A COST COMPARISON OF THE USE OF BUSINESS AIRCRAFT FOR PASSENGER SERVICE VERSUS COMMERCIAL AIRLINE SERVICE

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PREFACE

The use of "business aircraft" has become increasingly popular since the close of World War II. Most of the advantages given for the use of such aircraft in the current publications are expressed as "intangible benefits." There are few statistics given whereby one can evaluate the cost of transportation by means of business aircraft with the cost of using commercial facilities. The purpose of this study is to present some facts and observations concerning the cost of transporting passengers by some actual aircraft used in business flying and the cost of commercial facilities for the same passenger service.

The study would not have been possible without the help and co-operation of a number of companies who own and operate business aircraft. The writer would like to express his appreciation to those companies and the individual members of the companies who were responsible for, or played a part in, supplying information on the subject. The fact that their names can not be listed, in accordance with the agreement when the material was solicited, does not in any way lessen the feeling of gratitude.

The cooperation of the Oklahoma City offices of The Hertz Corporation and the Avis Rent-a-Car System as well as the Executive Offices of the National Car Rental System was of considerable help. This help is appreciated.

An expression of gratitude is, also, due three members of the Oklahoma State University faculty. Professor Wilson J. Bentley, in the capacity of thesis adviser, was very helpful. His ability and willingness to listen to proposed courses of action, and to make constructive suggestions is appreciated. The other members of the faculty referred to are Dean M. R. Lohmann and Professor H. G. Thuesen. The part they played was not large, but they were ready and willing to help when called upon. This, too, is appreciated.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page
XV.	Flights, Air Miles, and Passenger Miles for Aircraft "C" Given for Number of Passengers per Flight	35
XVI.	Flights, Air Miles, and Passenger Miles for Aircraft "D" Given for Number of Passengers per Flight	36
XVII.	Flights, Air Miles, and Passenger Miles for Aircraft "E" Given for Number of Passengers per Flight	36
XVIII.	Flights, Air Miles, and Passenger Miles for Aircraft "F" Given for Number of Passengers per Flight	37
XIX.	Flights, Air Miles, and Passenger Miles for Aircraft "G" Given for Number of Passengers per Flight	37
XX.	Flights, Air Miles, and Passenger Miles for Aircraft "H" Given for Number of Passengers per Flight	38
XXI.	Flights, Air Miles, and Passenger Miles for Aircraft "I" Given for Number of Passengers per Flight	38

LIST OF FIGURES

CHAPTER I

INTRODUCTION

On the inside of the front cover of the pamphlet, American Business On the Wing (1), the National Business Aircraft Association poses the question, "What is the business aircraft user?" The Association's answer is immediately given as:

> Business organizations owning and operating aircraft as vehicles of transportation for their own passengers and cargo in the same manner in which automobiles, trains, buses, airlines, and boats would be used. This excludes all aircraft operated for industrial, agricultural, charter or commercial purposes which long have been identified as "business" aircraft.

In current publications one sees many references to business aircraft in one form or another. Some of the references are to flights made by prominent businessmen in their company aircraft, while others may pertain to a new model or modification of a plane that is being presented for the business aircraft market. Many articles on the subject are to be found in the trade magazines of the industries related to aviation. Examination of these articles reveals that while there seems to be little but praise for business aircraft few facts and figures are presented. The advantages are generally spoken of as "intangible benefits." Most of the reasons advanced for operating company aircraft are included in, or are similar to, the reasons given on page 31 of a study conducted by the Civil Aeronautics Administration (2):

> Several factors have contributed to the rapid growth in business flying. Decentralization of industry has been a major

factor in stimulating this activity. Other reasons for owning a company plane are the saving of valuable travel time of high-salaried executives, reduction in wear and tear on executives and other personnel, and the provision of flexible travel schedules.

In view of the foregoing, and the fact that business flying is more than a passing fad, it seems that a study of the cost of transporting passengers by business aircraft compared with the cost of the same transportation using commercial facilities is in order. This is such a study. It is a comparison of the cost of a number of actual business aircraft used for passenger service and the cost of comparable commercial service.

Attention is invited to the fact that all aircraft included in this study were flown by professional pilots and co-pilots and consequently it will have little resemblance to a study of aircraft flown by someone such as the owner of a company or a salesman. Caution should be exercised against forming opinions for or against a particular type of aircraft as a result of this work. Indications are that the cost figures are influenced more by how the aircraft is used than by the type.

There is no doubt that the ownership and operation of aircraft by a company will offer some desirable features, but it will be left up to each reader to determine for himself whether or not the excess costs involved in the use of the aircraft studied can be justified in light of any intangible benefits that may have been received.

CHAPTER II

SOURCE OF DATA AND METHOD OF COST DETERMINATION

Data used in the preparation of this paper was supplied by businesses who own and operate aircraft for passenger purposes for personnel of their organization. Letters requesting information pertaining to actual use of an aircraft that they would consider typical of their use of aircraft were written to a number of companies in the petroleum and natural gas industries. A form was supplied which indicated the type of information desired. This information included the following: type of aircraft; passenger capacity; and cost of operation per hour. In connection with the cost of operation, spaces were provided for checking which of the following were included in the operational costs: insurance; hanger fees; maintenance; fuel; pilot's salary; and a space was provided for listing other items of expense which figured in the cost of operation. Space was provided for showing date, departure time, point of origin and destination of flight, arrival time and number of passengers.

Results of the requests for information were most gratifying. Fourteen companies supplied information, but the information furnished by 5 of the companies could not be used directly in the study due to the nature of the information or the lack of details. It may be said, however, that all information submitted contributed to the writer's understanding of the use of aircraft for business transportation purposes.

Meaning of "Flight" and "Trip"

Each pair of departures and arrivals was considered to be a flight. No effort was made to determine whether a pair or series of successive flights were in effect only one trip. The terms "flight" and "trip" are used interchangeably and should be construed to have the same meaning. The following is an example: a flight from Houston, Texas, to Atlanta, Georgia, followed by a flight from Atlanta to Washington, D. C. might well represent only one trip from Houston to Washington for part or all of the passengers. Inasmuch as there was no way of telling which passengers stopped off or continued (except for one of the aircraft) each individual flight was studied separately. This treatment of trips is somewhat in error in that commercial fare direct from the point of origin to the destination may be slightly lower than the sum of the fares between intermediate points. Any error thus introduced will, however, tend to make the cost of transporting passengers by commercial facilities more nearly equal to that of using business aircraft.

The term "commercial facilities", as it appears throughout this work refers to scheduled commercial airlines for the most part. However, when the origin or destination of a flight was from or to a location not served by commercial airlines, the use of charter aircraft and rental cars were included.

Calculation of Costs

In order to arrive at a comparison of the costs for commercial service and business aircraft, costs were figured for each means for each trip. The cost of the trip by business aircraft was determined by multiplying the cost per hour figure by the time required for the flight which was obtained by determining the elapsed time between the departure and arrival times. There were two exceptions to the foregoing. In the case of one aircraft the times of departure and arrival were not available and the cost was supplied as the cost per passenger mile. This was converted to a cost per mile figure which was multiplied by the air miles for each flight. The other exception was that the arrival and departure times were not given for another aircraft, but the time for each flight was given directly.

The cost of commercial facilities were determined by taking the commercial fares (including 10% federal tax) and adding to them any cost of charter aircraft or car rental. The commercial fares and the cost of some charter service were obtained from the Official Airline Guide (3). Costs for other charter service and car rental rates were obtained from rate information supplied by the car rental companies mentioned in the preface.

In a few cases where the cost of charter service was not available from the sources mentioned, and charter service was listed as being available in the Airport and Business Flying Directory (4), rates which appeared to be prevalent in the immediate area as given in the Official Airline Guide (3) were used.

As a general rule, car rental costs were used in instances where the destination was within 50 miles of commercial airline service and the subsequent departure of passengers from the destination was within 24 hours of the arrival time. In cases where the distance was in excess of 50 miles or passengers were not departing within 24 hours of the arrival, charter aircraft rates were used in the calculations of the costs. When car rental was used (or charter service when the passengers were departing from the original destination within a few hours), the cost was divided equally between the two trips. In the case of the charter aircraft, any waiting time was taken into consideration in the determination of the cost. Car rental or charter fees were distributed among the number of passengers involved.

