Principle, p. 14

2. Flight principles, p. 15

3. Bernoulli's Principle--misc. examples, p. 16

Films:

"Aerodynamics--Air Flow" (16 mm. sound, 18 minutes. Explains turbulence and skin friction through the flow of smoke over various solid shapes and forms. Also explains and defines the angle of attack, point of stall, drag, and lift through the use of smoke streams. Loan by CAA)

"Aerodynamics--Properties of Air" (16 mm. sound, 8 minutes. This film is divided into two parts. The first one demonstrates that air possesses sufficient mass to support certain objects. The second part consists of demonstrations of weight of air. Loan by CAA)

THEORY OF FLIGHT

Section III. Factors Effecting Lifting Action

Text references: Aviation Study Manual, Unit 3, pp. 4-9
Basic Aeronautics, Chapter 1
Civil Pilot Training Manual, pp. 8-12

I. Aerodynamic factors

A. Speed of the air across the airfoil

1. As the speed increases the lift increases.

2. As the speed decreases the lift decreases, and insufficient lift will cause the airplane to decrease in altitude. Gravity is then the greater force.

3. The lift increases as the square of the speed. (An airplane traveling 100 miles per hour produces four times as much lift as one traveling 50 miles per hour.)

4. Water skiing or surf board riding behind a boat furnishes a good example.

B. Density of the air

1. Lift varies directly with density.

2. The denser the air the greater will be the lift.

3. Because of denser air, the closer to sea level an airplane operates the greater will be the lift per square foot of wing area.

4. The higher an airplane flies the less the lift will become unless the speed is increased.

5. See Section IV, "The Significance of Atmospheric Pressure", Meteorology unit

C. Shape of the airfoil

1. The greater the airfoil camber, up to certain point, the greater the lift.

2. As the camber increases the drag also increases.

3. The hundreds of different airfoil shapes each produces a different amount of lift.

4. Airfoils must be clean and smooth for greatest lift.

D. Angle of attack of the airfoil

1. Angle of attack is the angle formed between the chord line of the airfoil and the relative wind.

2. As the angle of attack increases the lift increases.

3. As the angle of attack increases the impact air pressure increases on the bottom of the wing.

   a. 5 degrees = 25 percent of lift

   b. 10 degrees = 30 percent of lift

4. Center of pressure
   (The point of intersection of lifting action line with the airfoil chord line)

5. As the angle of attack increases the airplane will climb, or be able to lift a larger load.

E. Wing area

1. The lift varies directly with the total area.

2. The greater the total area of the wing the greater will be the lifting ability of the airplane.

F. Plan form of the wing

1. A long narrow wing produces more lift per square foot of area than a short wide wing.

2. The vortex is less on a narrow wing, resulting in:

   a. Less drag

   b. Less wing-tip loss

3. Aspect ratio

   a. Total length of wing divided by the average chord

   b. The higher the aspect ratio the more efficient the wing.

II. Mechanical factors which affect lift

A. Wing flaps

1. A mechanical device used to increase the camber of the airfoil while in flight, thereby increasing the lift

2. Drag increases as the flaps are lowered.

3. Types of flaps

   a. Simple flap
      (Lift is increased 51%.)

   b. Slotted flap
      (Lift is increased 53%.)

   c. Split flap
      (Lift is increased 70%.)

   d. Zap flap
      (Lift is increased 85%.)

   e. Fowler flap
      (Lift is increased 90%.)

4. Advantages of flaps

   a. Greater lift permits a lower landing speed.

   b. Airbrake action shortens landing roll.

   c. Steeper glide angle is possible without increasing speed.

   d. They prevent a tapered wing from stalling at tip first.

5. Disadvantages of flaps

   a. The pilot must know the results of sudden flap operation.

   b. More weight is added.

   c. They are not automatic.

   d. They increase hazards during cross-wind landings.

B. Slots

1. Located along the leading edge, toward the outer ends of the wings

2. A small effective airfoil separated from the main airfoil

3. The air flow created causes the air flow across the main wing to follow more closely the airfoil as stalling speed is approached.

4. Advantages of slots

   a. They give better lateral control at low landing speeds

   b. They reduce the length of the landing roll because of slower landing speed.

c. They reduce the take-off run.

d. They help prevent low-speed spins .

5. Slots are not used on most planes because of the disadvantage of drag increase.

III. Computation of lift problems

A. Total airfoil lift

1. Total airfoil lift in pounds is equal to the coefficient of lift (taken from a characteristics table) times one-half the density of the air (in slugs) times the square-foot area of the wing times the velocity squared. Velocity must be in feet per second.

$$\text{Lift} = C_L \,.\, \frac{d}{2} \,.\, S \,.\, V^2$$

C_L depends upon the angle of attack.

<u>Things to do</u>:

1. From the <u>Student Handbook for use in the Study of Theory of</u> Flight Kit, and with the aid of the <u>Theory of Flight Kit</u>, perform the following experiments:

   a. Lift--top of wing, p. 17

   b. Lift--bottom of wing, p. 18

   c. Total lift, p. 19

2. From the above book work the problems on pages 25-27.

<u>Films</u>:

"How an Airplane Flies--Lift" (16 mm. sound, 12 minutes. Explains that the action of air passing over a wing section is an extension of the principle of the Venturi tube. It shows how the changes in air pressure upon the upper and lower surfaces of the wing create the upward force which keeps the airplane in the air. It also demonstrates the relation of the angle of the wing to the amount of lift obtained. Loan by CAA)

"Air in Action (16 mm. sound, 10 minutes. Demonstrates the science of aerodynamics by explaining simple parlor tricks in terms of scientific knowledge and application of that knowledge to everyday living. Air resistance is analized, and applications to common experiences are explained. An interesting sequence, filmed in the giant wind tunnel of the Army Air Forces at Wright Field, shows air currents around a model, the breaking up of the stream lines behind the model, and the development of the most efficient aerodynamic shape. Loan by CAA)

THEORY OF FLIGHT

Section IV. Airplane Drag

Text references: Aviation Study Manual, Unit 3, pp. 9-11
Basic Aeronautics, Chapter 11
Civil Pilot Training Manual, pp. 17-20

I. Definition of drag

A. The resistance offered by the air to the movement of an airfoil or object through the air

B. The resistance offered by the air to a flying airplane

C. Drag increases with an increase of air density.

II. Types of airplane drag

A. Induced drag

1. Drag caused by the lifting action of the wings

2. Much smaller force than lift

3. Cannot be eliminated

B. Profile drag
(Caused by the shape of the airfoil and the skin friction of the airfoil)

C. Skin friction drag
(Caused by the air sliding along the surface of the wing or plane)

D. Parasite drag
(The resistance of airflow upon all surfaces which do not contribute to lift)

1. Can be reduced by streamlining

2. Examples of units causing parasite drag:

a. Landing gear

b. Tail wheel

c. Wing struts

d. Antenna mast

e. Air scoop

f. Flying wires on a biplane

III. Streamlining

A. The shaping of an object so as to reduce the drag

1. A round object produces 16 times as much drag as a streamlined object.

2. All external bracing and equipment on an airplane is streamlined.

B. Necessity of reducing drag

1. To increase air speed

2. To increase resulting lift

IV. Computation of drag problems

A. Wing drag

1. The airfoil drag force is equal to the drag coefficient obtained from a characteristic curve times one half of the air density times the wing area in square feet times the velocity squared. The velocity must be in feet per second.

$$Drag_{wing} = C_d \cdot \frac{d}{2} \cdot S \cdot V^2$$

(d must be in slugs per cubic foot.)
The resulting answer is in pounds.

B. Parasite drag

1. Parasite drag in pounds is equal to one half the density of the air times the flat plate area of the plane times the velocity square times a constant 1.28.

$$Drag_{para} = 1.28 \cdot \frac{d}{2} \cdot S \cdot V^2$$

(d must be in slugs per cubic foot.)

<u>Things to do</u>:

1. From the <u>Student Handbook for use with the Theory of Flight Kit</u> and with the aid of the <u>Theory of Flight Kit</u>, perform the following experiments:

    a. Streamlines, page 11

    b. Streamlining, page 12

2. Solve the problems on pages 28-31 of the above book.

<u>Films</u>:

"How an Airplane Flies--Drag" (16 mm. sound, 14 minutes. Deals with the resistance of the air to the forward movement of the airplane and shows that streamlining and a small frontal area will minimize "parasite drag" and that a long narrow wing will cut down "induced drag." "Skin friction" is also effectively demonstrated. Loan by CAA)

"Air Currents and How They Behave" (16 mm. sound, 10 minutes. This film shows, through the use of a smoke chamber, how air currents react to different shaped objects, what keeps a plane flying, and what happens when it is tilted too sharply. Loan by Washington office, CAA)

THEORY OF FLIGHT

Section V. Thrust and Torque

Text references: Aviation Study Manual, Unit 3, pp. 12-16
Basic Aeronautics, Chapter 2
Civil Pilot Training Manual, pp. 17-18

I. Propeller thrust

A. Thrust required to move an airplane forward (Thrust must be greater than drag.)

B. Propeller is a rotating airfoil

1. A high-pressure area exists on the airplane side of the propeller.

2. A low-pressure area exists in front of the propeller.

C. The thrust varies with the speed of the propeller.

1. High speed is used for take-off.

2. The propeller loses efficiency if the rotating speed becomes too great.

D. A large and more powerful engine requires a longer propeller to absorb the horsepower and to produce thrust.

II. Computing a horsepower-required problem

$$\text{Horsepower required} = \frac{\text{total drag} \,.\, V \text{ (in miles per hour)}}{375}$$

III. Torque

A. Definition of torque

1. Torque is the opposite force created by the propeller and engine crankshaft turning to the right or left, as the case may be.

2. This force best is understood by explaining Newton's Law of Motion.

3. It can also be explained by considering the air as a restraining device upon the propeller.

B. Effect of torque

1. It causes the airplane to turn toward the left as soon as the tail is lifted.

2. It causes the airplane to tend to roll about its longitudinal axis.

C. How torque is corrected

1. The pilot applies corrections for take-off and landing.

2. Angle of attack on left wing is increased.

3. Angle of attack on right wing is decreased.

D. Flight attitudes with greatest torque

1. Take-off

2. High-power climb

3. Corrected by applying opposite rudder

Things to do:

1. To demonstrate thrust, place an electric fan on a small piece of board equipped with wheels. Turn on the fan and note the movement.

2. Discuss air boat propulsion.

3. Discuss aircraft thrust.

   a. Tractor thrust

   b. Pusher thrust

4. From the Student Handbook for use with the Theory of Flight Kit, solve problems on "thrust", pp. 32, 33.

Films:

"How an Airplane Flies--Thrust" (16 mm. sound, 5 minutes. Thrust is the force which acts on an airplane and moves it forward. This film illustrates the reaction principle from which this force is derived and shows how it is applied to the airplane. Loan by CAA)

"Airscrew" (16 mm. sound, 22 minutes. This film explains the manufacture of airplane propellers. Shows various tests for proving strength of the metal; shaping in machine shop; treating blades, installation on plane. The principle of the propeller is explained by animated diagrams. Loan by CAA)

THEORY OF FLIGHT

Section VI. Gravity

Text references: Aviation Study Manual, Unit 3, pp. 17, 18
Aerodynamics for Pilots, pp. 136-138

I. Definition of gravity

A. Gravity is the pull of the earth upon the airplane.

B. Gravity is exactly opposite to lift.

C. Lift must equal gravitational pull (weight), or the airplane will not fly.

D. If the lift is greater than the gravity, the airplane starts to climb.

E. If the gravity is greater than the lift, the airplane descends or loses altitude.

II. Airplane center of gravity

A. The airplane's center of gravity must be located from 25 to 33 1/3 percent of chord distance back from the leading edge of the wing.

B. The airplane must be properly loaded.

C. All four forces must act through the center of gravity.

1. Lift

2. Drag

3. Gravity

4. Thrust

Films:

"How an Airplane Flies--Part IV--Forces in Balance" (16 mm. sound, 8 minutes. This film deals with the relationship between the forces of Lift, Drag, Thrust, and Weight which act on an airplane in flight. It shows how balanced forces acting in the right places are necessary in order to fly at constant speed, straight and level, and how equilibrium is maintained in a gliding attitude. Loan by CAA)

THEORY OF FLIGHT

Section VII. Airplane Stability

Text reference: Aviation Study Manual, Unit 3, pp. 19-24
Basic Aeronautics, Chapter VIII
Civil Pilot Training Manual, pp. 35-45

I. Kinds of stability

A. Positive stability

1. Static stability--the tendency to return to original position after a maneuver

2. Dynamic stability--the tendency to dampen or decrease oscillations

B. Neutral stability
(No restoring forces present)

C. Negative stability
(The forces present tend to force the body away from its original state.)

II. The axis of rotation of an airplane

A. Longitudinal axis
(Passes from nose to tail)

B. Lateral axis
(Passes from wing tip to wing tip)

C. Vertical axis
(Passes vertically through center of gravity)

III. Airplane stability around the axis

A. Longitudinal stability

1. The most important stability

2. The airplane is balanced in the nose-heavy condition to obtain longitudinal stability.

3. Longitudinal stability is desired to eliminate phuboid oscillations or tendency to pitch around the lateral axis.

4. An airplane that is unstable longitudinally will constantly hunt up and down and requires constant pilot attention.

B. Lateral stability

1. Defined as stability around the longitudinal axis

2. Lateral instability causes the wings to rock or roll around the thrust line.

3. Four factors determine lateral stability

   a. Dihedral angle of wings

   b. Keel effect of side of airplane

   c. Sweepback of wings

   d. Distribution of weight

C. Directional stability

1. Tends to keep the airplane flying in a straight direction

2. Obtained by having a sufficiently large vertical fin area on the tail and sweptback wings

3. Action like that of a weathervane

4. Directional stability is around the vertical axis.

5. A directionally unstable airplane wanders all over the sky and is usually not dangerous but very annoying.

Things to do:

1. Perform stability experiment as shown in Student Handbook for use with the Theory of Flight Kit, pp. 21-24

Films:

"How an Airplane Flies--Part V--Stability" (16 mm. sound, 10 min. An airplane in flight can be unstable, neutrally stable or stable. An airplane should tend to return to normal flight if it is pitched, rolled or yawed. This film shows how complete stability is achieved. Loan by CAA)

"The Story of the Flying Wing" (16 mm. sound, 23 minutes. Describes the structural and operational characteristics of the Northrop Flying Wing. The emphasis throughout the film is directed toward explaining how the Flying Wing achieves maximum efficiency of design, structure, maintenance and operation. Loan by CAA)

THEORY OF FLIGHT

Section VIII. Load Factors

Text references: Aviation Study Manual, Unit 3, pp. 24-29
Civil Pilot Training Manual, pp. 311-320

I. Wing loads

A. In straight and level flight the wing load equals the weight of the airplane.

B. The load will increase when the plane is in a turn.

C. Wing load will increase when changing from straight and level flight to a climb.

D. No additional wing load is applied in the climb.

E. Wing loads multiply several times during a "pull out."

F. Light plane wings are designed for a wing load of six times the weight of the airplane before disintegrating in flight.

II. Load factors
(The ratio between the total air load on the wing and the weight of the airplane)

A. When wing lift is twice the weight of the airplane, the load factor is two.

B. This factor is sometimes expresssed in "g" units, which is the ratio of a given weight to the pull of gravity.

III. How load factors are increased

A. By the airplane in a turn

B. By the airplane's suddenly changing flight attitude

1. An abrupt "pull-out" will impose a wing load which increases as the square of the speed at the time of pull-out.

2. A sudden change to a climb attitude will impose a great load.

C. Excessive loads can be imposed in gusty air.

1. Gusty air has the same effect as a sudden pull-up.

2. The angle of attack is increased, creating an abrupt lift.

IV. Rules for flying in gusty air

A. Retard the throttle and slow down.

B. Avoid sudden turns, climbs or maneuvers.

C. Remember, excessive loads can tear off the wings.

Things to do:

1. Build a model airplane and test the wing strength. Determine the proof load as described on page 14 of Pilot's Airplane Manual, Civil Aeronautics Bulletin #27.

2. Write several airplane manufacturing concerns and ask for the design load of the wing.

3. Compute the wing load, in pounds per square foot, of a modern light plane.

Films:

"Aerodynamics--Forces Acting on an Airfoil" (16 mm. sound, 27 minutes. The forces of air as they relate to aircraft structures are studied in this film. Topics treated are lift, drag, angle of attack and wing chord. A sequence is included on the development and use of wind tunnels to measure the various forces on a wing form. From a discussion and explanation of this activity arises the relationship between lift, drag, wing area, wind velocity, thrust and weight. Loan by CAA)

THEORY OF FLIGHT

Section IX. Airplane Control Surfaces and Their Effect

Text references: Aviation Study Manual, Unit 3, pp. 30-37
Basic Aeronautics, Chapter VII
Pilot's Airplane Manual, pp. 107-112

I. The ailerons

A. Located at trailing edge of each wing, out toward the wing tip

B. They constitute a small movable airfoil

C. The ailerons are operated by movement of the control stick to the right or left, or by turning the control wheel right or left.

1. When the control stick moves right, the right aileron moves up and the left aileron moves down. The airplane's right wing is forced down and the left wing is forced up.

2. When the control stick is moved left, the left aileron moves up and the right aileron moves down. The airplane's left wing is forced down and the right wing is forced up.

3. When the control stick is in neutral (center) position, the ailerons assume a newtral position, which is in line with the trailing edge of the wing.

D. The ailerons thereby control the airplane around its longitudinal axis.

II. The rudder

A. Located on the tail section immediately behind the vertical fin

B. It constitutes a rather large movable surface moving into the slipstream to the right or left.

C. The rudder is controlled by movement of two rudder pedals in the cockpit, operated by the pilot's feet.

1. When the right rudder pedal is pushed, the rudder moves to the right. The tail is thus forced to the left, which turns the nose of the airplane to the right.

2. When the left rudder pedal is pushed, the rudder moves to the left; the tail is thus forced to the right, which turns the nose of the airplane to the left.

3. When the rudder pedals are "even", the rudder is in a neutral position directly in line with the vertical fin.

D. The rudder thereby controls the airplane around the vertical axis.

III. The elevators

A. Located on the tail section immediately behind the horizontal stabilizers.

B. They constitute two large movable surfaces, one on each side of the rudder, moving in an up-and-down position.

C. The elevators are controlled by movement of the stick or control column to the front and to the rear.

1. When the control is pushed forward, the elevators move downward. This forces the tail of the airplane upward and the nose of the airplane downward. This results in a dive or glide.

2. When the control stick is pulled back to the rear, the elevators move upward. This forces the tail of the airplane downward and the nose upward. This results in a climb, if sufficient power is available.

3. When the control stick is in neutral, or center, position, the elevators assume a center position in line with the horizontal stabilizers.

D. The elevators thereby control the airplane around its lateral axis.

Things to do:

1. Visit an airport and arrange to have someone demonstrate the control surfaces of an airplane.

2. During your first orientation flight, have the pilot demonstrate the effect of the controls.

3. Construct a solid model airplane with movable control surfaces for use in the classroom.

Films:

"How an Airplane Flies--Part VI--Controls" (16 mm. sound, 9 min. Shows how we can use controls to modify straight and level flying and go where we want. It explains how an airplane is pitched up or down by using the elevators. It then shows how rolling and banking are achieved by ailerons, and how the use of the rudder in combination with the other controls makes efficient turning possible. Loan by CAA)

THEORY OF FLIGHT

Section X. Flying the Airplane

Text references: Aviation Study Manual, Unit 3, pp. 30-37
Basic Aeronautics, pp. 51-54
Fundamentals of Basic Flight Maneuvers
Civil Pilot Training Manual, pp. 114-197

I. Four basic flight maneuvers

A. Straight and level flight
(Maintaining a constant altitude, turning neither right nor left)

B. Climbs
(Increasing altitude)

1. Comparable to going uphill in a car

2. Airplane speed decreases.

C. Glides
(Decreasing altitude)

1. Comparable to going downhill in a car

2. Airplane speed increases

D. Turns

1. Turning to the right or left in a coordinated manner

II. How the basic flight maneuvers are made

A. Straight and level flight

1. All controls in center, or neutral, position

2. Sufficient power from the engine to provide the necessary lift--no more

B. Climbs

1. Increase the throttle setting to increase the horsepower.

2. The plane will climb without moving the controls.

3. If a steeper climb is needed, pull back on the stick. This will force the tail down and the nose up. The airspeed will decrease rapidly. A stall will occur if the airspeed drops below a point where sufficient lift is produced.

4. The airspeed is therefore controlled by the elevators.

5. The throttle controls the losing or gaining of altitude.

C. Glides

1. A glide is the result of insufficient lift.

2. To start a glide, simply retard the throttle, which reduces engine power. The airplane slows slightly and lift decreases.