All distances referred to are air miles and were obtained from 3 sources. Distances for Aircraft "A" (alphabetic designation is explained later) were furnished by the owning company. Distances for the other aircraft were obtained from either the Rand McNally Cosmopolitan World Atlas (5), or scaled to the nearest 5 miles from a "United States Aeronautical Planning Chart" (6). A check of some of the distances for Aircraft "A" was made with the other sources, and although some of them differed a small amount it was thought better to use them. The cost figures for the subject aircraft were presumably calculated using the supplied distances, so it was believed that a more accurate appraisal of the costs could be obtained by using these distances rather than those obtained from other sources. The foregoing statement is not intended to imply that the distances obtained from any of the three sources cited are necessarily more accurate or inaccurate than any of the others, but is given in order to explain the sources of information and any resulting differences that might exist.

Cost figures were calculated to the cent, but are reported in the tables in terms of the nearest dollar in order to conserve space and to present the information in meaningful units. It is believed that all other calculations were of a nature that might be considered as "standard", and that further description of method would prove boring rather than enlightening.

CHAPTER III

RESULTS

The 9 aircraft included in this study represent a total capacity of 61 passengers, and cover a total of 36 months operation. Enough air miles are included to encircle the earth at the equator over 10 times, and the passenger miles are enough to transport over 1000 people from New Orleans, Louisiana, to Denver, Colorado.

The foregoing is not given in an attempt to be dramatic. It is given to point out that the data included in this study contains information concerning considerable travel of passengers by business aircraft.

In studying this subject, there was a tendency to speculate as to the why and wherefore of some of the trips included. That, however, is beyond the scope of this paper, and the actual data and results pertain to the flights that were reported in the information furnished by the cooperating companies. An effort has been made to present enough tables and graphs to permit an interested reader to speculate as he may desire, but to restrict the remarks herein to facts as evidenced by the findings with a minimum of speculation.

Discussion of Tables and Graphs

The companies which furnished data were promised anonymity and consequently their identity will not be disclosed. Alphabetic designations were assigned to the aircraft for reference purposes. Table I gives the alphabetic designation, type of aircraft, passenger capacity, cost of operation, and time period for the data for each of the aircraft. Table II is a summary of the number of flights, passengers transported, average capacity utilized, miles flown and passenger miles for each aircraft. Included, also, are averages per flight for the number of passengers, miles flown, and air miles.

Table III gives the cost of using business aircraft, cost of comparable commercial service, and the average per passenger mile for each. In addition, the table indicates the cost per passenger mile difference between business aircraft and the use of commercial facilities for the same trips and number of passengers.

There is a definite division of the aircraft studied when considering the passenger carrying capacities. For this reason, subtotals are given for Aircraft "A" through "D" which have capacities of 9 and 12 and for Aircraft "E" through "I" which have capacities of 4 and 5 passengers.

Tables IV through XII show the number of flights, air miles, and passenger miles for 100 mile distance divisions for each aircraft. These tables also show the percentages of the total for each of the items named above.

Tables XIII through XXI have the same information as described for the previous group with the exception that the information is divided according to the number of passengers per flight instead of miles per flight.

Figures 1 through 7 are graphs of the cost of using business aircraft, expressed as percentage of the cost of comparable commercial service, plotted against the number of passengers per trip. There is a graph for each of the aircraft. Figure 8 is a graph of the cost per hour for Aircraft "B" plotted against hours per year. The graph has the "fixed costs", "variable costs", and the total cost per hour.

Figures 9 and 10 are graphs of averages for average speeds for flights of various lengths plotted against 100 mile distance divisions.

The tables and graphs mentioned above will be discussed in more detail later.

The Appendix contains breakdowns of the various operating expenses that go to make up the operating cost for three aircraft. These will not be discussed, but are presented in order that one might obtain some idea of the items that go to make up the total cost and the relation of each to the others and to the whole.

Comparison of Costs

There is a tendency in a study of this nature to become fascinated with all the numbers included in the data and the various combinations and percentages and the tables and graphs that may be prepared therefrom. Regardless of the combinations made and the considerations given, however, one end result was obtained--the business aircraft included in this study costs more than the same passenger service using commercial facilities. Of interest, is how much more and some of the reasons.

The answer as to "how much more" is contained, to some extent, in Table III which indicates that the cost of using business aircraft compared to the cost of commercial facilities ranged from a little over twice as much for Aircraft "D" to over 6 times as much for Aircraft "G". The answer to the question of why the cost of business aircraft is higher is not so readily evident.

At first inspection, one is inclined to attribute the cause in the variation of the differences to the costs per hour of operation. This does not necessarily follow, however. The aircraft arranged in the order of descending costs of operation per hour is as follows: "A", "G", "B", "C", "D", "H", "F", "I", and "E". On the other hand, the same aircraft arranged in the order of decreasing cost of the business aircraft, expressed as percentage of commercial facilities cost, is: "G", "H", "I", "A", "B", "F", "C", "E", and "D".

The answer apparently does not lie in the speed of the various aircraft as one might suspect since the cost unit being applied in all cases except for "A" is the cost per hour. Investigation of the aircraft whose speed was known revealed little, if any, direct relation to the difference in the costs between business aircraft and commercial facilities.

One might next turn his investigation to the fact that in some cases the aircraft were used to go to and from destinations not serviced by commercial facilities. Although this is true, it has very little effect in this study, and the effect that it does have is to increase the cost by commercial facilities and thus tends to narrow the range of the differences in the two modes of travel. This, incidentally, brings up a point of interest. Of the total of 714 trips included in this study, only 40 of them were to take passengers to or from airports not serviced by commercial airlines. There were 10 other trips to or from airports without commercial service, but they were without passengers. true?

The answer to the question of why the use of business aircraft costs so much more than the use of commercial facilities between the same destinations lies to some extent in all of the variables suggested above. The major factor influencing the cost of transporting passengers by business aircraft, however, seems to be in the number of passengers per trip. Upon casual examination, one can see why this is so. The cost of using the business aircraft may be divided into two catagories: (1) the fixed costs such as depreciation, hangar rental, pilot's and co-pilot's salaries, insurance, and license and taxes; (2) variable costs such as fuels and lubricants, storage fees, tires and tubes, maintenance, and expenses of pilot and co-pilot. The number of passengers carried per trip will have little effect on the operational costs. However, when the cost per hour figure is prorated to different numbers of passengers it makes a great deal of difference in the cost per passenger mile figure obtained. There is additional discussion of the fixed and variable costs in Chapter IV under the subtitle, "Cost of Owning and Cost of Operating Aircraft."

Figures 1 through 7, as mentioned previously, are graphs of the cost of commercial facilities plotted against the number of passengers per trip. The results are somewhat eye-opening, particularly for the aircraft with larger passenger capacities. These show a cost of from 961% of commercial service for Aircraft "D" to 1,557% for Aircraft "C" when transporting one passenger. The curves drop rapidly as the number of passengers increase. Aircraft "A" does not go below 223% when transporting passengers, but Aircraft "B", "C", and "D" decrease to not far above 100% (equal to cost of commercial facilities) as the number of passengers increase.

The graphs for the aircraft with capacities of 4 or 5 all show the same general characteristics. Not enough points were available, however, and the number of flights involved in most cases were not sufficient to smooth out the curves. That is, if there is only one or two flights with a given number of passengers, the information may not be representative of the results which would be obtained with a greater number of flights.

One can draw all sorts of inferences from studying Tables XIII through XXI. Examination of Table XIII will indicate that Aircraft "A" flew 11.70% of its flights with no passengers. This represents 7.05% of the air miles and, consequently, the total cost. Further investigation shows that 32.98% of the flights were made with 3 or fewer passengers, and these flights represented 26.12% of the air miles. As the costs will, for all practical purposes, be directly proportional to the air miles, it may be said that over one fourth of the cost of operating the aircraft was spent while transporting not more than three passengers per trip. At the same time, these trips accounted for only 7.88% of the total passenger miles which represent the productive output of the aircraft. Similar situations may be found by investigation of the tables for the other aircraft.