D. Turns

1. All controls are used in a turn.

2. The <u>ailerons</u> start the turn by banking the wings.

   a. The aileron which is lowered increases the lift and also the drag of this wing. The wing moves up because of the added lift.

   b. The aileron which moves up decreases the lift and also the drag. This wing moves down.

   c. The airplane starts a slight turn.

3. Because the increased drag of the aileron on the "up" wing, the airplane has a tendency to "yaw" or twist sideways in a turn.

4. Rudder is applied to correct the yawing. This is the <u>only</u> use of the rudder in flight.

5. The elevators are applied a small amount to keep the nose of the airplane level and to maintain altitude.

6. More power is needed in a turn to maintain altitude because the lift of the wings is not straight up but in toward the center of the turn. Therefore the throttle is advanced.

7. The <u>elevators control the speed</u> of the airplane.

III. Other flight maneuvers

A. All other flight maneuvers are combinations of the above four basic attitudes.

B. Maneuver listing

1. Climbing turns

2. Gliding turns

3. Stalls

4. Take-offs

5. Landings

6. "S" turns

7. Spins

8. Steep turns

9. Series of "8's"

10. Slips

11. Immelmans

12. Many more
    (See Fundamentals of Elementary Flight Maneuvers. Civil Aeronautics Bulletin #32)

Films:

"Aerodynamics--Problems of Flight" (16 mm. sound, 11 minutes. Explains and illustrates major principles of flight maneuvers. Clearly demonstrates manipulation of plane's controls while taking off, climbing, banking, stalling, spinning, diving, gliding, and landing. Contrasts correct and incorrect techniques of various maneuvers with special emphasis on gliding and landing. Animated drawings superimposed over natural photography clarify explanation of forces acting upon plane during flight. Loan by CAA, Washington office)

"Advanced Maneuvers" (16 mm. sound, 10 minutes. The following maneuvers are illustrated: stalling, spinning, flying a steep turn, mushing, ground looping, spirals and acrobatics. Loan by CAA, Washington office)

"Airplanes and how they Fly" (16 mm. sound, 10 minutes. Offers an elementary explanation of lift and a brief discussion of the basic controls (rudder, elevators, ailerons) used to maneuver a plane in flight. Also presents examples of the range in types and sizes of planes. Loan by CAA)

"A Plane is Born" (16 mm. sound, 19 minutes. Depicts the cooperative effort of airplane manufacturers and the Civil Aeronautics Administration to assure safety of new types of aircraft. Follows the development of a new aircraft from early design stages to completion of the prototype. Includes scenes of some spectacular tests, such as catapulting of fuel tank, firing of bird carcass at windshield, engine fires. Loan by CAA)

"Safe Aircraft" (16 mm. sound, 24 minutes. Tells how CAA and the aviation industry work together for safety during the manufacture and maintenance of aircraft. It is a sequel to "A Plane is Born," (above), but is complete in itself, and will be enjoyable and educational without reference to the preceding film. Loan by CAA)

UNIT IV

AIRCRAFT MODEL BUILDING

Introduction

In order to conduct a successful unit of work in airplane model building, it will be necessary for the instructor to plan and prepare well in advance of the time the unit will be presented. By careful organization this unit of study will do much to make the Aviation Education course one of the most interesting and dynamic classes offered. Model building will provide a means of putting into practice most of the material covered in the "Theory of Flight" unit, and at the same time start many of the students in a hobby which will be educational and useful to them in future studies of science or engineering.

Many leading men and women in aviation, who are aeronautical design engineers, pilots, flight engineers, industrial executives and educators, started with model airplane building as a hobby in their youth. Many of this group are still active enthusiasts of this fascinating hobby.

Not only does the student benefit from an educational viewpoint, but also from working with other students and people who are interested in the same hobby. The value of learning to associate and work with other individuals and groups of individuals, or becoming a member of a group all working on the same model or model problem, cannot be measured by monetary methods, but will have a far reaching effect upon an individual during his adult like. Industrial executives and personnel directors have said that the ability to work with and get along with people and groups of people is the biggest need in today's daily living and working picture. A supervised class in airplane model building will afford the student the opportunity to develop this valuable attribute.

Other valuable things the student will learn are: (1) the use of a few hand tools, (2) how to read simple blueprints, (3) how to lay out dimensions and plans of a part, (4) how to shape the parts into usable components, (5) how to apply different finishes, (6) how to assemble parts in proper sequence, (7) how to adjust airfoils for better flight, (8) how to evaluate damage and make repairs, (9) how to choose equipment and materials, (10) how to coordinate his hands with the thinking ability of his brain. Many of these items may be called hidden values that are accomplished in attaining the final goal of the flying model.

The flight test of the completed model is the climax to all the work and planning; its success or failure usually depends upon the quality of the student's work and the accuracy of his pre-flight balancing and analysis.

Recommendations for this unit of study

Time of teaching. The writer recommends that this unit of study and activity be used immediately after the unit entitled "Theory of Flight." This will give the student the advantage of his study in simple aerodynamics and will enable him to apply this knowledge to a tangible product; thus, the lessons taught are more meaningful because he has learned by study and manupulative activity.

Method of teaching. Several formal class periods should precede the time of actual building activity. This is necessary to acquaint the student with the different types and classes of models. The majority of the students will be beginners and will need to be thoroughly informed about the models preferred for beginning students.

Several methods can be used for the activity periods:

1. A definite two- or three-week period can be set aside for model building, during which all models must be constructed.

2. Two or three days of building activity can follow each formal class lesson relating to model building.

3. The formal class lessons can be presented first, with one or two weeks of building activity followed by one activity period per week until all models are completed.

The method used will depend upon the instructor and the available facilities.

The sections in "Aircraft Model Building" are arranged to provide activity in applying the basic principles of flight as covered in the "Theory of Flight" unit. If model building is to be studied separately, the book <u>Aerodynamics for Model Airplanes</u> would be valuable.

<u>Obtaining the airplane model</u>

The students are expected to furnish their own model airplane materials. The advantage of buying a model kit cannot be overemphasized; not only does a kit provide all the necessary parts and diagrams for a particular model, but it also saves time in looking for supplies. The obtaining of models can better be controlled and expedited if the entire class orders in a group, particularly if the school is located away from the metropolitan centers.

<u>Sources of model kits and supplies</u>

Monogram Models Inc.
3421 West 48th Place
Chicago, 32, Illinois

Comet Model Hobbycraft, Inc.
501 West 35th Street
Chicago 16, Illinois

Junior Aeronautical Supply Co. (Exceptional for gliders)
203 East 15th Street
New York 3, N. Y.

Douglas Model Distributors
201 East 2nd South Street
Salt Lake City, Utah

Many local stores throughout the state carry model kits. It may save considerable time to determine whether such a store is nearby.

CAP Model Plane Kit

Civil Air Patrol, Inc. has officially adopted a model airplane kit designed to be used in conjunction with the cadet training program as outlined in CAP Training Manual 30-2. The model airplane kit consists of three basic elements: The first element is a glider; the second element is a simple rubber-powered solid flying model; the third element is a rubber-powered, built-up fuselage and wing flying model.

Each model airplane kit includes the three elements described above, along with a booklet on model airplane building tips as well as other necessary plans and materials. High schools interested in this kit can obtain full information from the Civil Air Patrol headquarters, Bolling Air Force Base, Washington, D. C.

Books and periodicals

The following books and periodicals on airplane model building and flying are recommended for this unit of study: (See Bibliography)

Aerodynamics for Model Airplanes, Donald K. Foote

Airplane Model Building, Gene Johnson

The Model Plane Manual, Walter A. Musciano

Building and Flying Scale Model Aircraft, Walter A. Musciano

Flying Models

Model Airplane News

Young Men

Tools required

Small group requirements. The following is a list of tools required for each five students in a beginning class of model building.

1. One tack hammer
2. One pair of diagonal cutting pliers
3. One pair of long-nose pliers
4. One pair of slip-joint pliers
5. One 4-inch adjustable crescent wrench
6. Two boxes of "Bankers straight pins"
7. One coping saw
8. Two small wood planes (modelers)
9. One pair of scissors
10. Two pin vises
11. One small round file
12. One small three-corner file
13. One small half-round file
14. Five razor blades
15. Three X-acto knives with interchangeable blades
16. One bench vise
17. One try-square
18. One wood 12" rule
19. One flexible steel tape
20. One soldering iron
21. Two screwdrivers--2" blade
22. Two screwdrivers--3", 4" blade
23. One small Phillips screwdriver
24. One or two small paint brushes

The following is a list of desirable tools and supplies which can be used by the entire class as a group.

1. One complete X-Acto "Hobby Chest" (This unit contains 49 tools, including some of the tools in the above list, all contained in a wooden case, approximately $30.00.)

2. Several pieces of 1-inch pine board cut to 12" x 30" size (These are used as construction bases for wings, fuselage, etc.)

3. Rather than buy paint spraying equipment, it is recommended that the new type pressure cans of paint or lacquer be purchased.

4. A supply of the following types of abrasive:

   Grade 100
   Grade 180
   Grade 220
   Grade 300
   Grade 400

5. One hand drill with a set of fractional drills from 1/16 to 1/ 4 inches

6. Suitable work tables will be necessary for this activity. (It would be ideal if model building could be coordinated and supervised by the industrial arts instructor and held in the industrial arts shop.)

AIRCRAFT MODEL BUILDING

Section I. Types of Model Aircraft

Text reference: The Model Plane Manual, pp. 15-28

I. Non-flying models

  A. Used for exhibition and display

  B. These are usually scale models of famous airplanes, either civilian or military type.

  C. Types of construction

    1. Solid wood models

    2. Plastic preformed models
       (This group of plastic models will not be suitable for this unit of instruction.)

    3. Built-up models

II. Free-flight flying models

  A. Gliders

    1. Hand launched

      a. Solid balsa wood construction

      b. This type requires tracing, cutting, carving, sanding, assembling, balancing and finishing.

      c. This model is inexpensive and if properly constructed will give long flights.

      d. Recommended for beginners

    2. Tow line gliders

      a. This type is a built-up framework with tissue covering.

      b. This model is placed in flight by towing at the end of a long string.

      c. This model will provide the same building activity as a powered model, with less expense.

      d. Recommended for beginners

B. Rubber powered model

a. This is a built-up framework of balsa wood with tissue covering (similar to tow-line glider).

b. Power is produced by the unwinding action of rubber bands.

c. This model must have a very strong fuselage in order to withstand the strong rubber bands used for power.

d. Very good model kits can be purchased for around $2.00.

C. Engine powered model

1. Power is produced by a small reciprocating engine

2. Plane is built-up framework.

3. Some models are radio controlled.

4. Recommended only for the advanced student

D. Jet engine powered model

1. Usually of solid construction

2. Power is supplied by pulse-jet engines which operate on gasoline.

3. Used on speed models

4. This type model is expensive to purchase.

5. Not recommended for beginners

E. Rocket powered model

1. Power is produced by small rocket engines that burn powder to produce thrust.

2. Plane can be solid balsa or built-up wings with solid balsa fuselage and tail group.

3. Rocket produces thrust for about 10 to 15 seconds.

4. Recommended for advanced workers if they can afford the rocket fuel

III. Control line operated plane

A. Sporting model--reciprocating engine

1. Not built as a scale model

2. Usually quite rugged

3. This type is not a stunting model.

4. A good plane for beginners in the powered field

B. Stunting model--reciprocating engine

1. This model must be light and strong.

2. Construction characteristics

a. Large wings and tail area

b. Short fuselage body

3. This type model is not recommended for beginners.

C. Speed model--reciprocating or jet engine

1. This model is and must be strong.

2. All are equipped with high-powered engines.

3. Most are equipped with small wings and long fuselage body.

4. Definitely not a beginner's airplane

D. Scale model--reciprocating or jet engine

1. This type model is an exact reproduction of a large airplane.

2. Scale model flying is the "ultimate" in model building.

3. This model should be attempted only by the very experienced builder.

Things to do:

1. Each student should study model catalogs or visit the nearest hobby store to start choosing a model plane.

Films:

"The Nationals" (16 mm. sound, color. Depicts the activities of The Nationals of Model Airplane Flying held at Olathe, Kansas and featuring the PAA-Load Event. Through closeups of the various planes entered in the meet, one gains a real appreciation of the craftsmanship and ingenuity that went into their construction. Scenes include take-offs and landings of model land planes, seaplanes, jets, and those which are radio-controlled. Loan by Washington office, CAA)

"Learning to Sail" (16 mm. sound, color, depicts the art of gliding. Rent from Pictosound Movie Service, 4010 Lindell Blvd. St. Louis 8, Mo.)

AIRCRAFT MODEL BUILDING

Section II. Wing Construction

Text reference: Airplane Model Building, pp. 48-63

I. Types of wing construction

A. Solid balsa wood wings

1. This type is used mostly on gliders.

2. The airfoil shape is carved and sanded from 1/4-inch thick balsa wood.

3. This is the easiest type wing to construct and is relatively strong.

B. Built-up wings

1. This type wing is used on powered airplanes and tow line gliders because of its very light weight.

2. A built-up wing is a slow process, but will result in a better performing airplane.

3. Many model kits have the wing spar and wing rib outlines stamped on the stock material. It is only necessary to cut them out.

4. Steps of wing construction

a. Cut out and sand the spar pieces.

b. Cut out and sand the ribs.

c. Cut out and sand the trailing edge.

d. Cut out and sand the leading edge strip.

e. Arrange spars, ribs and false ribs in order and start gluing them together. If the ribs are all of different size, be sure to arrange in the proper sequence.

f. Mount the wing on a construction base board with pins as you proceed. Be sure the ribs are square with the spars.

g. Install and glue the trailing edge.

h. Install and glue the leading edge.

i. Allow several hours drying time.

j. Sand the rough corners when dry.

k. Construct wing tip of balsa or bamboo.

l. Cover with Japanese tissue or silk span as recommended with the kit.

m. Finish by spraying with dope as required.

II. Shapes of wings

A. Straight wings
(No change in angularity in any direction)

B. Wings with dihedral

1. Construct wing as two separate panels and fasten together.

2. Follow step II B 2 above for the additional change of wing angle near the tip.

III. Types of wing mountings

A. Solid mount wing
(The wing is attached permanently to the fuselage section.)

B. Demountable wing
(The wing is fitted into place with two dowel rods for convenience in transporting the model.)

C. Flexible mounted wing
(The wing is held in place on the fuselage with a large rubber band and is used widely on gliders and rubber-powered models.)

Films:

"Youth Trains for Aviation" (16 mm. sound, 8 min. Shows how our airminded youth, through their activities in building and flying model airplanes, are learning the fundamental principles of flight; how their eager fertile brains are creating new types--new wings--even radio-controlled planes; that here is the great reservoir from which will come the hundreds of thousands of designers, pilots, mechanics, and aircraftsmen that will be needed for the protection of our country and the development of the vast opportunities of aviation's great future. Loan by CAA)

AIRCRAFT MODEL BUILDING

Section III. Fuselage Construction

Text reference: Airplane Model Building, pp. 35-48

I. Types of fuselage construction

A. Solid fuselage bodies

1. Carved from solid pine wood or balsa wood

2. Used on solid scale models

3. This type is also used, after they have been "hollowed out", in some high speed models.

B. Built-up fuselage bodies

1. This type fuselage is used on tow line gliders and many powered models.

2. Built-up fuselage is slow, but results in a very light and strong frame.

3. Many model kits have all the longerons and formers outlined on the stock material. It is only necessary to cut them out and sand lightly.

4. Strips, formers and stringers are assembled and glued together to form the desired shape.

II. Shapes of fuselage bodies

A. Square fuselage

1. This type is easiest to construct and is recommended for beginners.

2. Steps of procedure

a. Cut four longeron strips to size.

b. Cut eight to twelve brace strips to a length which will determine width of the fuselage.

c. Assemble and glue two side truss assemblies, and allow to dry.

d. Complete the fuselage by gluing cross members between the two side trusses.

e. Formers must be inserted and glued into place if required.

B. Other fuselage shapes
(The building of the following shaped fuselage is essentially a building up of balsa strips around the formers, which determine the final body design. Model kits that have this type of fuselage always have plans for tracing the former shape onto the stock material or have the outline of the formers stamped on the stock material.)

1. Round

2. Eliptical shape

3. Diamond shape

4. Hexagon shape

5. Octagon shape

III. Points of special consideration

A. Engine mount section

1. Stronger construction for mounting purposes

2. Special construction for fuel tank

B. Wing attachment points

1. Dowel pin plate for demountable wings must be installed if required.

2. Other type wing attachments require different consideration.

C. Tail attachment points

D. Landing gear attachment.

AIRCRAFT MODEL BUILDING

Section IV. Tail Group Construction

Text reference: Airplane Model Building, pp. 51-58

I. Horizontal stabilizer construction

   A. Solid type

      1. This type is used on speed models, stunt planes, and gliders

      2. A solid horizontal stabilizer is shaped from a solid piece of balsa wood.

   B. Built-up horizontal stabilizers

      1. Constructed the same as a built-up wing

      2. This type is necessary for models requiring light weight

         a. Gliders

         b. Rubber powered models

         c. Scale models

II. Vertical stabilizer construction

   A. Solid vertical stabilizers
      (See I A 1 above)

   B. Built-up vertical stabilizers
      (See I B above)

AIRCRAFT MODEL BUILDING

Section V. Airplane Model Covering

Text reference: Airplane Model Building, pp. 97-105

I. Types of covering

A. Microfilm covering

1. This covering is made by pouring a small amount of the solution in a small pan of water; after the jelling process has occurred the solution is lifted out with a wire frame and allowed to dry.

2. This covering is very sensitive and is used only for indoor models.

B. Paper and cloth covering

1. Japanese tissue
(This covering must be used on small fragile models, for it does not shrink sufficiently to cause warpage.)

2. Bamboo paper
(Used only on large models)

3. Silk cloth covering
(Has considerable shrinkage and is used only on husky models)

4. Silkspan cloth
(Same precautions as silk; a very strong covering)

II. Covering techniques

A. Fuselage

1. Cut material in long narrow strips sufficient to lap over the desired area 1/4 inch.

2. Apply to fuselage with dope, keep taught enough to prevent wrinkles.

3. Trim all edges with a razor blade.

4. Apply a second coat of dope to the edges to insure a neat job.

B. Wings

1. Cover one wing panel at a time, bottom first.

2. Apply a coat of dope to the leading and trailing edge.

3. Apply tissue to the leading edge first, spread and apply across the bottom, to the trailing edge. Cover the top of the wing, ending at the top leading edge.

4. It will be necessary to dope each rib and press covering into place as the job progresses.

5. Cut covering to 1/4-inch overlap size and shape for wing tips; this will prevent wrinkling.

C. Water spraying

1. All covered surfaces should receive a very fine mist water spray. This allows the covering to stretch and form a smooth, even contour surface.

2. Pin the wings and tail group down to the construction base board during this process to prevent warping.

3. Hang the fuselage by a string from the propeller end to fascilitate the spraying process.

4. Allow to dry thoroughly.

AIRCRAFT MODEL BUILDING

Section VI. Finishing the Model

Text reference: Airplane Model Building, pp. 107-110

I. Finishing with dope

A. General requirements

1. Ideal room temperature, 60 to 80 degrees

2. Low humidity

3. Room free from dust

4. Model to be sprayed must be thoroughly dry.

B. Application

1. Thin the first coat with one part thinner to three parts dope.

2. Apply the first coat with a brush.

3. When dry sand with #7/0 or #340 sandpaper.

4. Additional coats should be sprayed on, if possible.

5. Sand lightly between each coat.

II. Finishing outdoor models

A. A minimum of seven coats of dope

B. Sand between each coat and rub with rotten stone or very fine rubbing compound for smooth final finish.

C. Wax and polish.

III. Finishing indoor flight models

A. Maximum of two coats of dope

B. Sand very lightly.

C. Wax and polish.

IV. Finishing of scale models

A. Flying models

1. Finish consists of 15 to 18 coats of dope.

2. Clear uncolored dope should be used for all except the final two coats, which will be the color coats.

3. Sand lightly between each coat of the first eight coats.

4. Rub with rotten stone after the final coat is dry.

5. Wax and polish to a high lustre.

B. Non-flying models

1. This group is judged solely upon accuracy and finish.

2. Use dope or clear lacquer as a base or primer coat.

3. Finish coats can be dope or enamel.

4. Caution: Do not use lacquer or dope as a finish coat if the first or primer coat is enamel or an oil base paint. This will result in severe cracking and blistering. Always use dope or lacquer for a primer coat.

5. If the model has external struts, skiis, or pontoons, assemble the plane after it has been painted.

6. Decalcomania type insignia should be applied for a neat and trim job.

AIRCRAFT MODEL BUILDING

Section VII. Model Contests

Text references: Official Rules of the Academy of Model Aeronautics
Pan American Airways Load Event. Rules and Specifications

I. Places of contests

- A. Most major cities of the U. S.
  (Academy of Model Aeronautics will furnish list of all model contests.)
- B. Many Air Force bases
  1. Sponsored by Naval Air Arm or U. S. Air Force
  2. Usually a national contest
- C. Foreign cities
  1. International contests
  2. Team entries
  3. Individual entries

II. Types of contests

- A. Gliders
  1. Hand launched
     - a. Indoor flights
     - b. Outdoor flights
  2. Tow line launched
- B. Free flight
  1. Rubber powered models
     - a. Indoor flights
     - b. Outdoor flights
     - c. Load or cargo carrying flights

2. Reciprocating engine powered

    a. Engine power class

        (1) Class A--up to .20 cubic inches displacement

        (2) Class B--up to .30 cubic inches displacement

        (3) Class C--.30 to 1.25 cubic inches displacement

    b. Flying non-scale models

    c. Flying scale models

    d. Load and cargo carrying models

    e. Radio controlled models

C. Control-line flying

    1. Control-line precision or stunt model

    2. Control-line flying scale model

    3. Control-line speed model

Films:

"From Little Wings" (16 mm. sound, color, 13 min. A picture of the National contest at Los Alamitos, Calif., in 1952. Shows the PAA Load event, and how these models are built and flown. Rent from Ideal Pictures Corp., 54 Post Office Place, Salt Lake City 1, Utah)

UNIT V

AIRCRAFT POWERPLANTS

Introduction

The great advancements of airplane flight made during recent years is largely the result of more reliable, lighter-in-weight and higher horsepower engines that have been developed. Engines of twenty years ago that required three to four pounds of weight to produce each horsepower have been replaced by high-compression, light-weight engines that, in many cases, develop more than a horsepower for each pound of weight.

Turbo-jet engines and turbo-prop engines are now standard equipment for the military forces, and within five years will be in use in many of the nation's airlines. A section of study about this fascinating new source of power is included in this unit and should increase student interest in this field.

Recommendations

It is recommended in the unit on Aircraft Powerplants that a properly organized field trip be taken to a nearby airport and that arrangements be made to have several different types of reciprocating engines shown and operated. If possible a trip to Hill Air Force Base should be arranged to witness operation of both reciprocating-engine-propelled aircraft and turbo-jet-propelled aircraft.

Books

The following books are recommended for this unit of study: (See bibliography)

Aviation Study Manual, Volume 1, Book II, Civil Air Patrol

Aircraft Powerplant Handbook, Civil Aeronautics Administration

Facts of Flight, Civil Aeronautics Administration

Basic Aeronautics, M. E. Tower

Jet Aircraft Simplified, Charles Edward Chapel

AIRCRAFT POWER PLANTS

Section I. Reciprocating Aircraft Engines

Text references: Aviation Study Manual, Unit 4, pp. 1-5
Basic Aeronautics, Chap. IV
Aircraft Powerplant Handbook, Chap. I, II

I. Aircraft Engine requirements

A. Reliability

1. The aircraft engine must operate continuously for many hours.

2. An engine must operate satisfactorily in all types of weather.

B. Weight

1. The aircraft engine must be light in weight and powerful.

2. Modern reciprocating engines produce more than one horsepower for every pound of weight.

C. Flexibility

1. Smoothness of operation

2. Lack of undue vibration

3. Responsiveness to throttle movement

D. Operating costs

1. Economy of fuel consumption

2. Ready availability of fuel.

II. Types of aircraft engines

A. Cylinder arrangement

1. Horizontally opposed

a. The cylinders are arranged horizontally and diametrically opposite to each other.

b. This style engine is used widely on light airplanes.

c. This engine is air cooled.

2. Inline engine

    a. The cylinders are arranged in a straight line, one behind the other.

        (1) Upright inline

        (2) Inverted inline

    b. Air cooled

3. Single-row radial engine

    a. The cylinders are arranged in a circle around the crankcase.

        (1) Five-cylinder radial engine

        (2) Seven-cylinder radial engine

        (3) Nine-cylinder radial engine

    b. Air cooled

4. Double-row radial engine

    a. The cylinders are arranged in a circle around the crankcase.

    b. There are two complete rows of cylinders, one toward the front, one toward the rear.

        (1) Fourteen-cylinder radial engine

        (2) Eighteen-cylinder radial engine

    c. Air cooled

5. Four-row radial engine

    a. This engine is called the Pratt and Whitney "Major"

    b. The cylinders are arranged radially around the crankcase.

    c. There are four rows with seven in each row.

    d. Air cooled

6. V-type engine

    a. The cylinders are arranged in two separate rows with a 60 degree angle between the rows.

b. All engines of this type have been twelve-cylinder models, arranged in two rows of six each.

(1) Upright V-type

(2) Inverted V-type

c. Air cooled or liquid cooled

7. Double V-type engine

a. Essentially two V-type engines, as described above, arranged in the same crankcase

b. Air cooled or liquid cooled

Things to do:

1. Visit your nearest airport and ask to be shown as many different types of engines as possible.

2. Visit an aircraft engine maintenance shop.

3. Observe the starting procedure for aircraft engines.

4. Visit a CAA approved, Aircraft and Engine Mechanic School.

Films:

"Methods of Starting the Engine" (35 mm. filmstrip, 45 frames. Shows how an engine may be started by the following methods: (1) by pulling the propeller, (2) with a shock cord, (3) direct hand crank, (4) combustion starter, (5) the inertia starter (hand and electric operated), and (6) direct electric starter. Loan by CAA)

AIRCRAFT POWERPLANTS

Section II. Aircraft Engine Construction and Operation

Text references: Aviation Study Manual, Unit 4, pp. 1-5
Facts of Flight, pp. 12-22
Aircraft Powerplant Handbook, Chap. 5
Basic Aeronautics, Chap. IV

I. Main engine sections

A. Power section

1. Crankcase

a. Crankshaft

b. Connecting rods

c. Bearings

2. Cylinders

a. Cylinder head

b. Cylinder barrel

c. Valves and valve springs

d. Piston and piston rings

B. Nose section

1. Nose case

a. Thrust bearing

b. Valve timing mechanism

c. Governor drive

2. Reduction gearing (if used)
(The reduction gearing is used to enable the crankshaft to turn faster without overspeeding the propeller.)

C. Manifold section

1. Intake pipes

2. Fuel-air distribution

D. Supercharger section

1. This section is present only on the higher horsepower engines.

2. The supercharger is an engine-driven air pump which enables the engine to operate or breath at high altitudes.

E. Accessory section

1. Many necessary engine and airplane accessory units are mounted on this section.

    a. Magnetos

    b. Starter

    c. Generator

    d. Fuel pump

    e. Oil pump

    f. Tachometer drive

II. The four-stroke principle of operation
(Two complete crankshaft revolutions are required to complete the following series of events.)

A. Intake stroke
(As the piston moves downward, the intake valve opens and a charge of fuel-air mixture is pulled into the cylinder.)

B. Compression stroke
(As the piston starts upward on the next stroke, both valves close, and the mixture is compressed very tightly into the combustion chamber.)

C. Power stroke
(As the piston reaches the end of the compression stroke, the spark plug arcs across the gap, and the fuel starts to burn. This burning mixture produces high heat and pressure. The pressure forces the piston downward and thereby applies power through the connecting rod to the crankshaft.)

D. Exhaust stroke
(After the majority of the fuel and air mixture is burned and the power transmitted to the crankshaft, the exhaust valve opens and the scavenging of the exhaust gases begins. The exhaust valve remains open all during the upward stroke and a few degrees after top center to allow more time for getting rid of the burned gases.)

Things to do:

1. Invite a certificated engine mechanic to talk to the class about engine operation and engine types.

2. Obtain and show one of the films listed below.

3. Visit an airline aircraft engine overhaul shop.

4. Have the students of the class write a report on one of the following:

    a. The Wright brothers first engine

    b. Horsepower and how it is measured

    c. The development of the reciprocating engine

5. Construct a radial engine mockup teaching aid that will show piston movement in relation to the crankshaft.

Films:

"The Airplane Engine" (35 mm. filmstrip, 28 frames. A very brief explanation of the basic principle of operation of all internal-combustion gasoline engines, as well as the principle of four-stroke cycle operation. Loan by CAA)

AIRCRAFT POWERPLANTS

Section III. Aircraft Engine Lubrication and Cooling

Text references: Aviation Study Manual, Unit 4, pp. 6-11
Facts of Flight, p. 20
Aircraft Powerplant Handbook, Chap. VIII and XIV

I. Types of lubrication systems

A. Dry-wump system

1. All the oil is contained in a separate tank mounted on the firewall.

2. The lubricating oil is drawn from the tank and forced through the engine under pressure. It is then pumped back to the tank after the engine lubrication requirements have been met.

3. The dry sump method is used on all inverted inline, radial, and V-type engines.

B. Wet-sump lubrication

1. All the oil is contained within the crankcase.

2. Oil is pumped from the sump to lubricate all bearings. It then runs back to the sump.

3. The wet-sump system is used on almost all low-horsepower engines, especially those in the horizontally opposed class.

II. Aircraft engine internal lubrication

A. Radial engines

1. The oil is forced by the oil pump through the oil filter into the hollow crankshaft, where it is directed to the main bearings, cylinder walls, piston pins, and the master rod.

2. Oil flow is also directed to the accessory case to lubricate the many drive gears in that section.

3. Oil flow is also directed to the nose section for lubrication and operation of some types of propellers.

4. All the oil then drains to the sump where it is picked up and forced through an oil cooler back to the tank.

B. V-type engines

1. The flow of oil in this engine is the same, generally; however, instead of using the crankshaft to transport all oil to the bearings, a separate drilled passageway is provided.

C. Horizontally opposed engines

1. The oil is contained in a sump and forced through drilled passageways to the main bearings.

2. The lubrication for the connecting rod bearings are conducted by drilled passageways in the crankshaft.

3. On airplanes equipped with close fitting engine cowling, a small oil cooler is utilized on horizontally opposed engines.

III. Aircraft engine cooling

A. Air-cooled engines

1. Air flow is directed to the cylinders.

2. Combustion heat is transferred to the cylinder head cooling fins, where the heat is transferred to the air flowing around the cylinders.

3. Pressure baffles are installed between cylinders to increase the mass air flow around the cylinders.

4. On some airplanes the airflow is controlled by the engine cowling flaps, which are operated from the cockpit.

B. Liquid cooled engines

1. The cooling of this engine is accomplished by directing a cooling liquid (usually a mixture of water and ethylene glycol) around each cylinder.

2. The liquid is then forced through a radiator for cooling.

C. Temperature indicating instruments

1. Thermocouple and cylinder-head temperature gauge

a. The thermocouple is placed under a spark plug.

b. The cylinder heat causes a very small amount of electricity which varies according to the temperature, to be produced in the thermocouple.

c. This small voltage is measured by a millivolt meter calibrated in Fahrenheit or centigrade.

<u>Things to do</u>:

1. Examine an aircraft engine and determine the method of cooling. Note the cooling fins on all air-cooled engine cylinders.

2. Study the engine operation manual of a small aircraft.

<u>Films</u>:

"Servicing the Oil System" (35 mm. filmstrip, silent, 41 frames. Explains the correct procedures for checking oil level, adding oil to the system, and changin the oil. Safety precautions to be followed in this work are also stressed. Sale by Jam Handy, Inc. 2821 East Grand Blvd., Detroit 11, Mich.)

AIRCRAFT POWERPLANTS

Section IV. Aircraft Engine Ignition

Text references: Aviation Study Manual, Unit 4, pp. 12-13
Aircraft Powerplant Handbook, Chap. X

I. Units of the ignition system

A. Spark plugs

1. Two per cylinder

2. Three or four electrodes on each spark plug

B. Ignition wires or harness

1. High tension--unshielded

2. High tension--shielded

C. Magnetos
(Two magnetos are used on each engine for safety and to provide better combustion.)

D. The distributor directs the high tension electricity to the right cylinder.

II. Operation of the ignition units

A. Spark plugs
(A highly insulated device which provides a very small spark gap inside the cylinder across which the high voltage electricity can arc and ignite the fuel and air mixture)

1. Spark plugs must withstand very high temperatures and pressures.

2. Two spark plugs are located in each cylinder.

B. Ignition wiring
(A very heavily insulated wire which conducts high voltage electricity from the magneto to the spark plugs)

C. Magneto

1. The magneto produces a very high voltage, 15,000 to 25,000 volts, to provide the spark plug with sufficient electrical energy to produce sparking across the gap.

2. The high voltage is produced by mutual induction between the primary coil and secondary coil. Breaker points and a condenser control the current flow through the primary coil, which is generated by the effect of the magnetic field from high-strength rotating magnets.

D. Distributor

1. The distributor is usually part of the magneto.

2. The distributor rotates at one half crankshaft speed and directs the high tension electricity to the right cylinder at the right time.

3. Engines equipped with a double magneto have separately driven distributors.

E. The ignition switch

1. The ignition switch controls the engine firing by controlling the magneto operation.

2. When the switch is "off" the magneto primary circuit is grounded.

Things to do:

1. Obtain a surplus aircraft magneto, mount it on a bench and connect several spark plugs to the unit with ignition wire. Observe the spark at the plugs as the magneto shaft is turned by hand.

Films:

"Aircraft Engines - Elements of Electricity as applied to Ignition Systems" (16 mm. sound, 28 minutes. Portrays elementary phenomena in electricity and magnetism and the application of these principles to engine ignition systems. Loan CAA)

AIRCRAFT POWERPLANTS

Section V. Carburetion and Fuel Systems

Text references: Aviation Study Manual, Unit 4, pp. 16-29
Aircraft Powerplant Handbook, Chap. IX, XIII

I. Fuel system

A. Fuel tanks

1. Fuel tanks are usually made of aluminum or neoprene.

2. Some fuel tanks are an integral part of the wing.

3. Military planes use a self-sealing tank that closes any holes immediately.

4. Most fuel tanks are located inside the wing.

5. Additional tanks are now being installed on the wing tips.

6. All fuel tanks connect into a fuel selector valve, which is operated by the pilot.

7. Some fuel tanks have an electric pump installed in the bottom of the tank to pump fuel to the engine for starting.

B. Fuel lines

1. Fuel lines simply connect the tank to the carburetor.

2. An engine-driven fuel pump is installed in the line of all pressure systems.

3. A fuel strainer is installed in all fuel systems.

II. Carburetion

A. Purpose of the carburetor

1. A carburetor measures the amount of air going to the engine and properly meters and atomizes the fuel for engine operation.

2. The carburetor controls the amount of air going to the engine by the throttle valve.

B. The venturi tube

1. The venturi tube is the air measuring device in the carburetor.

2. Action of a venturi tube

   a. As the air passes through, it must speed up or increase its velocity.

   b. As the velocity of the air increases, the air pressure decreases.

   c. The temperature of the air decreases.

   d. As the pressure in a venturi tube decreases, more fuel is lifted from the main discharge nozzle.

   e. As the throttle valve is opened more air flows through, thus lifting more fuel from the discharge nozzle.

C. The float chamber

1. Fuel from the tank is controlled by the float and needle valve.

2. A proper fuel level must be maintained in the carburetor.

D. Metering devices

1. Main metering jet
   (Most of the fuel passes through this jet.)

2. Power-enrichment jet
   (Functions only at high power)

3. Idle system
   (Functions only at idle speed)

4. Mixture control
   (The mixture control, located in the cockpit, regulates the amount of fuel issuing from the carburetor according to the pilot's desire.

E. Detonation

1. Detonation is a very rapid uncontrolled combustion of part of the mixture.

2. Severe detonation can damage the engine.

3. Effects of detonation

   a. High cylinder temperatures

   b. Loss of engine power

4. To prevent detonation

    a. Use high octane fuel.

    b. Enrich the mixture.

    c. Retard the throttle.

    d. Reduce carburetor heat.

III. The induction system

A. Non-supercharged engines

1. On sea-level engines the induction system consists of a set of intake pipes and a carburetor mounting system.

2. One intake pipe goes to each cylinder.

B. Supercharged engines

1. Engines are supercharged to enable operation to a higher altitude.

2. The supercharger is a high-speed centrifugal air pump which forces a greater quantity of fuel-air mixture into the cylinders.

3. Types of superchargers

    a. Engine driven, single speed

    b. Engine driven, two speed

    c. Exhaust-gas driven, turbo-supercharger (The turbo-supercharger is used on many military bombers and fighters and is now being used on some commercial transports.)

Things to do:

1. Perform a class demonstration with the venturi tube from The Theory of Flight Kit.

Films:

"Aircraft Engines: Carburetion" (16 mm. sound, 37 min. A detailed pictorial discussion of the functions, parts and variations of aircraft engine carburetors. It begins with a discussion of air and gas mixtures used in internal combustion engines, variations in ratio of gas and air desirable for idlin, acceleration, and maximum power. Animated diagrams and pictures show a simplified carburetor and various devices developed to permit control of the mixture under varying conditions. Rent from Ideal Pictures Corp., 10 Post Office Place, Salt Lake City, Utah)

AIRCRAFT POWERPLANTS

Section VI. Turbojet Engines

Text references: Aviation Study Manual, Unit 4 Supplement, pp. 1-35
Aircraft Powerplant Handbook, Chap. XIX
Basic Aeronautics, Chap. VI
Jet Aircraft Simplified, Chapters V, VI, VII

I. Theory of operation

A. Sequence of events

1. Incoming air is compressed to a high pressure as it passes through the compressor section. The compressor is turned at high speed by the turbine.

2. After the air is compressed, it enters the combustion chamber, where it is mixed with fuel and burned.

3. The burning gases produce high temperature and high pressure.

4. As the high pressure gases leave the combustion chamber, they strike the turbine wheel and cause the turbine to turn at a high speed, which in turn rotates the compressor.

5. The gases leave the engine through the nozzle, where they enter the atmosphere.

6. The force of the expanding gases within the combustion chamber forces the engine unit forward. This forward motion is transferred to the airframe as power.

II. Turbojet engine sections

A. Turbine section

1. Stator blades

a. These blades are stationary and are used solely to direct the expanding gases against the turbine blades, in order to obtain maximum energy transfer to the turbine wheel.

b. One set of stator blades is used for each turbine rotor.

2. Turbine rotor

a. The turbine rotor consists of a series of blades attached to the outer periphery of a steel disc.

b. The high velocity gases emerging from the combustion chamber strike the turbine blades and impart some of their energy to the blade. This energy causes the rotor to turn at high speed.

c. Some turbine engines use two or more turbine rotors.

d. Turbine rotors must be very strong to resist the high temperature of the exhaust gases and also be able to withstand the high centrifugal forces. The turbine wheel rotates between 10,000 and 20,000 r. p. m.

e. The turbine rotor is carried by a large steel shaft which connects the compressor section to the turbine.

B. Compressor section

1. The compressor forces air into the combustion chamgers.

2. Types of compressors

a. Centrifugal
(These are very similar to the supercharger on a reciprocating engine.)

b. Axial flow

(1) Consists of vanes set into a steel disc or drum.

(2) Some turbojet engines use fourteen stages of compression of this type.

(3) A stator section is used between each rotor section.

C. Combustion chamber section

1. The combustion takes place in a stainless steel cylinder. One end is open to the turbine section; the other end is open to the compressor section.

2. The fuel is sprayed into the air as it enters the combustion chamber.

3. The burning gases leave the combustion chamber and impinge upon the turbine blades.

4. Cooling air is directed around the combustion chambers.

5. Fuel used

a. Gasoline

b. Kerosene

D. Accessory section

1. The accessory section is located on the front of the engine.

2. The accessories are driven by gearing from the turbine shaft.

3. Accessories used

   a. Starter

   b. Generator

   c. Fuel pump

   d. Oil pump

   e. Fuel metering unit

   f. Vacuum pump

   g. Hydraulic pump

III. Gas-turbine-propeller (turbo-prop) engines

A. Principle of operation

1. The principle of operation for this engine is identical to the turbojet engine, except that the majority of the power developed in turbine rotors is used to rotate a propeller, or two contra-rotating propellers.

2. Airplane thrust is furnished by

   1. Propeller action

   2. Jet action from the engine

B. Advantages of the turbo-prop engine

1. More efficient at low speeds

2. Shorter runways required

3. Less noise and vibration than reciprocating engines

4. High horsepower per unit of weight

C. The disadvantage of the turbo-prop engine is that it is not as fast as a pure jet engine.

Things to do:

1. Arrange for a class tour of Hill Air Force Base and observe the following:

    a. Servicing of jet planes

    b. Cutaway jet engine

    c. Flight of jet aircraft

    (This trip will have to be planned well in advance and must have the approval of the Commanding General. The nearest Civil Air Patrol liasion officer can arrange all details.)