Consideration was given to the possibility that there may be some relation between the cost of the business aircraft and the length of individual trips. Graphs of the cost comparison between commercial service and business aircraft plotted against the length of the trips produced no discernable patterns. The only difference, it is believed, will result from the difference in the average speeds which will be discussed later.

Other Considerations

An effort was made to evaluate the additional cost of business aircraft with any possible saving of time, but lack of sufficient information precluded doing so. As was mentioned earlier, there was no way to tell "what people went where." For example, if 5 passengers went from Houston to Shreveport and 2 passengers from Shreveport to St. Louis, there was no way of knowing whether the net result was 5 passengers from Houston to Shreveport and 2 passengers from Shreveport to St. Louis, or 3 from Houston to Shreveport, and 2 from Houston to St. Louis. Then, too, one could not rule out the possibility of 4 passengers from Houston to Shreveport, 1 from Houston to St. Louis, and 1 from Shreveport to St. Louis. If there are additional points along the line or the number of passengers is larger, the problem becomes more complex. Also, there was the problem of calculating any time that might be saved. Was the time to be figured from the departure time of the business aircraft, or the arrival time? Various assumptions were considered, but were rejected in each case.

There is another thought to be taken into consideration along this line of thinking. Does the business aircraft save time for the passengers it transports? In some cases the answer is undoubtedly yes, particularly for the top executives who have priority in the use of the plane. For the bulk of the passengers, however, there appears to be a strong possibility that the use of the company aircraft might cause more delay than the use of commercial facilities. An example of this will be cited from one day's operation of one of the aircraft. While there is no claim made that this is a typical day, it is believed that it illustrates why the above question is asked.

The subject day's activity for the aircraft started when the plane left Dallas at 8:00 a.m. with 3 passengers and flew to Houston where it landed at 9:30 a.m. At 9:45 a.m. it left Houston and flew to Beaumont, Texas, without passengers; it landed in Beaumont at 10:15 a.m. The aircraft then left Beaumont, with 1 passenger at 10:30 a.m. and flew to

Baton Rouge, Louisiana, where it arrived at 11:45 a.m. There was no further activity until 2:30 p.m. when the plane left Baton Rouge, with 1 passenger, and returned to Beaumont where it landed at 3:35 p.m. It returned to Dallas with 2 passengers leaving Beaumont at 4:00 p.m. and arriving in Dallas at 5:30 p.m. To conclude the day's activities, the plane left Dallas, with no passengers, and flew to San Antonio where it landed at 8:45 p.m. only to take off again, with 2 passengers, at 8:45 p.m. for a return flight to Dallas where it landed at 10:35 p.m.

There is no question that the aircraft had a busy day on the one described above, but was it a productive one? The plane was in the air for 9.66 hours, and flew a total of 1,429 miles at a cost of $1,106.64.

There is another side of the picture, however. There are 10 commercial flights leaving Dallas for Houston between 7:30 a.m. and 4:30 p.m., four of them are in the morning. There are 3 commercial flights leaving Beaumont for Baton Rouge between 8:23 a.m. and 3:25 p.m., and 3 from Baton Rouge to Beaumont between 7:40 a.m. and 3:30 p.m. Three flights are offered from Beaumont to Dallas from 7:00 a.m. and 4:52 p.m., and one has a choice of 5 flights leaving San Antonio for Dallas between 2:30 p.m. and 10:00 p.m. The flights enumerated are not all of the flights offered between the cities in question, but are the ones that looked as though they might have served the purposes. The commercial fares for the passenger activity of the day would total $155.29.

The net result of the day's activities was that the business aircraft cost $951.35 more than would have had to be paid for the same commercial service. In addition, it is highly doubtful that the passengers, as a whole, had as much choice of when their flights would be made as they would have if commercial service were used. In most cases, they probably had to wait for the plane to become available.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

This investigation has disclosed that there is no doubt that the cost of using business aircraft for passenger service, in the manner that the aircraft studied were used, far exceeds the cost of transporting passengers by means of commercial facilities. It is realized that business aircraft might be used advantageously, but there does not appear that much effort has been applied toward this end. There seems to be little realization of the amount of money that is involved in the operation of the aircraft. There were many cases of an aircraft making a round trip of several hundred miles between cities served with numerous daily commercial flights to take one or two passengers one way. The writer has knowledge of companies that charge the using departments the cost of commercial fares when they use the company planes. It would seem that better results would be obtained if the departments were charged at actual operation costs for their use of the aircraft.

Estimation of Costs for Proposed Flights

An effort was made to develop some formula which could be used in the evaluation of the cost of a proposed use of business owned aircraft in order that a comparison might be made with the cost of using commercial facilities. It was concluded that dividing the distance of the proposed flight by a predetermined average speed for that distance would give the time for the flight. The time for the flight could then be multiplied by the cost per hour of operation of the plane and the quotient divided by the number of passengers to go on the trip. The result would be the cost per passenger which could then be compared with the commercial fare for the same trip.

Reference was made to a predetermined average speed for the distance of the flight. This is necessitated by the fact that the length of time required for taking off, making the flight, and landing at the destination is not the same as dividing the distance by what is ordinarily thought of as being the average air speed of the aircraft. This is particularly true for shorter flights. The time immediately after taking off and the time spent in the approach and landing are not as productive as the time in between. A study of the average speed (obtained by dividing the air miles by the length of time for the flight as reported in the data furnished by the company) for Aircraft "B" revealed that there is considerable difference between flights of different lengths. Figure 8 is a graph of the averages for the average speeds (obtained as described above) for different distances for the subject aircraft. The graph shows marked differences in the average speeds for different length flights. As an example, the average speed for flights from 100 to 199 miles in length was found to be 173 miles per hour as compared to an average speed of 202 miles per hour for flights between 600 and 699 miles. A similar graph was drawn for Aircraft "C", see Figure 9, and similar characteristics of the curves were found. The points found for Aircraft "C" do not produce a pattern that is as regular as the one for Aircraft "B", because the data for the latter is for an entire year and the former for only three months. Data over a longer period of time will tend to smooth out irregularities.

One might think that there would be little difference for a 250 mile trip whether an average speed of 181 miles per hour or 205 miles per hour, which appears to be the average flying speed of the plane, is used. The first would give a time of 1.38 hours and the second 1.21 hours; a difference of only 0.17 hours or 10.2 minutes. However, when consideration is given to the fact that the aircraft being discussed has an operation cost of $189.00 per hour, the difference of 0.17 hours has a value of $32.13. This difference between the calculations using the different average speeds is about one and a half times the cost of sending one passenger by commercial facilities if the rate of $0.083 per passenger mile (average cost of commercial facilities comparable to passenger service of the aircraft). The difference of $32.13 may also be thought of as equal to one day's salary for a $700 a month man.

A table of the various average speeds between destinations of different distances obtained by averaging the average speeds for flights made over an extended period of time would prove of benefit to department heads or others who may from time to time be in the position of having to decide whether to request company aircraft or use some other mode of transportation. If sufficient information is not available, it appears that reasonably accurate time information for such a table for short flights may be obtained by dividing the distance by the average air speed of the plane and adding ten or fifteen minutes depending upon the traffic conditions of the airports involved. For longer distances, little error would result if the distances were divided directly by a conservative estimate of the average air-speed.

Mention was made above of the traffic conditions at the airports.

Throughout the study a consistent pattern of lower average speeds was noticed when the flights were to the busier airports. Information as to the average amount of time required to get down at some of the busier airports would aid in estimating the amount of time and consequently the cost of a proposed flight. It should be borne in mind, however, that too many refinements to any plan for estimating the costs may reduce its effectiveness.

Cost of Owning and Cost of Operating Aircraft

One may think of the cost of the aircraft as being divided into fixed costs, that is, costs such as depreciation, pilots' salaries, insurance, hangar rental, licenses, etc., and variable costs such as fuel, lubricants, pilots' expenses and the like. The former will be incurred as a result of having the aircraft and having it ready for use. The fixed cost will not change appreciably regardless of the amount of use or even if the aircraft is not used. Variable costs, for all practical purposes, vary directly with the amount of usage. It may be stated that the first is the cost of having the aircraft and the other the cost of using it.