Films:

"Jet Propulsion" (16 mm. sound, color, 15 minutes. Shows the Wright brothers 1903 plane and the fact that conventional planes of today are still powered by improved versions of the reciprocating engine. Limitations of this plane are pointed out. Newton's Third Law of Motion is explained and how it may be used to propel aircraft. Animated drawings explain the construction and operation of jet engines. Includes "live" action shots of the P-80 "Shooting Star" showing how its flight characteristics differ from conventional aircraft. Loan by CAA)

"America's New Air Power" (16 mm. 18 minutes. Describes the steps being taken by our military leaders to develop the nation's first line of defense--The U. S. Air Force--as a weapon so formidable that no potential enemy will dare risk its counter-blows. Included are scenes of some of the latest types of jet fighters and bombers. Loan by CAA)

"Wonder Jet" (16 mm. sound, 20 minutes. The story of the development of the jet engine told against a pleasing and chronological background. Interesting highlights on the man, Whittle by name, who invented it are shown and also how today the product of this man's genius has given birth to a new industry which forebodes well for the economic future of England. The principles of operation of the jet engine are briefly discussed and reference made to its future potential as the motive power for trains and boats. Its application to military and commercial aircraft are well illustrated. Loan by CAA)

AIRCRAFT POWERPLANTS

Section VII. Ram Jet Engines

Text references: Aviation Study Manual, Unit 1, pp. 20, 21
Jet Aircraft Simplified, Chapter III

I. Theory of operation of a ram jet

A. Air is compressed in the combustion area by the forward movement of the engine.

B. Fuel is sprayed into the air as it enters the combustion area.

C. The mixture is burned and leaves the combustion area through a nozzle, thus forcing the engine forward.

D. A continuous burning of the fuel is always in process.

E. There are no moving parts in this engine.

F. The ram jet does not become efficient until a speed of Mach 2 is reached.

Things to do:

1. Write a report on the use of small ram jet engines as applied to small one man helicopters.

2. Discuss in class the roll of the ram jet in guided missiles.

3. Bring to class newspaper and magazine articles on the ram jet engine.

AIRCRAFT POWERPLANTS

Section VIII. Aircraft Engine Instruments

Text reference: Basic Aeronautics, pp. 32-34

I. Instruments used on reciprocating engines

A. Tachometer

1. This instrument indicates the speed of the crankshaft in revolutions per minute (RPM).

2. Two types are used.

a. Magnetic drag type--driven by a flexible shaft

b. Electric type--two units, a small generator and the meter

B. Manifold pressure gauge
(Indicates the pressure of the fuel-air mixture before it enters the cylinder)

C. Oil pressure gauge
(Indicates the pressure of the lubricating oil being circulated in the engine)

D. Oil temperature gauge
(Indicates the temperature of the engine lubricating oil)

E. Fuel pressure gauge
(Indicates the pressure of the fuel being delivered to the carburetor)

F. Fuel quantity gauge
(Indicates the quantity of fuel aboard, either in gallons or pounds)

G. Cylinder head temperature gauge
(Indicates the temperature of the air-cooled cylinder, either in Fahrenheit or centigrade)

H. Carburetor mixture temperature gauge
(Indicates the temperature of the fuel-air mixture after it passes the carburetor)

II. Instruments used on gas turbine engines

A. Tachometer
(Indicates power in percentage)

B. Temperature gauge
(Indicates the temperature of the tailpipe in degrees centigrade)

C. Fuel pressure gauge

D. Oil pressure gauge

E. Oil temperature gauge

Things to do:

1. Observe the operation of the following instruments in an airplane:

    a. Tachometer

    b. Manifold pressure gauge

    c. Oil pressure gauge

    d. Oil temperature aguge

    e. Fuel pressure gauge

    f. Fuel quantity gauge

    g. Cylinder head temperature gauge

    h. Carburetor mixture temperature gauge

Films:

"Engine Instruments" (35 mm. filmstrip. Purpose and use of engine instruments--Tachometer; details of its construction and how it works--Oil Pressure Gauge; how the Bourdon tube makes it work and what the Gauge does--Oil Temperature Gauge; its parts and purpose--Different types of gasoline gauges; Simple Float or Sight Glass, Distant-reading Gauge, Hydrostatic Gauge. Loan by CAA)

UNIT VI

METEOROLOGY

Introduction

Because weather, either good or bad, is around us at all times, the outdoors becomes the laboratory for this class. People of all ages like to talk about the weather, many delight in attempting to forecast weather by various means. The study of the weather as a unit in Aviation Education can be one of the most interesting and informative units studied.

Class interest can be greatly increased by the purchase of several basic weather indicating instruments and the provision of a suitable area in the classroom where the instruments can be observed by the students during the school day.

If the recording type instruments such as the barograph and thermograph cannot be purchased, a daily or twice daily observation can be plotted on graph paper and the graph brought forward at each observation. With careful utilization of the graph paper, both the atmospheric pressure and outside temperature can be plotted as separate lines on one sheet of graph paper per week. By trimming and matching four consecutive sheets and posting them on the bulletin board, the temperature and pressure changes for one month can be seen and discussed by the students. It is recommended that the class be divided into groups, with one group per week being responsible for the observing and recording of data.

Additional observations that could be recorded are of wind speed, wind direction, cloud forms, precipitation and visibility.

For the observing of wind speed, wind direction, and outside air temperature, the A-C Windometer manufactured by Aircraft Components, Inc., can be purchased for approximately $100.00. This instrument can be observed in the classroom and the above named observations made, without going outside.

When the daily weather condition is being discussed, the instructor should point out the flying conditions for that particular day. Student interest can also be motivated by discussions of the weather forecasts produced on many television stations.

Instruments used in weather observing

In order to aid the beginning teacher of meteorology in the selection of a few basic weather instruments, the following list is presented.[1]

1. Wind speed is measured with an anemometer, which is essentially a speedometer. This consists of a rotor with conical cups attached to the end of spokes. The rotor is exposed atop a pole, where the wind is caught in the cups and causes them to turn at a speed proportional to the speed of the wind. Indications of the rotor's speed are transmitted electrically to an indicator located inside the classroom.

2. Direction of the wind is indicated by the wind vane. The action of the wind on the vane causes it to point into the wind. Wind direction is reported as the direction from which the wind is blowing. Thus, a vane pointing toward the northwest indicates a northwest wind. Indications of the vane's position are transmitted electrically to an indicator inside the classroom.

3. Temperature of the air is read from thermometers very similar to the common household variety. When used in weather work, the thermometers are enclosed in a white shelter that permits the air to circulate freely around them, at the same time shielding the instruments from precipitation and direct radiation from the sun and surface objects.

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1. U. S. Department of Commerce, Weather Bureau, Instruments used in Weather Observing, September, 1955

4. Highest and lowest temperatures are read from specially constructed thermometers. The bore of a minimum thermometer is exposed in a nearly horizontal position and has a loose-fitting, tiny glass index located inside a column of alcohol. As the temperature falls, the glass index is carried downscale by the retaining action of the end of the column. During subsequent warming of the air, the alcohol expands and flows past the glass index, which remains stationary to mark the lowest temperature. The maximum thermometer has mercury for the liquid. Near the bulb, the bore of the thermometer narrows to a tiny passage through which the dense mercury cannot flow freely. As the temperature increases, the mercury in the bulb expands; some forces its way through this constriction and becomes trapped in the upper portion of the tube. As the air cools and the mercury contracts, the column separates at the constriction, leaving the portion in the upper part of the tube to mark the highest temperature. This is the same principle employed in a clinical thermometer. Both may be reset by whirling or shaking the thermometer until the column is again joined.

5. Dew point of the air is calculated from temperatures read from the pshchrometer. In addition to a regular thermometer, used to measure temperature of the air, the pshchrometer has another thermometer with a moistened wick attached to the bulb. The cooling effect, caused by evaporation of water from the wick, lowers the thermometer reading in proportion to the amount of evaporation that can take place. Therefor, as the relative humidity increases, the difference between the temperature of the air and the dew point becomes smaller.

6. Barometric pressure is measured with a barometer such as the aneroid type. This measurement expressed in inches is the weight of the air above the station. When the station is not at sea level, this pressure measurement is corrected by an amount equal to the weight of a column of air between the station and sea level.

7. Barometric tendency is recorded as a continuous line on the clock-driven chart of a microbarograph. The movement of large masses of air over a given location causes the weight of the atmosphere to vary constantly. Weathermen look at the fluctuations of pressure, and their rate of change, for a clue to the movement and intensity of storms.

8. Amount of precipitation is usually determined from the accumulation caught in a gage. In the weighing type recording gage, the weight of the precipitation falling through the 8-inch circular opening of the gage is recorded on a chart as depth of water in inches and hundredths. If 13 ounces of rain were cauth in the gage, the recording pen would indicate that 0.45 inch of rain had fallen. The time of the occurrence as well as the amount of precipitation can be determined from the chart. Precipitation can also be measured in a non-recording type gage which consists of an 8-inch diameter brass or galvanized steel tube. The accumulation is measured in a smaller tube attached to the bottom and which collects all precipitation entering the 8-inch tube.

9. Depth of snow on the ground is measured to the nearest inch. This is the average of the depth measured at several spots where the snow is least affected by drifting. It includes the depth of all frozen precipitation present--snow, sleet, glaze, hail and sheet ice.

Sources of weather instruments:

Friez Instruments Division
Bendix Aviation Corporation
Baltimore 4, Maryland

Aircraft Components, Inc.
Benton Harbor, Michigan

Taylor Instrument Company
Rochester, New York

Books

The following books were used as references for the preparation of this unit: (See bibliography)

Aviation Study Manual, Volume I, Book II, Civil Air Patrol

Realm of Flight, George S. Stanton

Pilots Weather Handbook, #104, Civil Aeronautics Technical Manual

Basic Aeronautics, M. E. Tower

A Student Guide for Aeronautics, M. E. Tower

Student Handbook for Use in the Study of Theory of Flight Kit, M. E. Tower

Manual of Cloud Forms and Codes for States of the Sky, Circular S
U. S. Weather Bureau

Instructions for Climatological Observers, U. S. Weather Bureau

Aerology for Pilots, U. S. Navy

The following books would also be helpful to the teacher in the meteorology unit as library reference books:

Techniques of Observing the Weather, B. C. Haynes

A Pilot's Meteorology, Charles G. Halpine

Clouds, Weather and Flight, Thomas Gilmer and H. E. Haynes

Government publications

It is suggested that the teacher write to the "Chief of U. S. Weather Bureau, Washington 25, D. C." for a price list of current publications and an "Educational Series Kit" which is furnished free to teachers. The teacher can then purchase the current available publications that best suit his classroom needs.

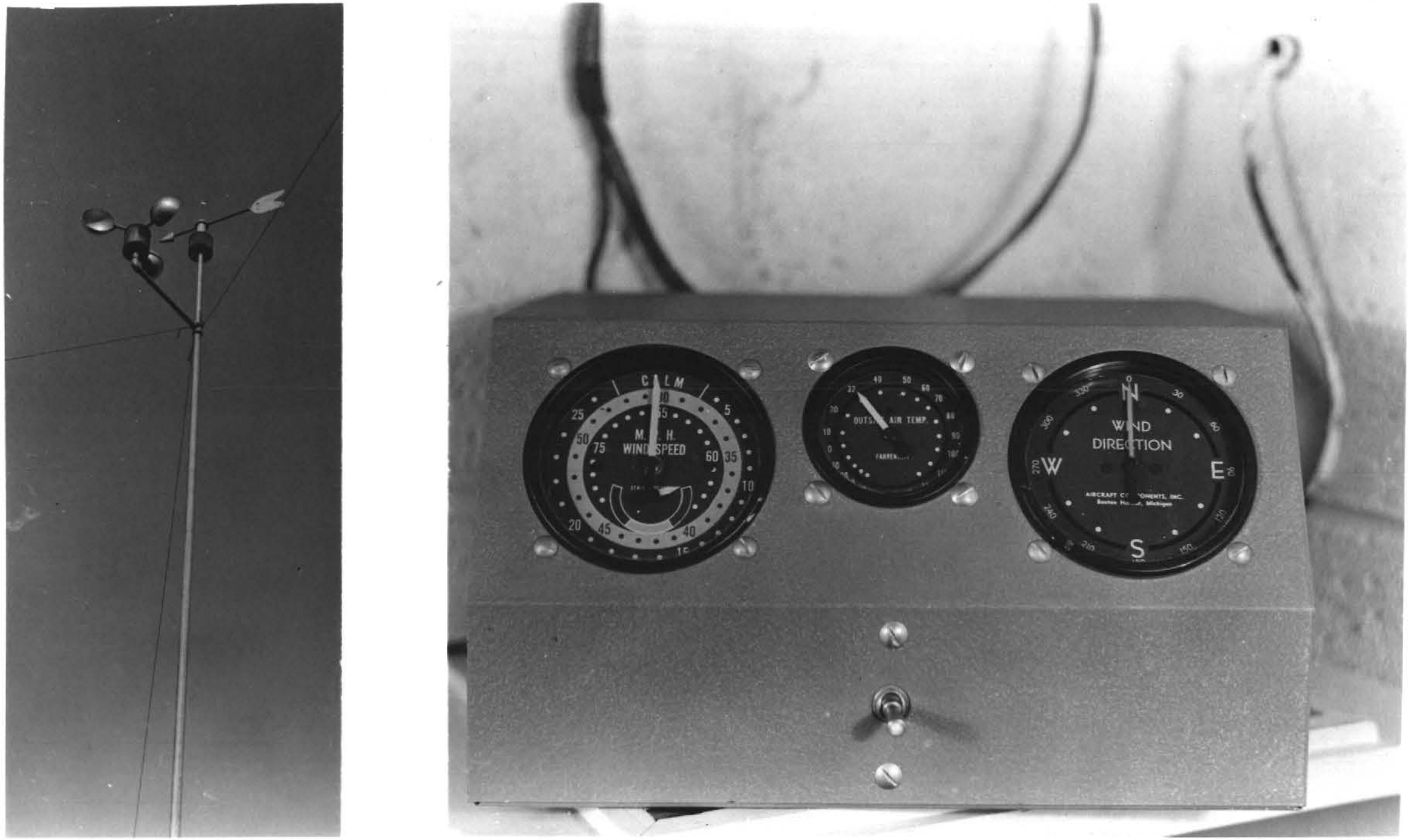


Figure 2. Windometer installation for indicating wind speed, wind direction and outside air temperature

Figure 3. Microbarograph--for the recording of barometric pressure changes

Figure 4. Standard weather barometer--aneroid type

METEOROLOGY

Section I. Weather Information for the Pilot

Text references: Aviation Study Manual, Unit 6, pp. 1-5
Aerology for Pilots, Chapter 1
Pilots' Weather Handbook, Chapter XV
Realm of Flight, Chapter I
Basic Aeronautics, pp. 89-93

I. Sources of information

A. U. S. Weather Bureau

1. Main office for Utah at Salt Lake City airport

2. Furnishes information to anyone

3. Observation of weather conditions at over six hundred weather reporting stations across the United States

4. Aviation weather reporting stations in Utah that report in to central office every hour are located at the following places:

a. Salt Lake City
b. Ogden
c. Delta
d. Milford
e. Cedar City
f. Bryce Canyon
g. St. George
h. Hanksville

B. Commercial airline weather offices

1. Use official weather bureau information, plus company station reports

2. Reports and predictions not available to anyone else

C. Aviation weather consultants

1. Private businesses selling weather information

2. Usually in large cities of U. S.

3. Cost of information is not prohibitive to pilots

II. Types of information available

A. Maps of weather

1. Weather maps are made up every six hours.

2. Maps showing weather condition at the surface are the most useful.

3. Surface maps show:

a. Low pressure areas
b. High pressure areas
c. Warm fronts
d. Cold fronts
e. Squall lines
f. Temperature at stations
g. Dew point at stations
h. Precipitation today and yesterday

4. Upper wind maps

a. Show wind direction and speed at various flight levels

b. May be useful for some pilots

c. Made up every six hours

5. Temperature and moisture maps of upper air

a. Show temperature and moisture conditions at various flight levels

b. Received from radios and balloons

B. Reports of current weather conditions

1. Conditions as observed from ground and in upper air

2. Reports of pilots in flight

3. Radar reports

C. Forecasts of flying weather

1. Area forecasts

a. For a definite area in U. S., usually a group of states

b. These forecasts are for a 12-hour period, plus general outlook for an additional 12 hours.

c. A weather report is made up every six hours

2. Terminal forecasts

    a. Detailed terminal forecasts

    b. For 12-hour periods, some for 24-hour periods

    c. Issues for over 300 principal air terminals in the U. S.

    d. Report on ceiling visibility and wind conditions

3. Trip forecasts

    a. Special flight weather folder made for pilots engaged in international flights

    b. Forecasts the following:

        (1) Winds at different flight levels, direction and speed

        (2) Indicates approximate points of frontal activity and storms

III. How to plan your flight--weatherwise

A. Visit your U. S. weather office

1. Read weather maps

2. Obtain terminal forecast for end of flight

3. Locate storm areas and fronts

4. Get help from weather bureau personnel

5. If your aircraft or you are not equipped for weather flying or flying on instruments, don't attempt it.

B. Phone your weather bureau aviation office.

1. Long distance calls may save your life.

2. Phone the nearest radio range station and ask for special weather report.

C. Listen to radio range stations on civil airways on a low-frequency radio receiver.

1. Weather reports are given at fifteen minutes before the hour and fifteen minutes after the hour.

2. Plan wisely and file a flight plan.

IV. Aviation radio range stations in Utah from which weather reports can be received:

A. Delta - 212 kilocycles

B. Enterprise - 341 kilocycles

C. Ogden - 263 kilocycles

D. Salt Lake City - 227 kilocycles

E. Wendover - 248 kilocycles

F. Hanksville - 113.7 megacycles

Things to do:

1. Visit an aviation weather bureau station.

2. Telephone a weather reporting range station and ask for a special weather broadcast.

3. Tune in one of the above named range stations and listen to the series of weather reports.

Films:

"Weather and Radar" (Illustrates some of the operational values to be gained by using radar in locating and identifying weather disturbances. 17 minutes. Rent from United World Films, Inc. 1445 Park Ave., New York 29, or 7356 Melrose Avenue, Hollywood 46, Calif.)

"How Weather is Forecast" (Shows the operation of a weather observation station and a weather forecasting station. By means of animation, a weather map is charted and its symbols explained. The instruments used in weather forecasting and their functions are discussed. 10 min. Rent from Coronet Films, Coronet Building, Chicago, Ill.)

METEOROLOGY

Section II. The Nature of the Atmosphere

Text references: Aviation Study Manual, Unit 3, pp. 4-6
Pilots' Weather Handbook, Chapter 1
Realm of Flight, Chapter II

I. Earth's atmosphere divided into three parts

A. Troposphere

1. From sea level to about 6.8 miles

2. Area where most flying is done and most of our "weather" forms

B. Stratosphere

1. From about 6.8 miles to about 40 miles

2. Very low pressure

3. Temperature varies with altitude, first remaining constant, -67 degrees below zero, Fahrenheit, to about 20 miles; then increasing to over 100 degrees F.; then decreasing again to about -50 degrees Fahrenheit.

C. Ionosphere

1. Located above 40 miles altitude

2. Contains ionized layers at about 40, 60, 125 and 185 miles

3. Ionized layers play a big part in reflecting radio signals.

II. Composition of our atmosphere

A. Nitrogen gas--78%

B. Oxygen gas--21%

C. Argon--1%

D. Carbon dioxide--.03%

E. Neon, helium, krypton, xenon, ozone, and radon total less than .01%.

III. Effect of altitude change on the human body

A. The rate at which lungs absorb oxygen is determined by the air pressure available.

B. Oxygen pressure decreases with altitude.

1. Oxygen is usually necessary above 15,000 feet in order to retain efficiency.

C. A pilot climbing to progressively high altitude experiences:

1. Fatique

2. Impaired vision

3. Loss of coordination of hands and feet with brain

4. Final unconsciousness, at about 23,000 to 25,000 feet, depending on the individual

IV. Equipment developed to enable pilot to ascend to higher altitudes

A. Oxygen breathing equipment--mask, tubes, regulator, tanks

B. Pressure cabins

1. Airplane cabin is pressurized by an air pump to maintain a lower altitude within the cabin.

2. Most airlines today have this arrangement.

Things to do:

1. Place a burning candle under an air-tight jar. Explain why the flame gradually goes out.

2. Take an aneroid barometer or airplane altimeter from basement of the school to the top of the school or nearby hill. Notice the pressure change.

3. From the book A Student Guide For Aeronautics conduct the experiments on oxygen and nitrogen on pages 43 and 44.

Films:

"Altitude" (Various types of altitude and air pressure, density; 27 minutes; loan by CAA)

Suggested reading:

"Aviation Medicine on the Threshold of Space," National Geographic Magazine, August 1955, p. 241.

METEOROLOGY

Section III. Temperature

Text references: Aviation Study Manual, Unit 6, pp. 7-10
Aerology for Pilots, Chapter 4
Pilots' Weather Handbook, Chapter II
Realm of Flight, pp. 3, 21
Basic Aeronautics, pp. 102-106

I. Temperature scales

A. Fahrenheit

1. 32 degrees is freezing.

2. 212 degrees is boiling at sea level.

B. Centigrade

1. 0 degrees is freezing.

2. 100 degrees is boiling at sea level.

II. Temperature conversion

A. Fahrenheit can be changed to centigrade by

$$C = 5/9 \ (F - 32) \text{ and}$$

$$C = \frac{(F - 32)}{1.8}$$

B. Centigrade can be changed to Fahrenheit by

$$F = 9/5 \ (C + 32) \text{ and}$$

$$F = (1.8 \times C) + 32$$

III. Temperature measuring instruments

A. Thermometers

1. Expansion of a liquid

2. Used for surface readings

B. Thermographs

1. Measures temperature by relative expansion between two metal strips with different rates of expansion (See Weather Instrument section)

2. Provides continuous chart graph record of the temperature

C. Electrical thermometers
(Used in radiosonde balloons)

IV. Temperature lapse rate

A. Decrease in temperature with increase in altitude

B. Average moist air lapse rate 3 1/2 degrees F. per 1000 feet

C. Average dry air lapse rate 5 1/2 degrees F. per 1000 feet

D. Standard air temperature

1. Sea level = 59° F.

2. 5,000 ft. = 41.2° F.

3. 10,000 ft. = 23° F.

4. 15,000 ft. = 5° F.

5. 20,000 ft. = -12° F.

6. 25,000 ft. = -30° F.

7. 30,000 ft. = -48° F.

V. Daily temperature range between night and day

A. Large change over barren, high level places, sand, plowed fields and rocks

B. Small change over thick vegetation and deep water

VI. Heat transfer

A. Conduction
(Means direct contact with heat energy)

B. Radiation
(Heat energy radiating from a source such as the sun)

C. Convection
(The conducting of warm air throughout the atmosphere by air currents.)

1. Warm air moves upward.

2. Cold air moves downward where it can be warmed by conduction and radiation.

<u>Things to do</u>:

1. When students take a flight, observe temperature on the ground and again at any altitude. Note the difference and determine lapse rate.

2. Make a daily record of outside air temperature and plot on the same chart as the atmospheric pressure.

3. If you are fortunate enough to have a thermograph, note the continuous temperature graph made by this instrument.

4. From the book, <u>A Student Guide to Aeronautics</u>, conduct the experiment, "Temperature--The Thermometer (Liquid)", p. 50.

METEOROLOGY

Section IV. The Significance of Atmospheric Pressure

Text references: Aviation Study Manual, Unit 6, pp. 11-15
Aerology for Pilots, Chapter 6
Pilot's Weather Handbook, Chapter 3
Realm of Flight, Chapter 3
Basic Aeronautics, pp. 115-117

I. Air pressure and what it is

A. Weight of air above a given area on the earth's surface

B. Air weighs .076 lbs. per cubic foot

C. Heaviest at sea level--standard pressure 29.92 inches of mercury, or 14.7 P. S. I.

II. Measuring presure

A. Units of measurement

1. Inches of mercury

2. Millibars of mercury

3. Pounds per square inch

B. Mercury barometer

1. Column of mercury supported by air pressure

2. Movable slide on glass tube indicates increase or decrease

C. Aneroid barometer

1. Operates from a sealed bellows

2. High pressure forces walls of bellows together, needle points to high reading.

D. The airplane altimeter

1. Essentially an aneroid barometer

2. Pressure changes with altitude indicated in feet, ten feet, hundreds of feet, thousands of feet and ten thousands of feet.

3. Contains a small window for adjusting altimeter to present barometric pressure

4. An altimeter can be used as an aneroid barometer.

    a. Set known elevation of school on main dial.

    b. Read present barometric pressure, corrected to sea level in the small window opening.

III. High pressure and low pressure

A. Pressure change due to temperature

1. Cold air is heavy.

2. Warm air is light.

3. A marked rise in pressure indicates good weather--cold air.

4. A marked drop in pressure indicates approaching bad weather--warm, moisture-laden air.

B. Pressure change due to altitude

1. Pressure is greatest at sea level.

2. Pressure decreases with increase in altitude.

Standard air pressures at increments of 1000 ft. of altitude:

Feet	Inches of Mercury
18,000	14.94
17,000	15.56
16,000	16.21
15,000	16.88
14,000	17.56
13,000	18.29
12,000	19.03
11,000	19.79
10,000	20.58
9,000	21.38
8,000	22.22
7,000	23.09
6,000	23.98
5,000	24.89
4,000	25.87
3,000	26.81
2,000	27.82
1,000	28.86
Sea Level	29.92

Altitude at one-inch pressure change increments:

Feet	Inches of Mercury
19,696	13.92
18,026	14.92
16,445	15.92
14,942	16.92
13,509	17.92
12,140	18.92
9,571	20.92
8,358	21.92
7,190	22.92
6,063	23.92
4,973	24.92
3,918	25.92
2,896	26.92
1,903	27.92
939	28.92
Sea Level	29.92

IV. Observation of pressure

A. Take daily reading before class.

B. Note change from previous reading.

C. Determine whether reading is indicative of high pressure or low pressure area.

D. Predict possible weather change.

V. Mapping pressures

A. High and lows are shown by isobars, lines connecting points of equal barometric pressures.

High	Low
1020	1006
1017	1007
1015	1009

Things to do:

1. Keep a daily record of pressure readings on a graph, which also records daily temperature readings.

2. Study official U. S. Weather maps and find high and low pressure areas.

3. Discuss winds and moisture conditions in these areas.

4. Plan a flight between Salt Lake City and Oklahoma City. What is the weather and what route would you take?

5. Study the daily weather map published in The Salt Lake Tribune. Find the high's and low's.

6. From the book, A Student Guide to Aeronautics, make a mercury barometer as described on page 47.

Films:

"Atmospheric Pressure" (Illustration of unbalanced air pressure. 15 minutes. Sale by Encyclopaedia Britannica)

"Atmosphere and Its Circulation" (Principles for distribution of air over earth--reveals composition of atmosphere. 11 minutes. Sale or rent by Encyclopaedia Britannica Films, Inc. 1150 Wilmette Avenue, Wilmette, Ill.)

"Weather" (Explains the development of high and low pressure areas on cold fronts. Rent from Iowa State College of Agriculture and Mechanical Arts, Visual Instruction Service, Ames, Iowa)

METEOROLOGY

Section V. Moisture

Text references: Aviation Study Manual, Unit 6, pp. 21-29
Aerology for Pilots, Chapter 3
Pilot's Weather Handbook, Chapter IV
Realm of Flight, Chapter V
Basic Aeronautics, pp. 110-114

I. Moisture in the air

A. Liquid states

1. Rain

2. Clouds

3. Fog

B. Gaseous state
(Water vapor, measured in percent humidity

C. Solid states

1. Snow

2. Hail

3. Ice-crystal clouds

4. Ice-crystal fogs

II. Saturated air

A. The maximum water vapor that can be held in air of a given temperature

B. As the temperature rises, the water-vapor holding capacity of the air increases.

C. As the air cools, water vapor condenses into clouds, fog or rain.

III. Relative humidity

A. Relative humidity is the ratio in percent of water vapor in the air to the total amount of water vapor the air is capable of holding at that temperature.

B. For every 20 degrees Fahrenheit increase in temperature, the capacity of a volume of air to hold water, in the vapor state, is almost doubled.

Example: If saturated (100%) air at 40° F. is heated to 60° F., the relative humidity drops to almost 50 percent.

C. Relative humidity is not used on weather reports, but measurement of dew point is necessary.

IV. Dew point

A. Dew point is the temperature to which air must be cooled, at a given pressure, in order that the air may become saturated.

Example: The dew point is reached when air at 60° F. and 50 percent relative humidity is cooled to 40° F.

B. Dew point is given in aviation weather reports along with temperature.

C. Low clouds and fog are caused by water vapor condensing and are likely when dew point and temperature are within 4 degrees of each other.

D. The closer the dew point reading and temperature reading become, the greater the possibility of precipitation in one form or another.

V. Measuring dew point

A. Sling psychrometer used

1. Consists of two thermometers mounted on a small frame that can be rotated by hand (whirled) in the air

2. One thermometer has a small cotton wick surrounding the bulb. This wick is moistened with water prior to whirling. The cooling effect caused by evaporation of water from the wick lowers the thermometer reading in proportion to the amount of evaporation that can take place. Therefore, as the relative humidity increases the difference between air temperature and dew point becomes smaller.

3. When the difference between the wet bulb reading and dry bulb reading is obtained, usually called wet bulb depression, the relative humidity and dew point can be determined by referring to a relative humidity and dew point chart.

(See <u>Aerology for Pilots</u>, p. 26, for this table, or the table furnished by the manufacturer of the instrument you are using. This table can also be obtained from the U. S. Weather Bureau.)

VI. Supercooled water

A. Water in the liquid state below freezing temperatures

B. Very unstable--will turn to ice by an agitation or by having other seeds of ice introduced. Cloud seeding works on this principle.

C. Shock of an aircraft through supercooled moisture turns it into ice crystals. This is the familiar "condensation trail" left in the sky by high flying aircraft.

D. At temperatures below freezing water vapors turn directly into ice without going into the water stage. This also produces "con trails" of aircraft.

VII. Condensation

A. Dew, frost, low clouds

1. Formed by cooling of air by the ground

2. Moisture condenses and forms dew, frost, or fog.

B. Rain, snow, hail

1. Formed by atmospheric cooling of air by rising currents

Things to do:

1. Make a sling psychrometer.

2. Measure daily relative humidity and dew point.

3. Predict condensation in form of clouds, fog, or rain from your results.

Films:

"Aerology--Warm Front" (16 mm. sound, 21 minutes. Explains the meeting boundaries of warm and cold air, types of visibility, precipitation and ceiling conditions. Loan by CAA)

METEOROLOGY

Section VI. Clouds and Their Formation

Text references: Aviation Study Manual, Unit 6, pp. 21-30
Aerology for Pilots, Chapter 2
Pilot's Weather Handbook, Chapter VI
Realm of Flight, Chapter VI
Manual of Cloud Forms, U. S. Weather Bureau
Basic Aeronautics, pp. 93-100

I. Basic cloud names
(All cloud names are basically only four different words. Most cloud types are one of these words or combinations of two words.)

A. Cirrus

1. White, fibrous clouds with a silky appearance

2. Usually the sun shines through without making a shadow

3. These clouds are always composed of ice crystals because of their extreme altitude.

B. Cumulus

1. Cumulus clouds are billowing or lumpy.

2. They are very often referred to as "woolpack" because of their resemblance to a band of sheep. They have characteristic round protuberances.

3. The base of cumulus clouds is nearly flat and horizontal.

C. Stratus

1. A sheetlike, well-defined layer of clouds not resting on the ground

2. If grouped with a stratus cloud, it is a nimbo-stratus or rain cloud.

3. If grouped with a cumulus cloud, it becomes a cumulo-nimbus, or thunderhead.

4. Rain and hail are almost always found inside the nimbo-stratus cloud.

5. Very strong vertical air currents are also encountered. (Do not fly into a nimbus type cloud, particularly cumulo-nimbus. The turbulence inside a cumulo-nimbus cloud may be great enough to tear your airplane apart.)

II. Types of clouds

A. High clouds (cirrus family)

1. Icy and fibrous, sun shines through without a shadow

2. Average upper level, 35,000 feet; average lower level, 20,000 feet

3. Cirrus--base height, 30,000 feet

4. Cirrus-cumulus--base height, 20,000 feet

5. Cirrus-stratus--base height, 35,000 feet

B. Middle clouds (alto family)

1. Average upper level, 20,000 feet; average lower level, 6500 feet

2. Alto-cumulus--lumpy, billowing, "wool-pack"

3. Alto-stratus--straight in a sheetlike layer

C. Low clouds (cumulus and stratus family)

1. Average upper level, 6500 feet; average lower level, close to ground surface

2. Strato-cumulus--straight layer, "woolpack"

3. Status

4. Nimbo-stratus--low straight layer with storm heads

D. Clouds with vertical development

1. Average upper level, near the cirrus group

2. Average lower level, about 1600 feet

3. This group of clouds may start near the surface and rise to great heights.

4. Cumulus--billowing or woolpack, start about 1,000 feet and may rise to 20,000 feet

5. Cumulo-nimbus--billowing clouds with storm head rising to great heights, may start at 500 feet and rise to over 35,000 feet

Things to do:

1. Hold three or four class periods outside on days of different cloud formations.

2. Have students sketch cloud formations and classify.

3. Hold a photo contest and give a prize for the best black-and white prints of typical cloud formations, taken from the ground or in a plane.

4. Repeat the above on a colored-slide basis.

5. Publish the prize-winning photos in the school paper.

6. Study the new Utah State Aeronautical map for cloud form information--available from the Utah State Aeronautics Commission.

7. From the book, A Student Guide to Aeronautics, demonstrate the solving of the cloud base problems on page 57.

Films:

"Classification and Recognition of Clouds" (High, middle and low clouds, and vertical development. 16 mm. sound, 4 parts; loan by CAA)

"Clouds" (Various types of clouds and movement, high and low pressure. 16 mm. sound, loan by Weather Bureau)

"Clouds and Weather" (16 mm. sound, 6 minutes. Commentary in detailed explanation of changes in weather and clouds)

"Fair Weather Clouds" (A series of pictures of cloud formations of various types. Rent from Teaching Film Custodians, Inc., 25 West 43rd Street, New York 18, New York)

"Foul Weather Clouds" (Presents pictures of clouds that bring bad weather, levels at which various types of clouds occur, and explains the weather which usually accompanies them. Loan or rent from Teaching Film Custodians)

"Clouds" (16 mm. sound, 10 minutes, Bell & Howell Film Sound Library, 30 Rockefeller Plaza, New York 20, New York)

METEOROLOGY

Section VII. Winds and Air Circulation

Text references: Aviation Study Manual, Unit 6, pp. 15-21
Aerology for Pilots, Chapter 2
Pilot's Weather Handbook, Chapter VII
Realm of Flight, Chapter IV

I. Effect of sun's heat on air circulation

  A. At the equator

  B. At the horse latitudes

  C. At the poles

II. Circulation of the atmosphere

  A. Flow from high pressure areas to low pressure areas

    1. A steep-pressure gradient means high velocity

    2. A shallow-pressure gradient means low velocity

  B. The earth's rotational effect

    1. Air circulates toward a low-pressure area in a counter-clockwise direction.

    2. Air circulates toward a high-pressure area in a clockwise direction.

  C. Friction with ground or sea surfaces

    1. Cause of turbulence and gustiness

    2. Slows down the wind

    3. Friction effects wind to about 1500 feet above flat surfaces and 3000 feet above mountain areas.

  D. The effect of gravity is to pull air toward the earth.

  E. Centrifugal force effect on wind

    1. Encreases speed of wind in high-pressure areas

    2. Decreases speed of wind in low-pressure areas

  F. Jet stream

III. Local wind movements

A. Convection currents

1. Vertical currents caused by uneven heating of the air

2. During daytime the land gets warm and water stays cool, causing an onshore breeze.

3. Nighttime land cools and water is warm, causing an off-shore breeze.

B. Eddy currents

1. Very turbulent

2. Caused by flow of wind over buildings, hills and mountains

3. Air flow is disturbed so as to make landing, take-offs, and flying dangerous in eddy current areas.

C. Mountain and valley breezes

1. Daytime up-slope winds

2. Nighttime down-slope winds

D. Foehn winds

1. Downhill winds cause heating of air by compression.

2. Common in western states as "chinook" wind

3. Low humidity because of warmer air

E. Fall winds

1. In cold plateau regions

2. Cold air flowing downhill

3. High velocities

4. They are seldom found in the U. S., but Europe and Greenland have many.

IV. Measuring and recording wind

A. Wind direction

1. Direction from which wind is blowing

2. It can be expressed in points of the compass or degrees of azimuth.

3. Wind from the east would be "wind 90°".

B. Recording instruments

1. Anemometers

a. Rotating-cup type

b. Pressure-plate type

c. Bridled or torque type

d. Pressure-tube type

2. Weather balloons--radiosonde

3. Wind vane

C. Methods used to record wind

1. Miles per hour from a certain direction (See explanation of weather report symbols in Aerology for Pilots, Chapter 1; Pilot's Weather Handbook, p. 89; Realm of Flight, pp. 40, 41.)

2. Beaufort scale numbers

Things to do:

1. Record daily wind speed and direction.

2. Use official weather bureau symbols to record.

3. Correlate wind speed and direction with barometer readings and temperature. Try forecasting possible approaching storms from your readings.

4. From the book, A Student Guide to Aeronautics, conduct the experiment on "Convection Currents" on page 60.

Films:

"Primary Circulation" (16 mm. sound. 19 minutes. Bell & Howell Film Sound Library, 30 Rockefeller Plaza, New York 20, New York)

"Operation Hurricane" (16 mm. sound. 14 minutes. Through the efficiency of the U. S. Weather Bureau, hurricanes can be prepared for which helps to cut down on the loss of lives and property and saves time and money for all. U. S. Weather Bureau. Can be obtained at USAC Visual Aids Department)

"Hurricane Hunters" (16 mm. sound. 15 minutes. The story of the flying weathermen who fly into the center of a hurricane to measure its force and plot its direction. Free--loan by U. S. Air Force)

METEOROLOGY

Section VIII. Air Masses

Text references: Aviation Study Manual, Unit 6, pp. 30-31
Aerology for Pilots, Chapter 10
Pilot's Weather Handbook, Chapter VIII
Realm of Flight, Chapter VII
Basic Aeronautics, pp. 119-122

I. Air mass source regions

A. Define air mass

B. Region where air mass acquired its characteristics is its source region.

II. Air mass classification

A. Arctic air masses indicated by "A"

1. Prefix "M" indicates maritime air.

2. Prefix "C" " continental air.

3. Suffix "K" " colder than surface.

4. Suffix "W" " warmer than surface.

B. Polar air masses indicated by "P"

1. Prefix "M" or "C"

2. Suffix "K"

C. Tropical air masses indicated by "T" with prefix "M" or "C"

D. Temperature of mass is not as important as temperature in relation to land or water over which it is moving. It is thus classified as warmer or colder than land or water over which it is passing.

E. Principal North American air masses

1. cAw--continental Arctic air, warmer than the surface over which it lies (stable in about the lower 5,000 feet)

2. cAk--continental Arctic air, colder than the surface over which it is passing (unstable in about the lower 5,000)

3. mAk--maritime Arctic air, colder than the surface over which it is passing (unstable)

4. cPw--continental polar air, warmer than the surface over which it is passing (stable in about the lower 5,000)

5. cPk--continental polar air, colder than the surface over which it is passing (unstable)

6. mPw--maritime polar air, colder than the surface over which it is passing (stable in about the lower 5,000 feet)

7. mPk--maritime polar air, colder than the surface over which it passing (unstable)

8. mTw--maritime tropical air, warmer than the surface over which it is passing (stable in about the lower 5,000 feet)

9. mTk--maritime tropical air, colder than the surface over which it lies or is passing (unstable)

III. Winter air masses (North American)

A. Continental Arctic--"cA"

1. Source region, American continent above 50° north latitude

2. Extremely cold heavy air

3. Flows southward over the land

B. Continental polar--"cP"
(Same as above)

C. Maritime Arctic--"mA", and Maritime polar--"mP"

1. Flows in from North Pacific ocean areas

D. Maritime tropical--"mT"

1. Flows in from Pacific ocean (Hawaii)

2. Flows in from Caribbean Sea and Gulf of Mexico

a. Warm and has high moisture content

IV. Summer air masses (North American)

A. Continental Arctic--"cA", Continental polar "cP"

1. Usually weak and hard to distinguish
2. May result in local thundershowers

B. Maritime polar--"mP"

1. Coastal fogs
2. Moves inland, becomes unstable

C. Maritime tropical--"mT"

1. Pacific area masses are insignificant.
2. Caribbean Sea masses cause rain, oppressive heat, and humidity in the Atlantic states.

Things to do:

1. Study frontal areas and storms from official weather maps and determine the source of the air masses involved.
2. Study the daily weather map in The Salt Lake Tribune and determine possible sources of the air masses.

Films:

"Aerology - Air Masses and Fronts" (20 minutes, color, 16 mm. sound. Describes the troposphere, the formation of clouds, warm and cold fronts and cyclones, and explains the conditions responsible for kinds of weather. Loan by CAA)

"Air Masses" (77 frame filmstrip. The formation of lows and highs in detail. Rain, the formation of ice, and the occurrence of radiation, advection, and upslope fogs are also discussed.

METEOROLOGY

Section IX. Fronts and Frontal Weather

Text references: Aviation Study Manual, Unit 6, pp. 31-35
Aerology for Pilots, Chapter 11
Pilot's Weather Handbook, Chapter IX
Realm of Flight, Chapter VII
Basic Aeronautics, pp. 122-126

I. Warm fronts

A. Warm air is replacing cold air.

B. Move slowly

C. Produce clouds, rain and fog

D. Produce serious aircraft icing conditions

E. Low ceilings and poor visibility

II. Cold fronts

A. Cold air moving in under warm air and forcing it up and out

B. Moves faster than a warm front

1. Slow moving cold front

2. Fast moving cold front

C. Steeper frontal surface slope

D. Fast moving, preceded by thunderstorm

E. Thunderstorms and heavy clouds advance with a cold front.

F. All towering cumulo form clouds are caused by great turbulence and usually produce thunderstorms.

III. Occluded front

A. Caused by warm air being trapped between two cold air masses

B. Warm air rises.

C. Lower ceiling, lower visibilities and rain until cold front arrives, then changes to squalls, turbulence and thunderstorms.