There seems to be a tendency for companies who own aircraft to think along these lines: "We have the plane, and the more we use it the less it costs, so let's use it as much as possible." This line of reasoning is true to a point, but until the benefits derived from the usage equal the variable costs, there is a loss incurred.

Figure 8 is a graph of the fixed costs, the variable costs, and the total cost (sum of the other 2) per hour plotted against hours of use per year. It is evident that the total cost per hour does decrease as the usage of the aircraft increases, but this is a result of prorating the fixed costs over the number of hours of use. The total cost could never go below, or even, equal the variable costs regardless of the amount of use.

It might be well, then, to consider the ownership and operation of the aircraft as two separate items. If this were done in the case of Aircraft "B", it would be found that the cost of having the plane available and ready for service is $26,108 per year or $102.35 per day based on a 255 working day year. Then, considering the variable costs as the cost of operation, it would be found that the cost of operation is $128 per hour of use or $0.675 per mile based on the aircraft's activities for 1957. Thus, it might be considered economical to use the plane when an average of 8.13 passengers per mile can be maintained (based on $0.083 per passenger mile for comparable commercial service). This average would be difficult to maintain since the plane has a capacity of 9 passengers.

It appears that companies owning and operating aircraft would do well to make a comprehensive study of the costs of their aircraft in relation to the benefits received therefrom. Then, it seems, that due to the amount of money involved, the use of the aircraft should be limited to uses that will produce suitable return on the expenditure. Inasmuch as so much of the returns will probably be in the form of intangible benefits, there should be a set of criteria to aid in the decision of whether or not company aircraft should be used.

The authorizing authority for the use of aircraft should be fully cognizant of the costs involved in the aircraft use; he should be in a position of sufficient status to permit him to evaluate properly intangible benefits involved; and he should be the final authority as far as usage of the aircraft is concerned.

Suggestions for Additional Study

It is evident that this study is just around the edges of a broad subject. It is believed that additional, and more comprehensive, study is highly desirable.

Further studies should include information as to the purpose of the trips, by whom were they made, and any possible benefit derived by the use of the company aircraft in each case. In order to accomplish this, it would be necessary to change the type of records being maintained on the aircraft. This, in most cases, would necessitate the study of flights made after the study was conceived.

It may be pointed out that knowledge that a study was in progress would probably alter the usage of the aircraft. This is probably true, but it would be a step in the right direction. A step towards promoting more efficient use of business aircraft.

TABLE I

ALPHABETICAL DESIGNATIONS AND GENERAL INFORMATION

PERTAINING TO AIRCRAFT

Air-craft	Type	Passenger Capacity	Cost of Operating	Time Period to Which Data Pertains
A	Lockheed PV1-Ventura	9	$0.291 per passenger mile*	1957 (Dec. 26, 1956 through Dec. 25, 1957) 12 Months
B	Douglas B-23	9	$189.00 per Hr.	Calendar year of 1957 12 Months
C	Douglas DC-3	12	$185.00 per Hr.	January through March 1957, 3 Months
D	Lockheed Lodestar	9	$125.00 per Hr.	January, 1958, 1 Month
E	Beechcraft, Twin Bonanza	4	$83.36 per Hr.	February, 1957, 1 Month
F	Beechcraft D18S	4	$113.04 per Hr.	March, 1958, 1 Month
G	Aero Commander	4	$198.33 per Hr.	Oct. through Dec. 1957, 3 Months
H	Beechcraft D18S	5	$114.56 per Hr.	Feb. and March, 1958 2 Months
I	Beechcraft D18S	5	$110.10 per Hr.	Aug. and Sept., 1957 2 Months

*Approximately $375.00 per hour

TABLE II

FLIGHTS MADE, PASSENGERS CARRIED, AIR MILES AND PASSENGER MILES FLOWN BY EACH AIRCRAFT

Aircraft	No. of Flights	Passengers Total	Passengers Avg.	Avg. % of Capacity	Miles Flown Total	Miles Flown Avg.	Pass. Miles Total	Pass. Miles Avg.
A	188	966	5.14	57.1	84,595	450	485,170	2581
B	208	884	4.25	47.2	81,185	390	365,918	1759
C	72	357	4.96	41.3	30,449	423	163,545	2271
D	20	80	4.00	44.4	7,596	380	31,480	1574
E	39	99	2.54	63.5	10,835	278	26,947	691
F	29	72	2.48	62.0	7,909	273	21,643	746
G	41	68	1.65	41.3	9,225	225	15,290	373
H	69	148	2.14	42.8	14,915	216	33,960	492
I	48	92	1.92	38.4	13,093	272	25,904	540
Totals (A to D)	488	2287	4.69	49.7	203,825	418	1,046,113	2144
Totals (E to I)	226	479	2.12	46.9	55,977	247	123,744	548
Grand Total	714	2766	3.64	49.1	259,802	364	1,169,857	1638

TABLE III

COSTS OF USING BUSINESS AIRCRAFT AND COMMERCIAL FACILITIES

AND COMPARISON OF THE TWO BY AIRCRAFT

	Cost of Using Business Aircraft		Cost of Using Commercial Facilities		Difference in Cost	
Aircraft	Total	Per Pass. Mile	Total	Per Pass. Mile	Per Pass. Mile	% of Commercial
A	$141,103	$0.291	$38,983	$0.083	$0.208	362*
B	80,862	0.221	30,905	0.084	0.137	262
C	34,083	0.208	13,995	0.086	0.122	244
D	5,155	0.164	2,561	0.081	0.083	201
E	5,362	0.199	2,576	0.096	0.103	208
F	5,146	0.238	1,986	0.092	0.146	259
G	9,549	0.625	1,456	0.095	0.530	656
H	11,087	0.326	2,809	0.083	0.243	393
I	9,450	0.365	2,583	0.100	0.265	365
Totals (A to D)	$261,203	$0.250	$86,444	$0.083	$0.167	302
Totals (E to I)	$40,594	$0.328	$11,410	$0.092	$0.238	356
Grand Totals	$301,797	$0.258	$97,854	$0.084	$0.174	308

*Obtained by dividing total cost of using business aircraft by total cost of using commercial facilities

TABLE IV

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "A"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0 to 99	12	6.38	870	1.02	2,855	0.59
100 to 199	22	11.70	3,175	3.75	15,235	3.15
200 to 299	39	20.74	8,790	10.39	41,175	8.49
300 to 399	24	12.76	8,085	9.56	32,395	6.68
400 to 499	16	8.51	7,015	8.29	34,645	7.14
500 to 599	16	8.51	8,765	10.36	48,285	9.95
600 to 699	4	2.13	2,605	3.08	20,355	4.20
700 to 799	36	19.14	26,760	31.63	171,320	35.31
800 to 899	5	2.66	4,040	4.78	19,280	3.97
900 to 999	7	3.72	6.560	7.75	47,660	9.82
1000 & Over	7	3.72	7,930	9.37	51,965	10.71
Totals	188		84,595		485,170	

TABLE V

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "B"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	7	3.37	436	0.54	1,991	0.54
100 to 199	60	28.85	8,135	10.02	29,270	8.00
200 to 299	24	11.54	5,602	6.90	29,008	7.93
300 to 399	21	10.10	6,972	8.59	32,656	8.92
400 to 499	34	16.35	15,556	19.16	55,605	15.20
500 to 599	26	12.50	14,178	17.46	66,940	18.29
600 to 699	10	4.81	6,515	8.02	22,215	6.07
700 to 799	7	3.37	5,013	6.17	29,908	8.17
800 to 899	3	1.44	2,655	3.27	16,815	4.60
900 to 999	11	5.29	10,713	13.20	56,624	15.47
1000 & Over	5	2.40	5,410	6.66	24,886	6.80
Totals	208		81,185		365,918	