Things to do:

1. Study daily weather map in The Salt Lake Tribune and determine type of weather associated with the front.

2. Observe any frontal activity in your area and determine type, direction of movement and temperature change.

3. Ask an experienced pilot about flying in frontal activity of the type being studied.

4. From the book, A Student Guide to Aeronautics, construct a "sliding cloud sequence rack" as described on page 65.

Films:

"Aerology - Air Masses and Fronts" (16 mm. sound, 20 minutes, color. Describes the troposphere, the formation of clouds, warm and cold fronts and cyclones, and explains the conditions responsible for different kinds of weather. Loan by CAA)

"Aerology - The Cold Front" (16 mm. sound, 18 minutes, color. Explains the formation, characteristics and dangers of a cold front, demonstrates how to avoid the hazards of the cold front by either high or low level flight. Loan CAA)

"Aerology - The Warm Front" (16 mm. sound, 20 minutes, color. Explains the meeting boundaries of warm and cold air, dangerous stratified layers of clouds formed, how to plan a course around them, types of visibility, precipitation, and ceiling conditions, their locations, cirrus, cirro-stratus, and alto-stratus clouds.)

"Aerology - Occluded Fronts" (16 mm. sound, 22 min. color. Shows the development and movement of cyclones and the initial stages which are the warm and cold fronts. Demonstrates on a weather map the action of a cold and warm front occlusion. Points out the weather problems in flight operation in warm and cold front type occlusion. Loan by CAA)

"Weather" (Explains the development of high and low pressure areas and cold fronts. 16 mm. sound. Rent from Iowa State College of Agriculture and Mechanical Arts, Visual Instruction Service, Ames, Iowa)

METEOROLOGY

Section X. Thunderstorms

Text references: Pilot's Weather Handbook, Chapter X
Aerology for Pilots, Chapter 16
Realm of Flight, p. 25

I. Thunderstorm formation

A. Moist, unstable air heated from below causes it to rise.

B. Moist, unstable air forced up over a mountain

C. Atmospheric convection

II. Life cycle of a thunderstorm

A. Formation of the cumulus stage

1. Always starts with a cumulus cloud

2. Very pronounced updraft in center, up to 3,000 feet per minute

3. Small water droplets in precipitation

B. Mature stage

1. Indicated by heavy rain emerging from bottom of cell

2. Part of cloud now has a very pronounced down draft, about 2,000 feet per minute.

3. A sharp, gusty surface wind flows out from the bottom.

4. Heavy turbulence

5. Usually lasts 15 to 30 minutes

C. Dissipating stage

1. Air spreads horizontally.

2. Entire cell becomes a downdraft.

3. Top of cell is tilted by wind.

4. Rain at base gradually diminishes.

5. Wind subsudes and surrounding air returns to normal.

III. Electricity within a thunderstorm

A. Severe lightning occurs within cell during a storm.

B. Severe lightning occurs between cloud and ground.

C. Twenty to thirty million volts are required to produce an arc 10,000 feet long. Current is probably in excess of sixty thousand amperes.

D. Conclusions concerning lightning in a thunderstorm cell:

1. As a rule the thunderstorm cloud must reach an altitude where environmental temperature is -4° F. before lightning occurs.

2. Maximum lightning frequency is observed at the time the thunderstorm cell reaches its maximum height.

3. As the height of the thunderstorm decreases the frequency of the lightning also decreases.

4. It appears that a greater cell height (or lower temperature of the cloud top) is necessary to initiate lightning than is required to maintain it once it has begun.

5. The maximum lightning frequency precedes the time of maximum five-minute rainfall at the ground surface.

IV. Thunderstorms and airplanes in flight

A. Severe drafts in vicinity, up to four miles

1. Updrafts at forming of cell

2. Downdrafts toward the maximum intensity of storm

B. Severe gusts

1. Most severe at 5,000 to 10,000 feet below crest of cell

C. Lightning

1. Can cause severe damage

2. Less frequent in lower levels

D. Hail

1. Probably the worst hazard of thunderstorm flying

2. Can severely damage aircraft and may ruin control surfaces.

V. Thunderstorms and ground operation

A. Wind and turbulence

1. Ahead of storm, strong wind

2. Affects take-offs and landings

B. Effects on altimeter readings

1. Fall of pressure ahead of storm

2. Rise of pressure during rain period

3. Return to normal after the storm

4. Can effect altimeter readings more than 100 feet

Things to do:

1. Show a movie on thunderstorm formation

2. Observe a thunderstorm in action.

3. Observe a single thunderhead cloud from a distance and note:

a. Direction of movement

b. Approximate height

c. Precipitation

d. Dust ahead of cloud movement

Films:

"Aerology - Thunderstorms" (16 mm. souhd, 41 minutes. Explains formation of thunderstorms and dangers in flying. Loan by CAA)

"Thunderstorms" (16 mm. sound. Bell & Howell Film Sound Library, 20 Rockefeller Plaza, New York 20, New York)

METEOROLOGY

Section XI. Icing and Turbulence

Text references: Aerology for Pilots, Chapter 15
Pilot's Weather Handbook, Chapter XI
Realm of Flight, p. 28
Basic Aeronautics, pp. 136-37

I. Ice formation

A. A major aviation problem

B. Two fundamental requirements for ice formation on flying aircraft.

1. Craft must be flying through visible water in form of rain or mist.

2. Temperature of air must be 32° or lower.

3. Icing can be prevented by flying in areas of low moisture or warmer temperature.

II. Types of ice

A. Clear ice--glaze

1. Transparent, glossy

2. Forms on leading edge of wings, antenna, and tail

3. Difficult to remove

B. Rime ice

1. Milky, opaque and granular

2. Rough surface

3. Very detrimental to smooth air flow

4. Does not necessarily follow airfoil

C. Frost

1. Light, feathery, whitish, crystalline structure

2. Usually disappears if formed in flight
(Never take off with an airplane coated with frost. It spoils airflow, cuts down lift and increases drag.)

III. Effect of ice on aircraft in flight

A. Decrease in wing lift

1. Spoils airfoil shape

2. Increases stalling speed

B. Increase in drag (Due to airflow over rough ice)

C. Decrease in propeller efficiency

1. Spoils airfoil

2. Unbalances propeller

D. Increase in overall weight (Caused by accumulation of ice on wings, tail, etc.)

E. Carburetor ice may form

1. Reducing power

2. Stopping engine

IV. Rules concerning the conditions under which icing may be expected

A. Icing can occur at any time a flight is conducted through liquid water clouds when the temperature is near freezing or lower.

B. Icing is almost certain when flying in rain or wet snow if the temperature is near freezing or lower.

C. Given conditions favorable for icing in clouds lying over mountainous terrain, the heaviest icing will usually be found at altitudes within 5,000 feet of the tops of the ridges.

D. Heavy glaze or rime should be expected in the tops of cumulus clouds when the temperature is near or below freezing at that level.

E. Frost formation on propellers and aft wing and tail surfaces may be expected when running up engines in freezing weather, provided the relative humidity is high.

F. Ice formation, due to water splash, should be expected in brakes, landing gear, and flap mechanism when taxiing on wet pavements during freezing temperatures.

V. Rules concerning protection of aircraft from icing while on the ground

A. Keep aircraft in heated hangar, if possible.

B. Wing covers and engine covers should be used if aircraft is kept in the open.

C. Cover pitot tube to keep out snow during snowstorm or blowing snow.

D. A rubber scraper should be used to remove frost. Waste rags may also be used.

E. Removal of ice by application of hot water is not advisable. It will only freeze again and may produce a condition worse than existed before application.

VI. Good operating practices when flying in icing weather

A. When flying in regions of possible icing condition, plan your flight so as to be in the region for the shortest possible time.

B. Caution should be exercised when flying through rain or wet snow with the temperature at flight levels near freezing.

C. When flying into clouds above the crest of ridges or mountains, maintain a clearance of 4,000 or 5,000 feet above the ridges if the temperature within the cloud is below freezing. Icing is more probable over the crest of ridges than over the adjacent valleys.

D. Watch for ice when flying through cumulus clouds with the temperature at flight level near freezing.

E. When ice has formed on the aircraft, avoid maneuvers that will increase the wing loading.

F. Remember that gas consumption is greater when flying under icing conditions, due to increased drag and the additional power required.

G. Consult the latest forecasts for expected icing conditions.

VII. Turbulence

A. Convection currents

1. Caused by updrafts of heated air

2. Caused by downdrafts of cool air

B. Terrain turbulence

1. Caused by wind flowing over hills or mountains

2. Can be very severe

C. Wind shear

1. Change of wind direction in a short distance

2. Can be horizontal shear or vertical shear or both.

D. Clear-air turbulence

1. No warning clouds

2. Two causes

   a. Passage of another aircraft

   b. Wind shear in vicinity of jet stream

3. High-level turbulence

   a. Found between thirty and forty thousand feet

   b. Best explanation is jet stream effect.

<u>Things to do</u>:

1. Place an electric fan outside on a cold day (about 32° F. or lower) and spray a fine mist of water into the blades from a spray bottle window cleaner dispenser. Study ice formation.

2. Repeat the above, but place a small metal airplane behind the fan and spray moisture into slip stream between the fan and model. Study ice formation.

3. Note cloud formations in the sky and discuss possible areas of greatest turbulence.

<u>Films</u>:

"Air Masses" (35 mm. filmstrips, 77 frames. The formation of lows and highs is explained in some detail. Rain, the formation of ice, and the occurrence of radiation, advection, and upslope fogs are also discussed. Loan by CAA)

METEOROLOGY

Section XII. Fog and Low Stratus

Text references: Aerology for Pilots, Chapter 17
Pilot's Weather Handbook, Chapter XII
Realm of Flight, Chapter VI
Basic Aeronautics, pp. 133-136

I. Fog formation

A. Minute water droplets in the air

B. In extreme cold, ice needles form, known as ice fog.

C. Caused by cooling of moisture-laden air close to the ground

II. Fog types

A. Radiation fog

1. On or near surface

2. Deepest in valleys

3. Four miles per hour wind causes rising to great thickness.

B. Advection fog

1. Warm moist air over a cold surface

2. Sea coast fogs are advection fogs.

C. Upslope fog

1. Adiabatic cooling of air with upslope winds causes fog.

2. Upslope fog covers large areas.

3. Wherever moist winds blow upslope, this fog forms.

D. Frontal fog and stratus

1. Warm moist air riding up on a cold front

2. Causes rain and fog

Things to do:

1. Observe fog conditions and discuss the causes.

2. Watch for fog above streams on a cold morning. Discuss its cause. Why is this called "arctic smoke"?

3. Determine ground visibility in miles from your classroom.

Films:

"Aerology - Fog" (16 mm. sound, color, 25 minutes. The theory of fog formation is discussed briefly. The characteristics and conditions conducive to fog are considered in detail.

METEOROLOGY

Section XIII. Upper Air Soundings and Special Instruments

Text references: Pilot's Weather Handbook, Chapter XII
Observing the Weather, Chapters XI, XII

I. Upper air soundings

   A. Every 12 hours

   B. Fifty stations across United States

   C. Pressure, humidity and temperature up to 70,000 feet obtained

II. Upper wind reports

   A. Every 8 hours

   B. 125 stations across U. S.

   C. Wind speed and direction every 1,000 feet to 10,000
      Wind speed and direction every 2,000 feet to 20,000
      Wind speed and direction every 5,000 feet to 50,000

III. Special instruments used

   A. Radiosonde

      1. Pressure

      2. Temperature

      3. Humidity

   B. Radar
      (Tracks storms)

   C. Pilot balloons

      1. Wind speed

      2. Wind direction

   D. Ceilometers

      1. Height of ceiling from ground

      2. Automatic recording devices

      3. Observed reflected light computed by trigonometry

<u>Things to do</u>:

1. Listen to Air Force Transport Service radio station reports on weather and upper air soundings on a frequency of 5.50 megacycles, short wave.

<u>Films</u>:

"Weather and Radar" (16 mm. sound, 17 minutes. Illustrates some of the operational values to be gained by using radar in locating and identifying weather disturbances, including cold fronts, warm fronts thunderstorms, typhoons, and hurricanes. Characteristic echo patterns on the planned position indicator scope are shown. Rent from United World Films, Inc., 1445 Park Avenue, New York 29, or 7356 Melrose Ave. Hollywood 46, Calif.)

METEOROLOGY

Section XIV. Weather Maps and Charts

Text references: Aviation Study Manual, Unit 6, pp. 35-40
Aerology for Pilots, Chapter 1
Pilot's Weather Handbook, Chapter XIV
Realm of Flight, Chapter VII
Basic Aeronautics, pp. 129-133

Additional valuable material: Explanation of Weather Code Figures and Symbols, U. S. Weather Bureau. (Also included in many books on meteorology)
Sample copy of U. S. Weather Bureau map (all for same date) for each student

I. Surface weather maps

A. Made from four daily weather observations

B. Lists only actual weather occurring

II. Station model

A. Arranged around center symbol clockwise as follows:

1. Amount of cloud cover at center

2. Barometric pressure in millibars at 2 o'clock position

3. Pressure change in past 3 hours at 3 o'clock position

4. Precipitation and time at 4 o'clock position

5. Precipitation amount at 5 o'clock position

6. Low-cloud height and amount at 6 o'clock position

7. Low-cloud type at 7 o'clock position

8. Dew point at 8 o'clock position

9. Weather condition at 8:30 position

10. Visibility in eighths of miles at 9 o'clock position

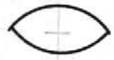
11. Temperature reading at 10 o'clock position

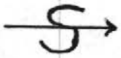
12. Wind direction and speed at any position

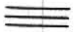
13. Middle- or high-cloud type at 12 o'clock position

III. Basic weather symbols for pilots

A.  Haze

B.  Smoke

C.  Dust or sandstorm

D.  Fog

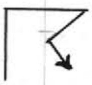
E.  Drizzle

F.  Rain

G.  Snow

H.  Showers

I.  Hail

J.  Thunderstorm

IV. Symbols used for cloud sky cover

A.  Clean, no clouds

B.  1/10 cover

C.  2/10 - 3/10 cover, scattered

D.  4/10, 5/10, 6/10 cover

E.  7/10, 8/10 cover, broken

F.  9/10 cover

G.  Complete cover, overcast

H.  Sky obscured, dust, smoke, haze

V. Front symbols

A. Blue line--cold front

B. Red line--warm front

C. Purple line--occluded front

D. Dashed blue line--upper cold

E. Dashed red line--upper warm

F. Solid alternating blue and red--stationary front

G. Dashed and dotted purple line--squall line

Things to do:

1. Study recent copies of U. S. Daily Weather Map.

2. Make a station model report for your school or town each day.

3. From the book, A Student Guide to Aeronautics, construct a "pin-up weather map", and a "classroom station model" as described on pages 63-64.

Films:

"Story of a Disturbance" (16 or 35 mm. sound or wilent, 13 min. Describes the conditions indicated by isobars, fronts, and other symbols on a weather map. Illustrates the sequence of cloud formations to be found during the passage of a disturbance across the British Isles. Also show pictures of cumulus and strato-cumulus clouds which follow in wake of a disturbance. Rent from International Film Bureau, 6 North Michigan Ave., Chicago 2, Ill.)

"Weather Forecasting" (16 mm. silent, 15 min. The collection, tabulation, and interpretation of weather data obtained from observations and instruments. Data sent to headquarters is charted on a map. Rent from University of Kansas, Bureau of Visual Instruction, Lawrence, Kansas)

"Flying the Weather Map" (16 mm. sound, color, 27 minutes. Shows observers determining weather conditions at posts. Illustrates the map's features and shows various fronts represented by colored lines. Explains symbols indicating precipitation areas, thunderstorms, rain showers, air masses and pressure areas.

"How Weather is forecast" (16 mm. sound, 10 min. Shows the operation of a weather observation station and a weather forecasting station. By means of animation, a weather map is charted and its symbols explained. The instruments used in weather forecasting and their functions are discussed. Rent from Coronet Films, Coronet Bldg., Chicago, Ill.)

UNIT VII

NAVIGATION

Introduction

This unit of study will present to the student some of the problems encountered by a pilot in planning and making a cross-country flight. During this unit the student will be introduced to the many different kinds of charts used by pilots and navigators, he will learn to read the basic symbols of a chart, and understand the civil airways markings that are shown.

Additional subjects covered are: longitude and latitude, magnetic variation, the use of the compass, the measurement of distance, time, and speed, the effect of the wind on an airplane in flight, basic flight planning, and a general overview of radio navigation.

The study of navigation should stimulate student interest in geography, mathematics and cartography.

Books

The following books are recommended for this unit of study (See Bibliography)

Basic Aeronautics, M. E. Tower

A Student Guide for Aeronautics, M. E. Tower

Practical Air Navigation, Thoburn C. Lyons

Path of Flight, George S. Stanton

Aviation Study Manual, Volume I, Book II

Supplies

Navigation plotters (obtain from Aero Publishers)

Navigation computer-student model (obtain from Aero Publishers)

$8\frac{1}{2}$ x 11 graph paper

Sufficient copies of Salt Lake City, Grand Junction, and Grand Canyon Sectional Charts and/or World Aeronautical Charts of Utah for the class

Wall charts of different types of aircraft instruments from the Kollsman Instrument Co., Elmhurst, New York

NAVIGATION

Section I. The Earth We Live On

Text references: Practical Air Navigation, Chapter 2
Aviation Study Manual, Unit 7, pp. 1-10

I. Shape of the earth

  A. Not exactly round

  B. Difference in diameter between poles and at the equator of 27 miles

  C. Classed as a spheroid

II. Mapping reference points

  A. The equator

    1. Divides the earth into two halves at a point midway between the poles

    2. Imaginary line

  B. Prime meridian

    1. An imaginary line running from pole to pole, passing through Greenwich, England

    2. Starting point for the measurement of all longitude lines

  C. Longitude lines or meridians

    1. Imaginary lines running from pole to pole across the equator

    2. Divide the earth into one-degree increments as measured at the equator

    3. East longitude measured from Greenwich eastward to 180-degree line

    4. West longitude measured from Greenwich westward to 180-degree line

    5. The 180-degree longitude line is known as the International date line.

D. Latitude lines or parallels

1. Measured in a north-south direction along a meridian

2. Used to indicate number of degrees north or south of the equator

3. The equator is zero degrees latitude.

4. The poles are 90 degrees north or south latitude.

5. As the parallels approach the poles, they become progressively smaller.

III. Distance measurements

A. Great circles

1. Any line passing through the center of the earth dividing the earth in two equal parts

2. The equator is a great circle.

B. Small circles

1. Any line not passing through the center of the earth which divides the earth into two unequal parts

2. All parallels, except the equator, are small circles.

C. Great circle routes

1. Airplanes fly great circle routes in long flights.

2. A great circle route is the shortest distance between two points on the earth's surface.

IV. Time zones

A. World time zones

1. Every 15 degrees of longitude represent a new time zone and one hour change.

2. Some discrepancies have crept in due to geographical and cultural areas.

B. U. S. time zones

1. Eastern standard time

2. Central standard time

3. Mountain standard time

4. Pacific standard time

Things to do:

1. Find the longitude and latitude of your town.

2. Find the spot on the earth which is exactly 180 degrees opposite from your town, both in longitude and latitude reading.

3. Construct a time converter for the class or have each student make one for himself.

   a. Use a heavy cardboard paper.

   b. Lay out a 5-inch circle.

   c. Divide the circle into 15-degree sectors.

   d. Designate one radial line as Greenwich and the line 180 degrees opposite as the International date line.

   e. Mountain standard time is seven sectors away from Greenwich, on the plus or west longitude side.

   f. Fill in the rest of the time zones.

   g. Lay out a 4-inch circle and divide it into 15-degree sectors.

   h. Subdivide each sector into four equal parts.

   i. Label each 15-degree sector as one hour of time, marked in a counterclockwise direction.

   j. First mark from 12 midnight to 12 noon to midnight again; there are 24 sectors.

   k. Now go around again and number from 01 to 24 to correspond to the 24-hour system of numbering.

   l. Cut out the 4-inch circle and mount on top of and in the exact center of the larger 5-inch circle with a small brad or rivet, so that the top circle can rotate.

   m. You can now set any hour of the day on Mountain standard time and instantly see the time in any part of the world.

<u>Films</u>:

"Navigation - The Earth" (16 mm. sound, 16 minutes. Explains the arrangement and meaning of the poles, great circles, parallels, meridians, longitude, latitude, nautical mile and departure. Loan by CAA)

"Navigation - Time - Parts I, II, and III" (16 mm. sound, 56 minutes. Divides the globe into time zones, divides time into apparent, sidereal, and mean time; illustrates the use of chronometer, and gives examples of three means of computation of time and its reckoning. Animated diagrams used. Loan by CAA)

NAVIGATION

Section II. Map Making

Text references: Practical Air Navigation, Chapter 3
Aviation Study Manual, Unit 7, pp. 1-32
Basic Aeronautics, pp. 141-145

I. Problems of transferring surface area of a sphere to a flat surface

A. Spherical surface is nondevelopable.

1. Wide gaps appear at and near the poles

2. The equator line is the only complete section.

3. A map of this type is not very satisfactory.

4. Maps must be a complete flat surface to be useful.

B. Flat surface maps

1. Majority of maps are flattened small sections of the earth's surface.

2. Flat maps are distorted.

a. Distances changed on some

b. Areas changed on some

c. True directions changed on some

3. Map design is determined by the type of navigation to be accomplished.

a. Mercator projection used by mariners

b. Lambert conformal projection used in aviation

II. Types of flat maps most widely used

A. Mercator projection

1. How the Mercator is made

a. Developed in 1569 by Gerhard Kramer, known as Mercator

b. Developed by mathematical formulae

c. This projection is a development of the spheroid shape into a cylinder tangent to the earth at the equator

d. The cylinderical shape is then cut down one side and laid out flat.

2. Characteristics of the Mercator

   a. Longitude lines are treated as not converging at the poles.

   b. All longitude lines or parallels are at every point the same distance apart.

   c. Meridians and parallels are at 90 degree angles to each other at all points.

   d. Meridians, or latitude lines, are spaced a greater distance apart as they approach the poles of the earth so as to keep the area of a rectangle proportional to the shape of the same rectangle on the earth.

3. Advantages of the Mercator projection

   a. For navigation 10 to 15 degrees on each side of the equator, it is very accurate.

   b. It is designed to show all rhumb lines as straight lines.

4. Disadvantages of the Mercator projection

   a. Earth areas located more than 50 degrees away from the equator are greatly distorted.

   b. Scale of miles changes rapidly away from the equator.

   c. Great circle lines are curved lines, resulting in a misleading perspective.

   d. The polar concept of the earth is entirely lost.

5. Modified Mercator projections

   a. Transverse Mercator projection

      (1) Cylinder development turned 90 degrees to the equator

      (2) Cylinder tangent along one meridian

      (3) Used for series of charts for polar navigation

   b. Oblique Mercator projection

      (1) Axis of cylinder turned at any angle desired

(2) Can be made tangent to great circle route between two points

B. Lambert conformal conic projection

1. How the Lambert is made

a. Developed in 1772, used very little until World War I

b. Developed by mathematical formulae

c. This projection is a development of the sphere into a flat surface by treating the half sphere above and below the equator as a cone, with the meridians all intersecting at an imaginary point out in space. The projection is first developed as a tangent cone; then the scale is shrunk until the conical lines intersect the desired parallels at the outer periphery of the sphere.

d. The flat area map is then bounded by two parallels, between which there is little change of scale.

e. On the U. S. map the scale is exact on the 39-degree latitude line. A variation of one half of one percent is noted at the 45- and 33-degree parallel.

2. Characteristics of the Lambert

a. Shapes of limited areas are retained.

b. Affords maximum accuracy of direction and distance

c. The majority of aeronautical charts are Lambert conformal conic projections.

(1) World aeronautical charts

(2) Sectional charts

(3) Planning charts

d. Parallels and meridians do not cross each other at 90 degree angles.

e. The U. S. planning chart has a series of scales for various latitudes on the chart. This makes the Lambert even more accurate in distance measurements.

f. Maximum change in scale on the Lambert is about one percent, or one mile in one hundred.

3. Advantages of the Lambert

   a. Afford maximum accuracy of direction and distance

   b. A great circle line is very close to a straight line on this chart.

   c. Both above items are ideally suited to aerial navigation.

   d. Permits a good match between maps if several separate charts need to be used

   e. Very simple to use for all problems of dead reckoning

   f. Well suited to all problems of position plotting, including celestial navigation

C. The Gnomonic projection

1. How the gnomonic is made

   a. Believed to have been developed by Thales in 550 B. C.

   b. This type of chart is developed by projecting the lines of meridian and parallels on a flat surface which is tangent to the one point on the earth's surface, the point of projection being the center of the earth's sphere.

2. Characteristics of the gnomonic

   a. All meridians appear as straight lines.

   b. All parallels appear as curved lines.

   c. At the center of the chart all bearings are true.

   d. Bearings change away from center.

   e. It is used by the United States Air Force in "Great Circle Tracking" charts.

3. Advantages of gnomonic

   a. Great circles are straight lines.

   b. Straight line great circle routes are advantageous for direction finding.

4. Disadvantages of the gnomonic

    1. Distorted compass rose must be used or other methods resorted to for reading bearings.

    2. Distances, direction and areas distort rapidly as the distance from the center increases.

Things to do:

1. Study your school wall maps and study the type of construction. Note the following:

    a. Angles at which longitude and latitude cross

    b. Are longitude and latitude lines straight or curved?

2. Obtain chart #3093 from the U. S. Coast and Geodetic Survey, Washington, D. C., and construct a Lambert globe. This is a special chart printed on heavy paper and especially designed for this project. Full instructions accompany the chart for making into a 9-inch globe. Cost is 25¢ per chart. Obtain sufficient copies for all students in your class and use as a class project on an individual basis.

Films:

"Navigation - Charts" (16 mm. sound, 19 minutes. Employs animated diagrams and some straight photography to explain the meaning, advantages, and limitations of Mercator, gnomonic, and Lambert conformal projections. Loan by CAA)

"Global Concepts and the Age of Flight" (35 mm. filmstrip, 24 frames) Explains the development of map projections; also highlights the implications of a global geography and global flight on youth. Loan by United Airlines, School and College Services, 5959 South Cicero Ave., Chicago 38, Ill.

NAVIGATION

Section III. Reading Aeronautical Charts

Text references: Practical Air Navigation, Chapter 4
Path of Flight, Chapter IV
Aviation Study Manual, Unit 7, pp. 38-41
Basic Aeronautics, pp. 160-162

I. Topographic information

A. Drainage symbols

1. Streams

2. Lakes

a. Permanent

b. Intermittent

c. Dry

3. Canals

4. Swamps

5. Other bodies of water

a. Reservoirs, etc.

B. Culture symbols

1. Towns

2. Cities

3. Roads

4. Railroads

5. Radio towers

6. Power lines

C. Relief

1. Mountains

2. Hills

3. Valleys

4. Plateaus

II. Aeronautical data

A. Civil airways

1. Ten miles wide

2. Usually straight line between two cities or two prominent landmarks

B. Airports

1. Civil

2. Military

C. Danger areas

1. Usually military areas

D. Navigational aids

E. Radio facilities

1. All facilities of every field

2. Range stations

3. Omni stations

III. Legend data

A. Dates

1. Date of aeronautical information in large red figures

2. Date of cultural and topographic information in smaller black figures

3. Sectional charts are printed every six months.

B. Notes

1. Symbol explanations

2. Unusual conditions and explanations

3. Key to elevation gradient tints

4. Index showing relation to other charts
5. Relation of chart to international mapping indexes
6. Longitude and latitude figures
7. Chart coverage of longitude and latitude

C. Projection

1. Type of projection
2. Parallels used

D. Scale

1. Scale of chart
    a. 1:500,000
    b. 1:1,000,000
2. Measuring scales
    a. Statute miles
    b. Nautical miles
    c. Kilometers
3. Compass rose
    a. True compass rose
    b. Magnetic compass rose at each omni range station
    c. Reciprocal reading compass rose

Things to do:

1. Study sectional charts of Utah. Find the following items:

   a. Your town

   b. Your airport

   c. Nearby streams

   d. Power lines

   e. Nearest civil airway

   f. Nearest navigation lights

   g. Danger and prohibited areas

   h. Nearest mountain

   i. Nearest lake

   j. Radio range station

   k. Scale of map

   l. Compass rose

Films:

"Navigation - Aerial Map Reading" (16 mm. sound, 22 minutes. How to read aerial maps and the use of landmarks and features in finding position are studied. Briefly touches on changing seasons, features to look for at sea, night flying, and flying when lost. Plots a course from Corpus Christi to Sabine Pass, determines ETA using landmarks in the demonstration. Loan by CAA)

NAVIGATION

Section IV. Types of Charts Used in Air Navigation

Text references: *Practical Air Navigation*, Chapter 1
Path of Flight, Chapter I
Aviation Study Manual, Unit 7, pp. 36-40
Aeronautical Chart Catalog, U. S. Coast and Geodetic Survey

I. Planning charts

A. Scale of 1:5,000,000 or 80 miles to the inch

B. One chart covers the entire United States (Number 3069-B or AP-9)

C. Used for long flight planning

D. The entire world is covered by 43 charts, size 32" x 47" each.

II. Radio directional finding charts

A. Scale of 1:2,000,000 or 32 miles to the inch

B. Six charts cover U. S. with wide overlaps

C. Used by pilots flying on instruments to facilitate plotting bearings

III. World Aeronautical charts (WAC)

A. Scale of 1:1,000,000 or about 16 miles to the inch

B. Used for navigation or piloting

C. 43 charts cover the U. S.

D. Utah is covered by two charts.

1. WAC - 305

2. WAC-362

E. Size is 21" x 28", folds to 7½" x 11", cost--25¢ each

IV. Flight charts

A. Scale 1:1,000,000 or 16 miles to the inch

B. Strip charts of principal U. S. air routes

C. Identical in detail to WAC

D. Size 14" wide: covers an area 100 miles on either side of civil airway and 50 miles beyond terminal points.

E. Thirty-seven charts published for the United States.

V. Sectional charts

A. Scale 1:500,000 or 8 miles to the inch

B. Covers 2 degrees of latitude and 6 degrees of longitude

C. Suitable for all forms of navigation, but mostly used by private flyers for visual flying (VFR), or landmark flying

D. Great detail, particularly on landmarks

E. Most widely used chart

F. Eighty-seven charts cover the U. S., size 20" x 42", cost 25¢ each

G. Designated by name, such as Salt Lake City

H. Utah covered by three sectional charts:

1. Salt Lake City

2. Grand Junction

3. Grand Canyon

VI. Local charts

A. Scale 1:250,000 or 4 miles to the inch

B. Available for highly developed industrial areas only

VII. Special charts

A. Instrument approach and landing charts

B. Instrument landing charts for G. C. A.

C. Route charts

D. Great circle chart of U. S. #3074-A

E. Airline distance chart of U. S. Cities #3064

F. Wall chart in two sections covering U. S. (Large size AP-9 essentially) #3060-d

1. Ideal for classroom wall chart

<u>Things to do</u>:

1. Obtain wall chart #3060-d and mount on wall in your class room.

2. Study World Aeronautical Chart for your section of Utah.

3. Study Sectional chart for your section of Utah.

NAVIGATION

Section V. Measurement of Direction

Text references: Practical Air Navigation, Chapter 7
Path of Flight, Chapter II
Aviation Study Manual, Unit 7, pp. 34-36
Basic Aeronautics, pp. 148-155

I. Measurement of course

A. The compass rose

1. Uses 360° of circle measurement to denote angles

2. Angles measured from true north in clockwise direction

a. Northeast--45 degrees

b. East--90 degrees

c. Southeast--135 degrees

d. South--180 degrees

e. Southwest--225 degrees

f. West--270 degrees

g. Northwest--315 degrees

h. North--360 degrees (zero degrees, also)

3. Single degree increments must be used, such as 173 degrees.

B. Determining true course

1. Draw a line on sectional chart between two airports.

2. Measure angle of course (true course) by using a protractor at mid-point of route.

3. If course extends more than one-half of sectional chart, divide course into three or more segments.

4. True course is a chart measurement.

5. Reciprocal course is the return trip of the first course measured. Example: 65° true course is a 245° return course.

II. Factors which change true course readings

A. Variation

1. True north and magnetic north are not the same.

2. Variation is the angle between true north and magnetic north at any given place.

3. Magnetic north pole is located at 71 degrees north latitude and 96 degrees west longitude, about 1300 miles from North Pole.

4. All points of the same variation are connected with an "isogonic" line.

5. Variation is shown on sectional and world aeronautical charts as a dashed red line with variation figure.

6. Variation for Salt Lake City is approximately 17 degrees east.

7. The compass needle at Salt Lake City is pulled to the east of true north by 17 degrees.

8. True heading changes to magnetic heading by adding or subtracting the variation.

9. If variation is east, subtract from true heading. If variation is west, add to true heading.

B. Deviation

1. Change in compass needle reading caused by magnetic fields in the airplane:

   a. Electric curcuits

   b. Radio

   c. Engines

   d. Tools

   e. Steel rods

   f. Magnetized metal parts

2. Deviation error not the same in all directions

3. The compass can be compensated for some of this error.

4. Remaining error must be corrected by the pilot.

5. Compass deviation card

   a. Small card mounted near the compass

   b. Deviation card gives new magnetic heading to steer by when flying in a given heading area.

      Example: For magnetic 90 degrees, steer 84 degrees.
      For magnetic south, steer 182 degrees.

   c. Gives course to steer for the 12 points of the compass

III. Changing "true course" to a usable navigation value

A. Obtain true course from chart.

B. If no wind is present, true course becomes "true heading."

C. True heading plus westerly variation or minus easterly variation equals "magnetic heading."

   1. TH + WV = M. H.

   2. TH - EV = M. H.

D. Magnetic heading plus or minus deviation equals "compass heading."

   1. M. H. $\pm$ Dev. = C. H.

<u>Things to do</u>:

1. Plot a course from Logan to Grantsville.

2. Measure the true course.

3. Apply variation correction and obtain the magnetic heading.

4. Apply deviation correction and obtain the compass heading.

5. Determine the reciprocal course.

<u>Films</u>:

"Aerial Navigation - Dead Reckoning Procedure" (16 mm. sound, 26 minutes. Demonstrates the procedure involved in a typical navigation training mission by dead-reckoning, and explains the use of the various instruments. Loan by CAA, Washington office only)

NAVIGATION

Section VI. Measurement of Distance, Time and Speed

Text references: Practical Air Navigation, Chapter 7
Path of Flight, Chapter III
Aviation Study Manual, Unit 7, pp. 45-47
Basic Aeronautics, pp. 156-166

I. Distance measurements

A. Statute miles

1. One mile is 5280 feet.

2. Used most widely in United States

B. Nautical miles (knots)

1. One nautical mile is 6082 feet.

2. One degree of longitude at the equator is 60 nautical miles.

3. One minute of longitude at the equator is one nautical mile.

4. Used by all mariners and naval aviators

5. Coming into wide use by all phases of aviation

C. Kilometers

1. Used by all European countries

2. One kilometer is 1000 meters.

3. One kilometer is 0.62 miles.

4. One statute mile is 1.6 kilometers.

II. Time measurements

A. Time belts

1. There is a different time belt every 15 degrees of longitude around the world.

2. The United States has four time belts:

a. Eastern standard time

b. Central standard time

c. Mountain standard time

d. Pacific standard time

B. Daily time measuring units

1. 12-hour system

a. The day is divided into two 12-hour periods.

b. Beginning at midnight, the first 12 hours are labeled A. M.

c. Beginning at noon, the second 12 hours are labeled P. M.

2. 24-hour system

a. Beginning at midnight, the day begins with 0000 hours.

b. The designations A. M. and P. M. are not used in the 24-hour system.

1 A. M.--0100 hours	9 P. M.--2100 hours
3 A. M.--0300 hours	10 P. M.--2200 hours
9 A. M.--0900 hours	11 P. M.--2300 hours
12 Noon--1200 hours	11:15 P. M.--2315 hours
1 P. M.--1300 hours	11:30 P. M.--2330 hours
3 P. M.--1500 hours	11:45 P. M.--2345 hours
6 P. M.--1800 hours	12:00 P. M.--2400 hours

C. Hourly time measuring units

1. Hours

a. One day is 24 hours.

b. One hour is 60 minutes.

2. Minutes

a. One minute is 60 seconds

3. Seconds

a. One hour is 3600 seconds.

D. Converting minutes to decimal equivalent hours

Divide minutes by 60.

$\frac{30}{60} = .50$ hours

E. Converting decimal equivalent hours to minutes

Multiply hours by 60.

.75 hours = .75 x 60 = 45 minutes

III. Basic navigation computations

A. Time required to fly a given course

$$\text{Time required} = \frac{\text{D (distance)}}{\text{GS (ground speed)}}$$

Example: Course 320 miles long, ground speed is 80 miles per hour.

$$T = \frac{320}{80} = 4 \text{ hours}$$

B. Distance traveled in a given time

D (distance) = GS (ground speed) x T (time)

Example: D = 80 miles per hour x 4 hours = 320 miles

C. Ground speed of airplane

$$\text{GS (ground speed)} = \frac{\text{D (distance)}}{\text{T (time)}}$$

$$\text{Example: GS} = \frac{\text{320 miles}}{\text{4 hours}} = \text{80 miles per hour}$$

D. Fuel consumption

1. FC (fuel consumption) = Fuel consumption per hour x time of flight

   Example: FC = 4 gallons per hour x 4 hours = 16 gallons used

2. If engine fuel consumption per hour is not known, multiply the horsepower of the engine by .09. This will also allow sufficient reserve for 45 minutes of extra flight time. Thus, a 90-horsepower engine's fuel consumption would be:

   90 x .09 = 8.1 gallons per hour

Things to do:

1. Plot a course from Spanish Fork to Delta.

2. Measure the distance.

3. Determine time required to fly course at various speeds.

4. Determine ground speed if you have a 20-mile per hour head wind.

5. Compute new time required by using problem 4.

Films:

"Navigation - Time, Parts I, II, and III" (16 mm. sound, 46 min. Divides the globe into time zones, divides time into apparent, sidereal, and mean time; illustrates the use of the chronometer, and gives examples of three means of computation of time and its reckoning. Animated diagrams are used. Loan by CAA)

NAVIGATION

Section VII. The Effect of the Wind

Text references: Practical Air Navigation, pp. 120-126
Path of Flight, Chapter III
Aviation Study Manual, Unit 7, pp. 44-46
Basic Aeronautics, pp. 167-167

I. Effect of wind on airplane in flight

A. Wind from the right, airplane drifts to the left of course.

B. Wind from left, airplane drifts to the right of course.

C. Wind from directly behind results in faster ground speed.

D. Wind from directly in front results in slower ground speed.

E. Air speed will remain the same for all the above conditions. (Air speed is the speed of the aircraft relative to the air in which it is flying.)

II. Wind direction and speed

A. Wind direction

1. Always given in direction from which it is blowing

2. Always given in compass rose points

B. Wind speed

1. Given in miles per hour

III. Determining wind-drift angle

A. Plot true course on a sheet of paper.

B. Plot wind direction from the beginning end of your true course line.

C. The angle between these two lines as measured with protractor gives drift angle.

D. Determine whether drift is right or left of your course.

IV. Determining true heading

A. If wind is from the right of your course, add it to "true course" as measured on your chart.

B. If wind is from the left of your course, subtract it from "true course" as measured on your chart.

C. The resulting figure from the above correction is known as "true heading."

D. Correcting from wind drift in flight is called "crabbing." (Airplane crabs into the wind.)

<u>Things</u> <u>to</u> <u>do</u>:

1. Plot a course from Provo to Wendover.
2. Find the true course.
3. Find the true heading if the wind is from 215 degrees at 20 miles per hour.
4. Is drift to the right or to the left?

NAVIGATION

Section VIII. The Wind Triangle

Text references: Practical Air Navigation, Chapter 7
Path of Flight, Chapter VI
Aviation Study Manual, Unit 7, pp. 58-59
Basic Aeronautics, pp. 172-180

I. Uses of the wind triangle

A. To find drift angle

B. To determine "true heading."

1. "True heading" is "true course" corrected for wind effect.

C. To determine ground speed

1. Ground speed is different from air speed, except when there is no wind. If no wind is present, both speeds will be the same.

II. Constructing a wind triangle

A. Plot a course on the chart from one airport to another and measure its true course bearing.

B. Obtain wind speed and direction report from weather bureau.

1. Listen to weather broadcast on low frequency receiver at 15 minutes to the hour and 15 minutes after the hour.

C. Draw a true north and south line on a sheet of paper.

1. Place this line about $2\frac{1}{2}$ inches from the edge of the paper, which represents the point of departure. If the flight is 90 degrees (east), place the line closest to the left hand edge of the paper. This will provide ample room for the triangle.

D. Find the midpoint of the line and make a dot. Label this E. (E stands for earth, or point of departure.)

E. From point E lay out a line representing true course. Label this line TC.

F. From point E lay out a line representing wind direction and speed. Label this line EW.

   1. This line starts at point E.

   2. Use protractor and ruler or scale.

   3. For sectional chart, scale is 8 miles to the inch.

   4. Length of wind line will depend on wind speed for one hour.

   5. Place an arrow on wind line, indicating direction of wind.

G. Measure on the ruler the number of units representing the air speed of the airplane, and draw a line from the end of wind line W to the point of intersection of the airspeed on the ruler and true course line. Label this point of intersection P. (P means position of airplane at the end of one hour of flight.)