TABLE VI

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "C"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	2	2.78	60	0.20	450	0.28
100 to 199	16	22.22	2,718	8.93	8,214	5.02
200 to 299	18	25.00	3,940	12.94	21,320	13.04
300 to 399	3	4.17	1,030	3.38	6,800	4.16
400 to 499	6	8.33	2,683	8.81	10,702	6.54
500 to 599	11	15.28	5,978	19.63	26,459	16.18
600 to 699	4	5.56	2,645	8.69	13,925	8.51
700 to 799	4	5.56	2,995	9.84	17,890	10.94
800 to 899	1	1.39	890	2.92	3,560	2.18
900 to 999	1	1.39	900	2.96	5,400	3.30
1000 & Over	6	8.33	6,610	21.71	48,825	29.85
Totals	72		30,449		163,545	

TABLE VII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "D"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	None					
100 to 199	7	35.00	1,030	13.56	4,365	13.88
200 to 299	2	10.00	470	6.19	270	0.86
300 to 399	4	20.00	1.365	17.97	7,815	24.83
400 to 499	3	15.00	1,326	17.46	4,420	14.04
500 to 599	1	5.00	550	7.24	1,100	3.49
600 to 899	None					
900 to 999	3	15.00	2,855	37.59	13,510	42.92
1000 & Over	None					
Totals	20		7,596		31,480	

TABLE VIII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "E"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	3	7.69	210	1.94	500	1.86
100 to 199	5	12.82	845	7.80	1,095	4.06
200 to 299	22	56.41	5,527	51.01	15,978	59.29
300 to 399	4	10.26	1,438	13.27	4,316	16.02
400 to 499	None					
500 to 599	5	12.82	2,815	25.98	5,058	18.77
600 & Over	None					
Totals	39		10,835		26,947	

TABLE IX

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "F"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	4	13.79	225	2.84	260	1.20
100 to 199	4	13.79	630	7.79	2,000	9.24
200 to 299	14	48.28	3,608	45.62	7,399	34.19
300 to 399	2	6.90	660	8.34	2,640	12.20
400 to 499	1	3.45	486	6.14	1,944	8.98
500 to 599	3	10.34	1,600	20.23	5,300	24.49
600 to 699	None					
700 to 799	1	3.45	700	8.85	2,100	9.70
800 & Over	None					
Totals	29		7,909		21,643	

TABLE X

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "G"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	3	7.31	85	0.92	190	1.24
100 to 199	13	31.71	2,100	22.76	3,510	22.96
200 to 299	20	48.78	4,920	53.33	8,390	54.87
300 to 399	2	4.88	665	7.21	600	3.92
400 to 499	2	4.88	920	9.97	460	3.01
500 to 599	1	2.44	535	5.80	2,140	14.00
600 & Over	None					
Totals	41		9,225		15,290	

TABLE XI

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "H"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	8	11.59	520	3.49	840	2.47
100 to 199	19	27.54	3,145	21.09	6,100	17.96
200 to 299	36	52.17	9,100	61.01	18,950	55.80
300 to 399	6	8.70	2,150	14.42	8,070	23.76
400 & Over	None					
Totals	69		14,915		33,960	

TABLE XII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "I"

GIVEN FOR 100 MILE DISTANCE DIVISIONS

Flight Distances (Miles)	Flights		Air Miles		Passenger Miles	
	No.	% of Total	No.	% of Total	No.	% of Total
0 to 99	3	6.25	120	0.92	80	0.31
100 to 199	20	41.67	3,457	26.40	6,635	25.61
200 to 299	5	10.42	1,125	8.59	2,280	8.80
300 to 399	7	14.58	2,317	17.70	5,311	20.50
400 to 499	10	20.83	4,409	33.67	8,818	34.04
500 to 599	3	6.25	1,665	12.72	2,780	10.73
600 & Over	None					
Totals	48		13,093		25,904	

TABLE XIII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "A" GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	22	11.70	5,965	7.05		
1	10	5.32	3,155	3.73	3,155	0.65
2	10	5.32	3,820	4.52	7,640	1.57
3	20	10.64	9,150	10.83	27,450	5.66
4	17	9.04	5,990	7.08	23,960	4.94
5	11	5.85	5,710	6.75	28,550	5.88
6	22	11.70	10,285	12.16	61,890	12.76
7	21	11.17	9,235	10.92	65,065	13.41
8	22	11.70	14,255	16.85	114,040	23.51
9	32	17.02	16,880	19.95	151,920	31.31
10	1	0.53	150	0.18	1,500	0.31
Totals	188		84,595		485,170	

TABLE XIV

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "B"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	13	6.25	3,044	3.75		
1	18	8.85	7,186	8.85	7,186	1.96
2	29	13.94	9,009	11.10	18,018	4.92
3	20	9.62	8,316	10.24	24,948	6.82
4	32	15.38	11,131	13.71	44,524	12.17
5	22	10.58	9,371	11.54	46,855	12.80
6	33	15.87	15,391	18.96	92,346	25.24
7	23	11.06	11,445	14.10	80,115	21.89
8	12	5.77	5,042	6.21	40,336	11.02
9	5	2.40	910	1.12	8,190	2.24
10	1	0.48	340	0.42	3,400	0.93
Totals	208		81,185		365,918	

TABLE XV

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "C"

GIVEN FOR NUMBER PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	7	9.72	2,374	7.80		
1	5	6.94	834	2.74	834	0.51
2	8	11.11	4,052	13.31	8,104	4.96
3	11	15.28	4,224	13.87	12,672	7.75
4	2	2.78	1,070	3.51	4,280	2.62
5	6	8.33	2,574	8.45	12,870	7.87
6	11	15.28	4,887	16.05	29,322	17.93
7	5	6.94	1,719	5.65	12,033	7.36
8	6	8.33	3,305	10.85	26,440	16.17
9	2	2.78	510	1.67	4,590	2.81
10	3	4.17	1,960	6.44	19,600	11.98
11	5	6.94	2,710	8.90	29,810	18.23
12	None					
13	1	1.39	230	0.76	2,990	1.83
Totals	72		30,449		163,545	

TABLE XVI

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "D"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	2	10.00	642	8.45		
1	1	5.00	270	3.55	270	0.86
2	3	15.00	1,640	21.59	3,280	10.42
3	2	10.00	320	4.21	960	3.05
4	2	10.00	802	10.56	3,208	10.19
5	1	5.00	115	1.51	575	1.83
6	8	40.00	3,462	45.58	20,772	65.98
7	1	5.00	345	4.54	2,415	7.67
8 or 9	None					
Totals	20		7,596		31,480	

TABLE XVII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "E"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	1	2.56	229	2.11		
1	6	15.38	1,542	14.23	1,542	5.72
2	13	33.33	4,431	40.90	8,862	32.89
3	10	25.64	2,284	21.08	6,852	25.43
4	8	20.51	2,054	18.96	8,216	30.49
5	1	2.56	295	2.72	1,475	5.47
Totals	39		10,835		26,947	

TABLE XVIII

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "F"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	5	17.24	1,086	13.73		
1	1	3.45	80	1.01	80	0.37
2	9	31.03	2,087	26.38	4,174	19.29
3	3	10.34	1,235	15.62	3,705	17.12
4	11	37.94	3,421	43.25	13,684	63.23
Totals	29		7,909		21,643	

TABLE XIX

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "G"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	7	17.07	1,800	19.51		
1	14	34.14	2,920	31.65	2,920	19.10
2	10	24.39	2,075	22.49	4,150	27.14
3	6	14.63	1,500	16.26	4,500	29.43
4	4	9.76	930	10.08	3,720	24.33
Totals	41		9,225		15,290	

TABLE XX

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "H"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	15	21.74	3,184	21.35		
1	9	13.04	1,325	8.89	1,325	3.90
2	14	20.29	3,234	21.68	6,468	19.05
3	17	24.64	3,601	24.14	10,803	31.81
4	10	14.49	2,491	16.70	9,964	29.34
5	4	5.80	1,080	7.24	5,400	15.90
Totals	69		14,915		33,960	

TABLE XXI

FLIGHTS, AIR MILES, AND PASSENGER MILES FOR AIRCRAFT "I"

GIVEN FOR NUMBER OF PASSENGERS PER FLIGHT

Passengers Per Flight	Flights No.	Flights % of Total	Air Miles No.	Air Miles % of Total	Passenger Miles No.	Passenger Miles % of Total
0	9	18.75	2,155	16.46		
1	11	22.92	2,949	22.52	2,949	11.38
2	11	22.92	3,299	25.20	6,598	25.47
3	9	18.75	2,403	18.35	7,209	27.83
4	8	16.67	2,287	17.47	9,148	35.32
Totals	48		13,093		25,904	

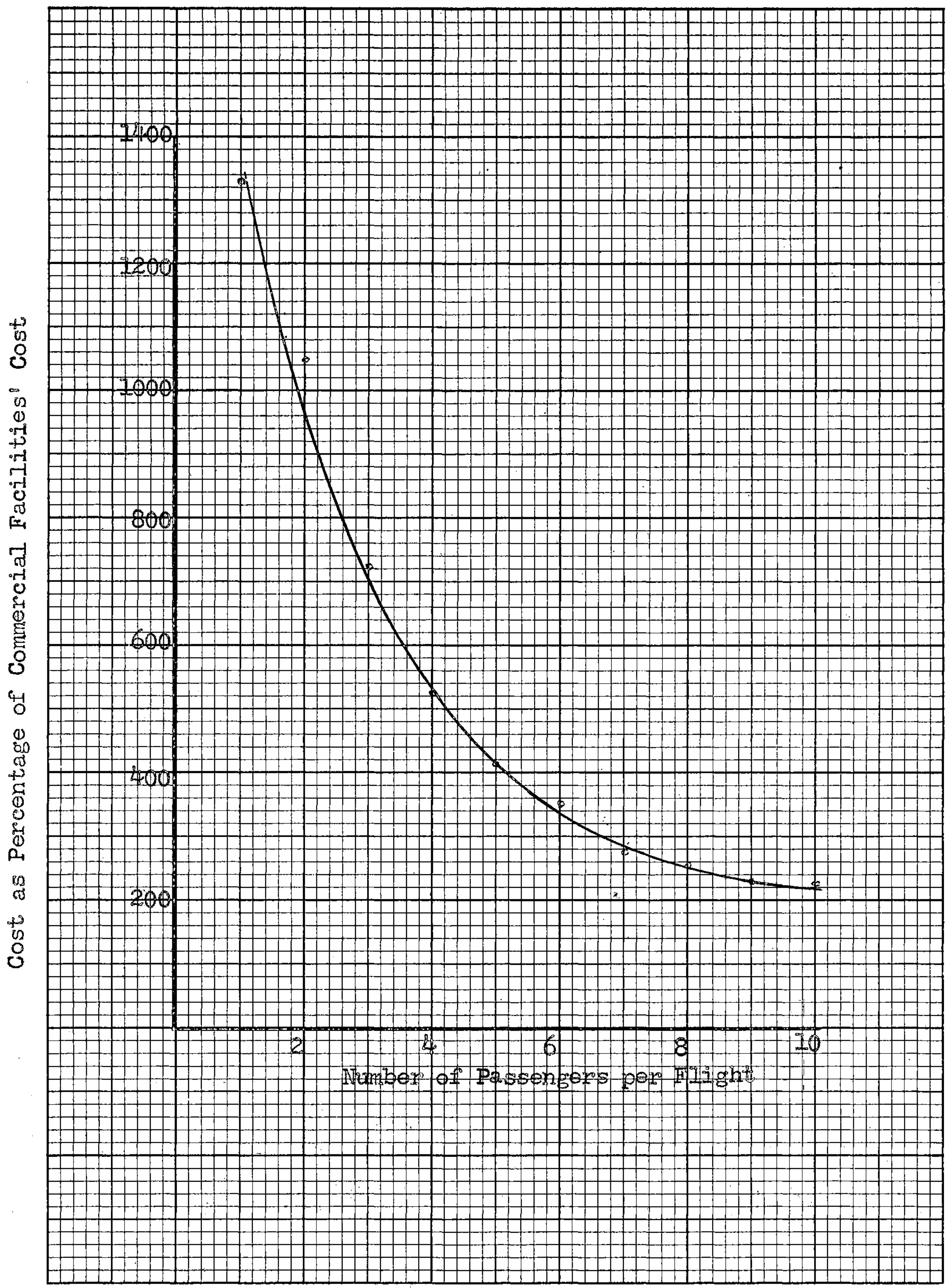

Fig. 1 Cost of Transporting Various Numbers of Passengers With Aircraft "A" Compared to Cost of Commercial Facilities

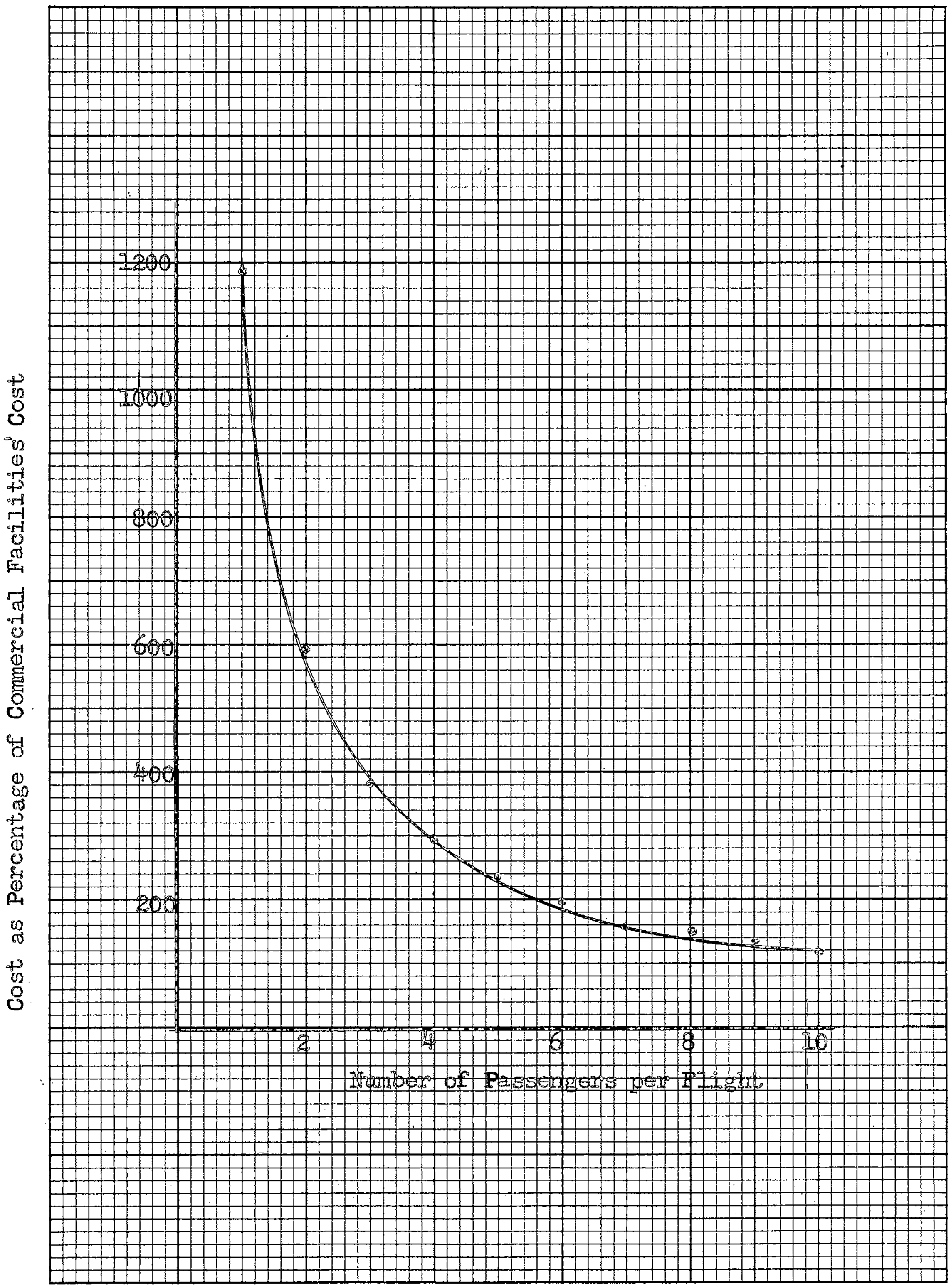

Fig. 2 Cost of Transporting Various Numbers of Passengers With Aircraft "B" Compared to Cost of Commercial Facilities