H. Measure ground speed along the true course line between EP.

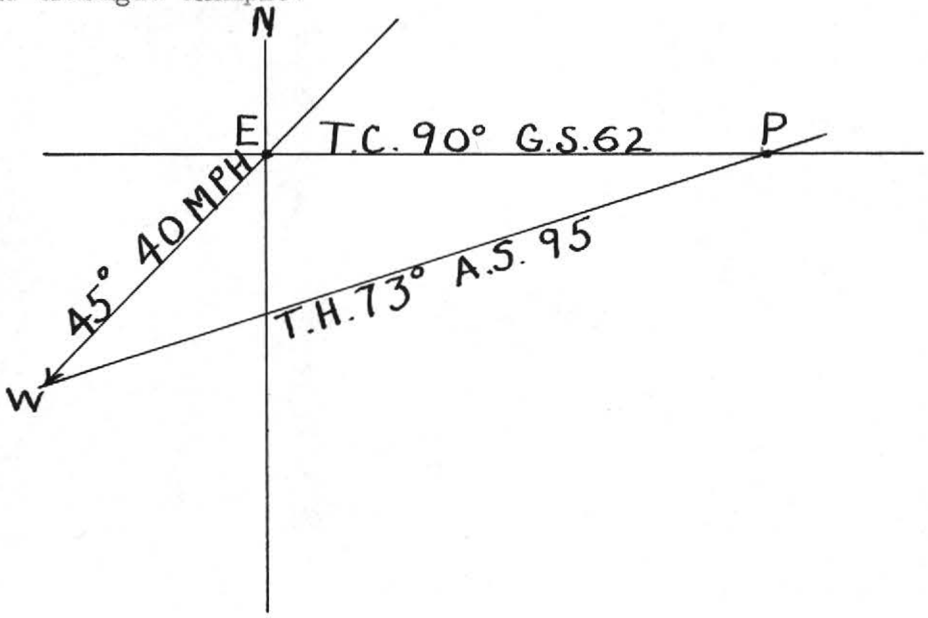
I. Measure wind correction angle (WCA) at point P. (Use protractor at P and measure the angle between line EP and line WP.

J. Determine true heading.

   1. If the wind is blowing from the right of your true course line, add the wind correction angle, WCA.

   2. If the wind is blowing from the left of your true course line, subtract the WCA.

K. Wind triangle example:



L. Because of the effect of wind, on a round-trip flight two different wind triangles must be plotted, one for a flight out and one for a flight back along the same route.

<u>Things to do</u>:

1. Plot a course from Logan, Utah, to Strevell, Idaho.

2. Find true heading and ground speed for the following conditions:

   a. Wind from 270 degrees at 15 miles per hour

   b. Airplane air speed, 100 miles per hour

3. Find time required for trip out.

4. Find time required for trip back.

<u>Films</u>:

"Navigation - Dead Reckoning (Air)" (16 mm. sound, 42 minutes. Shows ground track, air track, wind effect, correction angle, drift angle, establishment of wind direction and velocity for both grid method and drift method and principles underlying each. Loan by CAA)

"Dead Reckoning" (Jam Handy Pilot Training Kit 3, #5. Silent 69 frames, 35 mm. Theory of dead reckoning and its practical application--wind triangle. Loan by CAA)

NAVIGATION

Section IX. Flight Planning

Text references: Practical Air Navigation, pp. 116-118
Path of Flight, pp. 24-26
Aviation Study Manual, Unit 7, pp. 60-61
Basic Aeronautics, Chapter 7

I. Determining best route

A. Chart evaluation

1. A straight line may not be the best route to take.

2. Hazards which should be avoided, and should change your route

a. High mountains

b. Large bodies of water

c. Rough, uninhabited terrain

B. Weather evaluation

1. Weather hazards

a. Thunderstorms

b. Rain, hail or snow storms

c. Dust or sand storms

d. Frontal activity

II. Determining the course

A. Review of terms

1. True course--direction of the line connecting two points, measured in clockwise rotation from true north meridian

2. Wind correction angle--measured from the wind triangle, adding right wind, subtracting left wind

3. True heading--the direction the airplane must be headed to allow for a wind correction

4. Variation--angle between true north and magnetic north, obtained from isogonic lines on the chart. Add to true heading if variation is west, or subtract from true heading if variation is east.

5. Magnetic heading--an intermediate step in computations

6. Deviation--a compass installation error. Obtain this reading from the cockpit compass card.

7. Compass heading--the compass reading which must be maintained to make good the desired course

8. Total distance--the measured length of the route line on the chart

9. Ground speed--the measured length of the true course line on wind triangle

10. Total time for flight--total distance divided by ground speed

11. Fuel rate--known fuel consumption for a given engine

12. Fuel consumption--fuel rate multiplied by total time. (Forty-five minutes of reserve should be carried.)

III. Pilot's Planning Sheet

A. Must be completed before flight

Airplane # Date

Cruising Air Speed	TC	Wind From MPH	WAC R+L-	TH	Var. W+ E-	Mag. Head.	Dev.	CH	Total Miles	GS	Tot. Time	Fuel Rate	Total Fuel
From To													
From To													

IV. Pilot's Flight Log Sheet

A. Points to fill in before flight

1. Check points
2. Distances
3. Estimated times
4. Brackets

B. Points to fill in during flight

1. Actual times
2. Actual ground speed
3. Actual compass heading
4. Weather enroute

Airplane # Date

Departure	Distance	Elapsed Time	Clock Time	Ground Speed	Compass Heading	Remarks
Check Points						Brackets Radio Weather
1.						
2.						
3.						
4.						

<u>Things to do</u>:

1. Completely plan a flight from Salt Lake City to Tremonton, then to Strevell with the following conditions:

    a. True air speed, 110 miles per hour

    b. Wind from 200 degrees at 15 miles per hour

    c. Deviation 0 degrees north, minus 2 degrees at 330

    d. Fuel rate of consumption, 4.5 gallons per hour

<u>Films</u>:

"Flying the Weather Map" (16 mm. sound, 13 minutes, color. Follows the charting of a flight from Newfoundland to Scotland, showing navigator at work. Loan by CAA)

NAVIGATION

Section X. Radius of Flight

Text references: Practical Air Navigation, Chapter 8
Path of Flight, Chapter VII
Aviation Study Manual, Unit 7, pp. 62-65

I. Purpose of radius-of-action problem

A. Used to determine distance from the airport the plane can fly and return

1. For a given fuel quantity

2. In a given time

II. Plotting a radius-of-action problem

A. Construct a round-trip diagram for your proposed course. (See Section 8, Item L)

B. Mathematical solution

Ground speed out, multiplied by ground speed back, divided by ground speed out, plus the ground speed back:

$$\frac{G_s\,O \times G_s\,B}{G_s\,O + G_s\,B} = \text{Radius of action for one hour}$$

C. Graphic solution

1. Use round-trip diagram

2. Draw a line from the base of wind arrow (point E) parallel to the "true heading back" and intersect the "true heading out" line. Label as point X.

3. Through point X draw a line parallel to the wind line and intersect the "true course out" line. Label point X.

4. Distance to the turning point is measured along the "T.C. out" line, from point E to point Y.

III. Radius of action for more than or less than one hour

A. Distance to the turning point

R.A. distance = R. A. for one hour multiplied by the time in hours

Example: R. A. for 1.5 hours = 40 x 1.5 = 60 miles

B. Time to the turning point

1. Radius of action for one hour divided by the ground speed, or

$$\frac{R.\ A.}{G_s} = \text{Time to the turning point}$$

Example: $\frac{40}{70}$ = .57 hours to turning point

2. Converting to minutes, .57 x 60 = 34 minutes for the time out, leaving 26 minutes for the time back.

Things to do:

1. Compute a radius-of-action problem from your home airport for a plane carrying fuel for two hours of flying.

Films:

"Aerial Navigation, Dead Reckoning Problems, Radius of Action, Returning to the Same Base" (35 mm. filmstrip. Points out the factors which determine the radius of action and shows how to compute R/A.

NAVIGATION

Section XI. The Navigational Computer

Text references: Practical Air Navigation, Chapter 9
Basic Aeronautics, pp. 163-180

I. Purpose of the computer

A. It is a modified circular slide rule.

B. It is used as an aid to quickly figure or compute problems of navigation.

C. It is very essential for a pilot to be able to operate the navigational computer in flight.

II. Uses of the computer

A. Time-distance, time-speed, and distance-speed side

1. Computes speed over a known course with one setting

2. Computes distance traveled with one setting

3. Computes total fuel consumed in a given time with one setting

4. Computes true air speed from indicated air speed when altitude and outside air temperature are known

5. Converts statute miles to nautical miles and nautical miles to statute miles with one setting

B. Navigation side

1. Computes magnetic heading by using variation, true course, and wind direction

2. Computes drift angle by using true air speed and wind velocity

3. Computes ground speed by using magnetic heading and drift angle

III. Recommendations to the instructor:

A. This computer can be obtained in an inexpensive cardboard model

B. The computer should not be used until the student fully understands the dead reckoning procedures of determining wind drift, ground speed, and compass headings.

C. The use of this computer will stimulate the majority of your class to increased interest in mathematics.

NAVIGATION

Section XII. Radio Navigation

Text references: Practical Air Navigation, Chapter 10
Basic Aeronautics, pp. 181-192
Aviation Study Manual, Unit 7, pp. 73-94

I. The radio range system

A. Characteristics

1. Four radio beams directed outward from a transmitter site at approximately 90-degree angles

2. Range stations are located on the civil airways.

3. Not all beams from range stations are along airways.

a. Two legs are on the airways

b. The other two legs may only lead into the station from directions off the civil airway.

c. Some stations have three legs on the civil airway, with one leg off by itself.

4. Areas between legs of the beam are called quadrants.

a. Signal is sent in Morse code.

b. Signal transmitted to one qudrant is A (.-); the next quadrant is N (-.); the remaining quadrants alternately A and N.

c. Flight into any quadrant is indicated by the signal A (.-) or N (-.) being received by the pilot.

d. When equidistant between two quadrants, a steady hum is heard. This indicates on course or "on the beam".

e. Flying the beam will lead directly to, or away from the range station.

5. Additional range characteristics

a. Cone of silence

(1) Located directly over the range station

(2) No signal heard by the pilot

(3) "Z" marker located in cone of silence

b. Fan markers

(1) Small radio beams projected upward across the range leg

(2) Used to indicate mileage distance from range station

(3) Very small area included in fan marker transmission

(4) Fan marker indicates leg of range beam. Numbers 1, 2, 3, 4, indicated by signal pulses of 1, 2, 3 or 4 dashes

6. Identification

a. The station is identified by code signals sent every half minute.

b. Three letter symbols represent the name of the station.

c. The station is usually named after the nearest city or town.

d. Some stations have a voice weather broadcast every half hour.

7. Radio frequency

a. Low frequencies from 200 to 400 kilocycles

b. VHF (very high frequency) from 112 to 118 megacycles

II. The visual omni-directional range (VOR)

A. Characteristics

1. Very high frequency transmissions

2. Now installed nationwide on all civil airways

3. Gradually replacing low frequency ranges

4. Radio beam sent out in all directions from the station

5. Voice broadcast also made

B. Indicating instruments for VOR

1. Vertical-needle instrument

a. Indicates when plane is right or left of desired course

b. Horizontal needle used on the same instrument for let-down procedures

2. Scope type indicator

a. A radar-type screen is used for the indicator

b. A small projection occurs on the periphery of the screen circle that points toward the station.

c. The compass rose around the screen gives the bearing.

III. Distance measuring equipment (DME)

A. Characteristics

1. Used in conjunction with some VOR receivers

2. Automatically shows distance to omni range station on a mileage indicator dial

B. Operation

1. Determines distance by measuring time for a radio impulse to be sent to and returned from a DME station

2. Operates in the VHF band

IV. Radio direction finder

A. Manual operating type

1. The radio receiver loop antenna is rotated until a null signal is obtained from a given radio station.

2. Compass bearing to station is 90 degrees from the position of the loop antenna.

B. Automatic direction finder (ADF)

1. The radio receiver is tuned to the station desired.

2. The loop antenna is automatically turned toward the direction which gives the strongest signal.

3. The radio compass needle on the instrument panel points to the bearing of station tuned in.

4. This system will indicate direction to any broadcasting or range station and is very reliable.

Things to do:

1. Tune in a radio range station in the 200 to 400 kilocycle band, identify the station and determine the quadrant in which you are located.

2. Visit an airport and ask for a demonstration of omni range equipment.

Films:

"Omni Bearing Distance Navigation System" (16 mm. sound, 32 min. Describes the principles of operation of the VOR range and explains how to use the aircraft instruments developed to fly this type of radio range. Loan by CAA)

"Instrument Flying and Landing - Air Force Landing System" (16 mm. sound, 12 min. Shows how the radio compass, runway localizer, altimeter, directional gyro, artificial horizon, and marker beacons are utilized in the Air Force landing system. Loan by CAA)

"Radio Compass - The Radio Compass in Flight" (16 mm. sound, 20 minutes. Shows how the radio compass is used in aerial navigation. Loan CAA)

"Instrument Flight Control - Radio Navigation - Radio Range Flying" (57 frames, 25 minutes, 35 mm. filmstrip. Explains the characteristics of low frequency radio range; how its courses are produced; the signals heard by the pilot in each quadrant, along each course and how their intensity varies with the flight direction and position of the aircraft; the fan markers used to identify each course. Loan by CAA)

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APPENDIX A

Utah State Agricultural College
Department of Aeronautics
Logan, Utah

November 8, 1955

Dear Sir:

As part of a study in Aviation Education, I am attempting to determine the present status of Aviation Education in the secondary schools of Utah and the trend which has taken place during the past 3 years.

I will appreciate the answering of the enclosed information form by you or your instructor associated with this class. All questions can be answered very briefly. The enrollment questions can be answered by the secretary of your school.

Aviation Education can be defined as education of a non-technical nature and is concerned with communicating general knowledge, skills and attitudes about aviation and its impact upon our every day lives and society.

This type of class is intended to attract students of both sexes, in fact, some schools which I have personally contacted have a very good mixed group studying and enjoying Aviation Education.

The completed information form can be returned in the self-addressed stamped envelope.

Thank you for your very kind consideration of this request.

Yours truly,

Lowell P. Summers

LPS:mae
Enclosure

L. P. Summers
U.S.A.C.
Logan, Utah

INFORMATION FORM TO SECONDARY SCHOOLS OF UTAH ON AVIATION EDUCATION

1. Name of High School________________________________.

2. What is your present total student body enrollment?____________.

3. Does your school now offer a class in Aviation Education as defined in the accompanying letter? Yes__________ No____________

   If your answer to question 3 is "yes", please answer questions 4 through 10 only. If your answer to question 3 is "no", skip questions 4 through 10, and answer questions 11 through 15 on page 2.

4. How many class periods per day are taught in Aviation Education?___.

5. How many instructors are assigned to the Aviation Education Program in your school____.

6. In what year was your Aviation Education Program first started?____.

7. Please indicate total school enrollment and enrollment in Aviation Education for the following years:

Total School Enrollment	Enrolled in Aviation Education
1955-56____________	1955-56______________
1954-55____________	1954-55______________
1953-54____________	1953-54______________

8. Does your school sponsor a Civil Air Patrol student cadet program?

9. Is your school a member of the National Aviation Education Council?

10. Do you have model plane building activity as part of the Aviation Education Program?__________________________________.

(optional) Signed______________

Title______________

If your answer to item #2 on the first page was "no", please answer the following questions:

11. During the next two years, is it possible your school may be offering a class in Aviation Education as defined in the accompanying letter? Yes________ No_________ Undecided_________

12. Would your school be interested in offering a program of Aviation Education if help was offered from the State Department of Public Instruction?_____________.

13. Please check one or more of the following reasons why your school does not offer a class in Aviation Education at the present time:

__________ a. Insufficient student interest.

__________ b. Insufficient funds.

__________ c. Course of study not available.

__________ d. Trained teachers not available.

__________ e. School administration not interested.

__________ f. Other reasons (write in)________________________

____

____

____

____

14. Would your school be interested in establishing a Civil Air Patrol student cadet program? Yes__________ No__________

15. Would you like to receive full information about the Civil Air Patrol student cadet program? Yes_________ No_________

(optional) Signed__________________

Title___________________

APPENDIX B

For details of Transcontinental and Local Routes see the Sectional Maps in the

A B C WORLD AIRWAYS GUIDE

TABLE	COMPANY
1, 2	AEROLINEAS ARGENTINAS
3, 4	AEROVIAS NACIONALES DE COLOMBIA, S.A.
6	AEROFLOT
9 to 15	AIR FRANCE
18, 18A	AIR INDIA INTERNATIONAL
20, 20A, 21	ALITALIA
25	BRANIFF INTERNATIONAL AIRWAYS
27 to 30	BRITISH OVERSEAS AIRWAYS CORP.
31	BRITISH OVERSEAS AIRWAYS CORP. QANTAS EMPIRE AIRWAYS, LTD.
32, 34, 36	BRITISH OVERSEAS AIRWAYS CORP.
37	BRITISH OVERSEAS AIRWAYS CORP. SOUTH AFRICAN AIRWAYS
40, 40A	CANADIAN PACIFIC AIR LINES
41	CENTRAL AFRICAN AIRWAYS CORP.
41A	COLONIAL AIRLINES
41B	COMPANIA CUBANA DE AVIACION, S.A.
42	DELTA-C & S AIR LINES

TABLE	COMPANY
42A	LUFTHANSA
43, 44	ISRAEL NATIONAL AIRLINES, LTD.
45 to 46A	IBERIA
47	JAPAN AIR LINES CO. LTD.
48 to 53	K.L.M. ROYAL DUTCH AIRLINES
54	LINEE AEREE ITALIANE, S.p.A.
55, 55A	LINEA AEROPOSTAL VENEZOLANA
56	BRAATHENS S.A.F.E. AIR TRANSPORT LOFTLEIDIR, H.F.
57, 58	NORTHWEST ORIENT AIRLINES
59	PAN AMERICAN-GRACE AIRWAYS
60	PANAIR DO BRASIL
61 to 67	PAN AMERICAN AIRWAYS, INC.
68	PAN AMERICAN AIRWAYS, INC. PAN AMERICAN-GRACE AIRWAYS
69 to 72	PAN AMERICAN AIRWAYS, INC.
74	PAKISTAN INTERNATIONAL AIRLINES
75	BRITISH OVERSEAS AIRWAYS CORP. QANTAS EMPIRE AIRWAYS, LTD.

WORLD MAP KEY TO OPERATORS OF ROUTES

NOVEMBER 1955 EDITION
valid until April 30th, 1956

TABLE	COMPANY
76, 77	QANTAS EMPIRE AIRWAYS, LTD.
77A	QANTAS EMPIRE AIRWAYS, LTD. TASMAN EMPIRE AIRWAYS, LTD.
77B	REAL S.A. TRANSPORTES AEREOS
78 to 80	SABENA
80A to 80C	"SAFARI" SERVICE: AIRWORK, LTD. HUNTING-CLAN AIR TRANSPORT, LTD.
81 to 84	SCANDINAVIAN AIRLINES SYSTEM
85	BRITISH OVERSEAS AIRWAYS CORP. SOUTH AFRICAN AIRWAYS
86, 86A	SWISSAIR
87	TACA INTERNATIONAL AIRLINES, S.A.
88, 89	TRANS-CANADA AIR LINES
90 to 92	COMPAGNIE DES TRANSPORTS AERIENS INTERCONTINENTAUX
94	TRANSPORTES AEREOS PORTUGUESES
95	TRANS WORLD AIRLINES
97, 98	UNION AEROMARITIME DE TRANSPORT

TABLE	COMPANY
99	AIR VIETNAM UNION AEROMARITIME DE TRANSPORT
99A	UNION AEROMARITIME DE TRANSPORT
99B	S.A. EMPRESA DE VIACAO AEREA RIO GRANDENSE
181	AQUILA AIRWAYS, LTD.
339A	AIR LIBAN
379	ETHIOPIAN AIR LINES, INC.
485	AEROFLOT
617D	TRUST TERRITORY OPERATIONS
646A	TASMAN EMPIRE AIRWAYS, LTD.
913	AIRWORK, LTD.
924	BRITISH OVERSEAS AIRWAYS CORP.
945	HUNTING-CLAN AIR TRANSPORT, LTD.
950	K.L.M. ROYAL DUTCH AIRLINES
971	PAN AMERICAN AIRWAYS, INC.
973	QANTAS EMPIRE AIRWAYS, LTD.
977	SABENA
984	SWISSAIR
991	TRANS WORLD AIRLINES

For all routes in Europe and the Mediterranean area see the

ABC WORLD AIRWAYS GUIDE MAP OF EUROPE

(published concurrently with this Map)