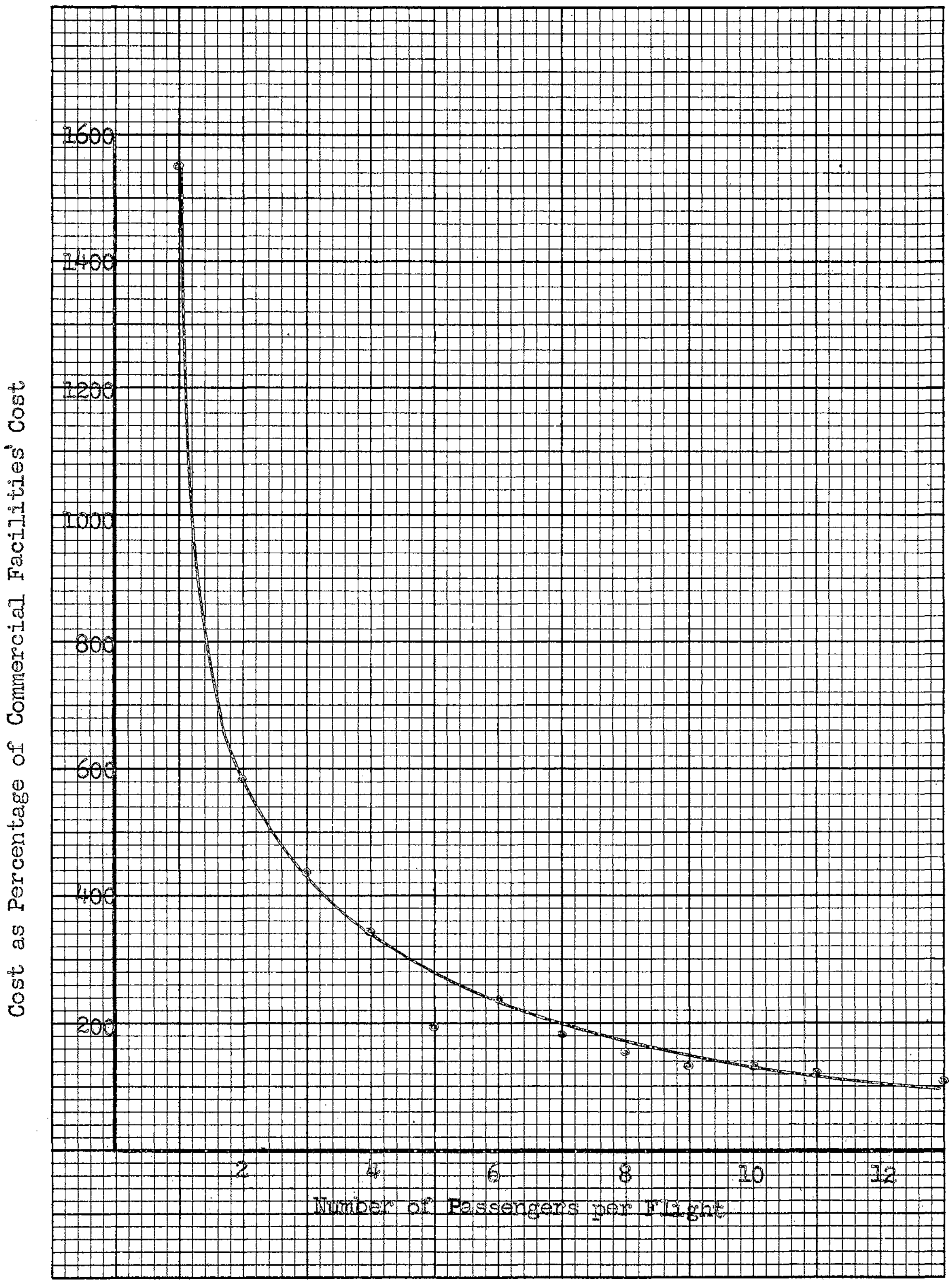

Fig. 3 Cost of Transporting Various Numbers of Passengers With Aircraft "C" Compared to Cost of Commercial Facilities

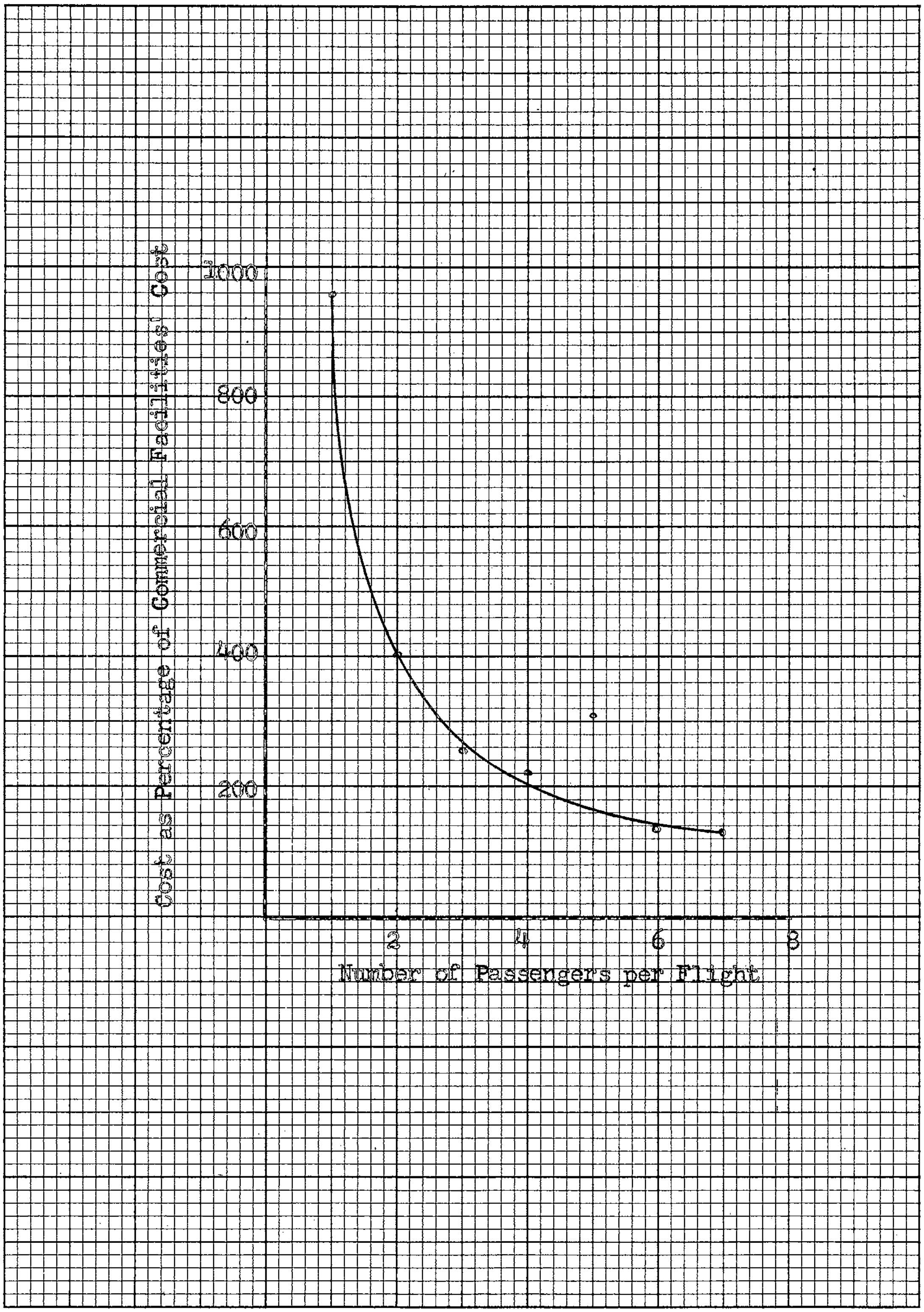

Fig. 4 Cost of Transporting Various Numbers of Passengers With Aircraft "D" Compared to Cost of Commercial Facilities

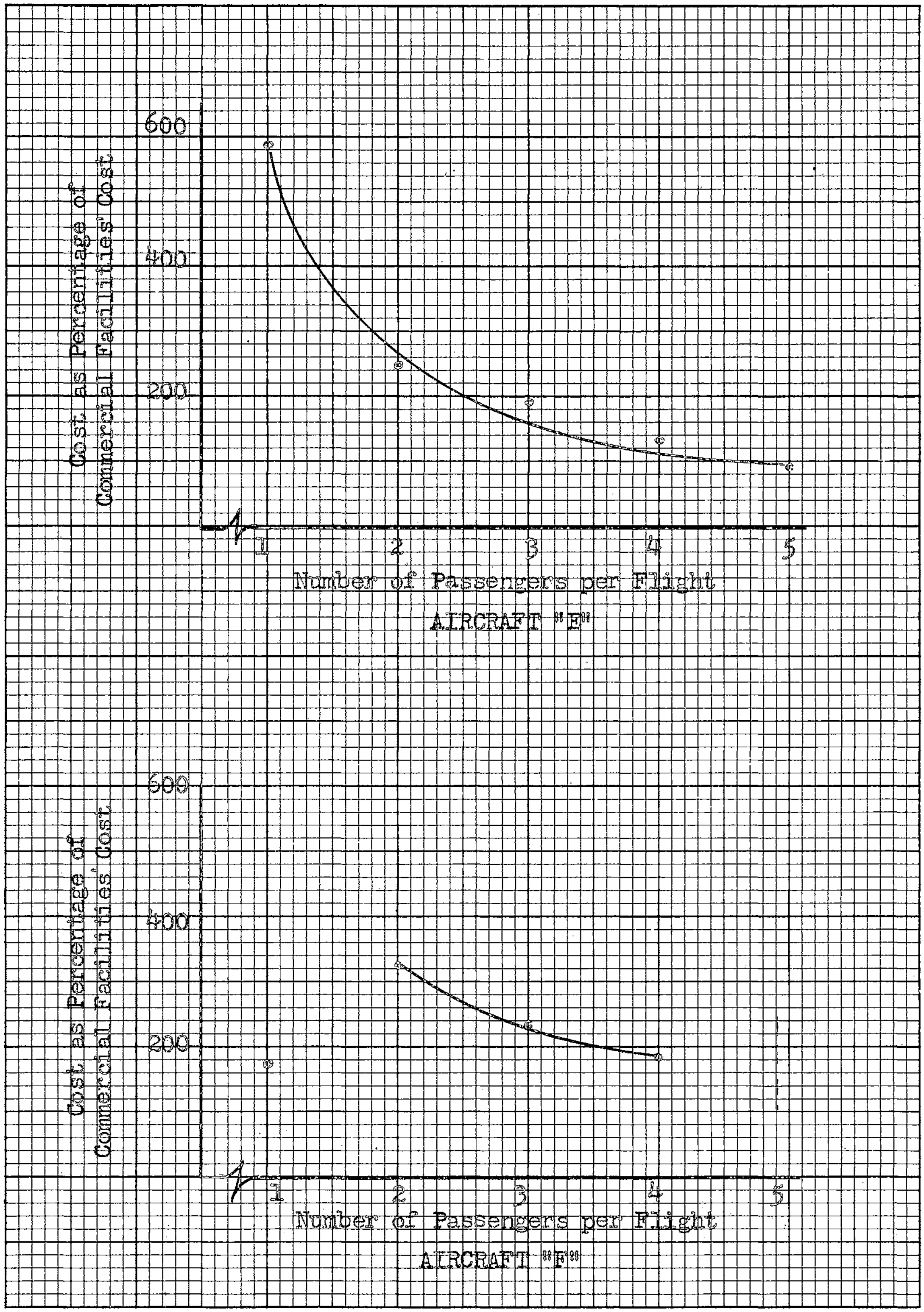

Fig. 5 Cost of Transporting Various Numbers of Passengers With Aircraft "E" and "F" Compared to Cost of Commercial Facilities

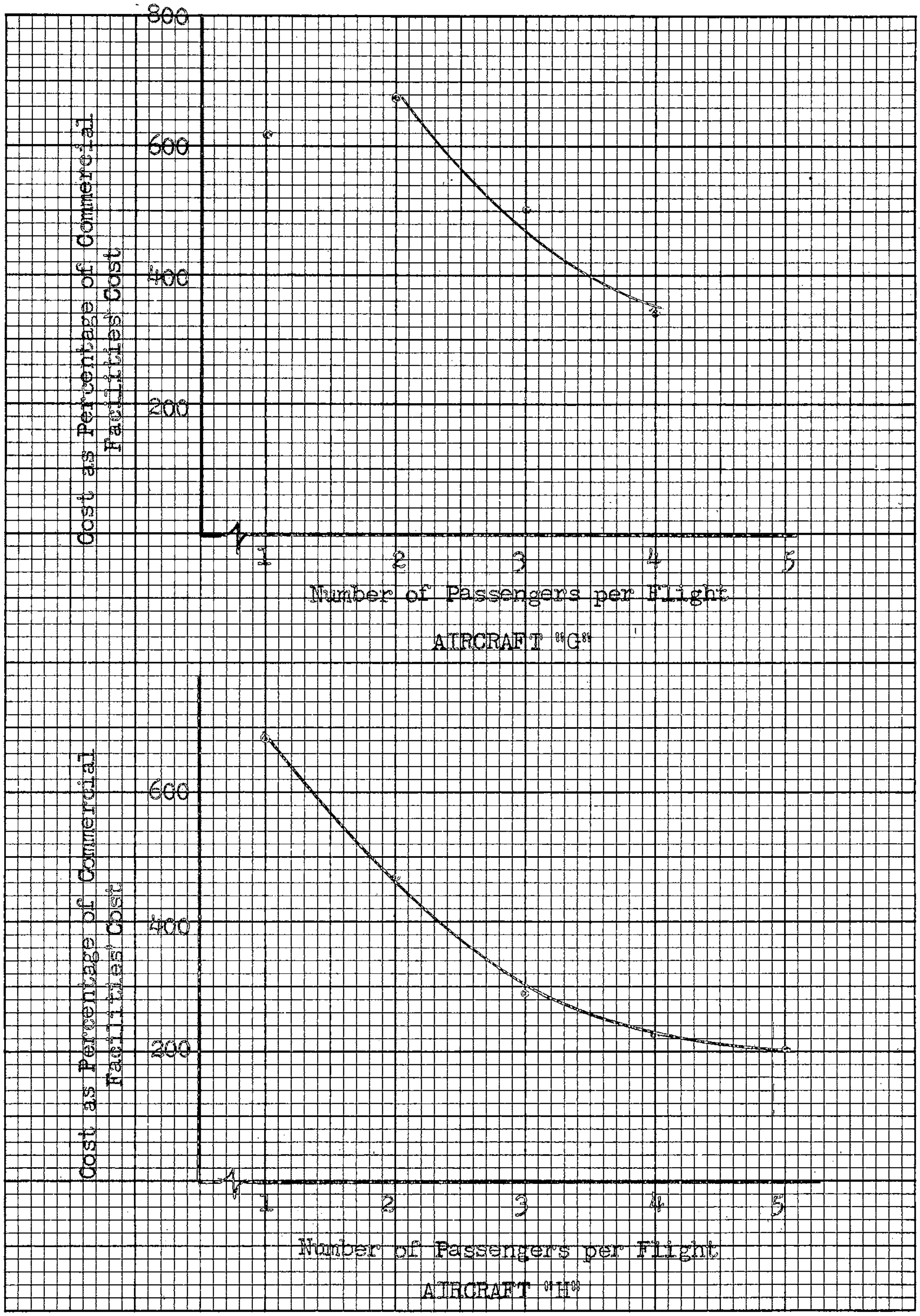

Fig. 6 Cost of Transporting Various Numbers of Passengers With Aircraft "G" and "H" Compared to Cost of Commercial Facilities

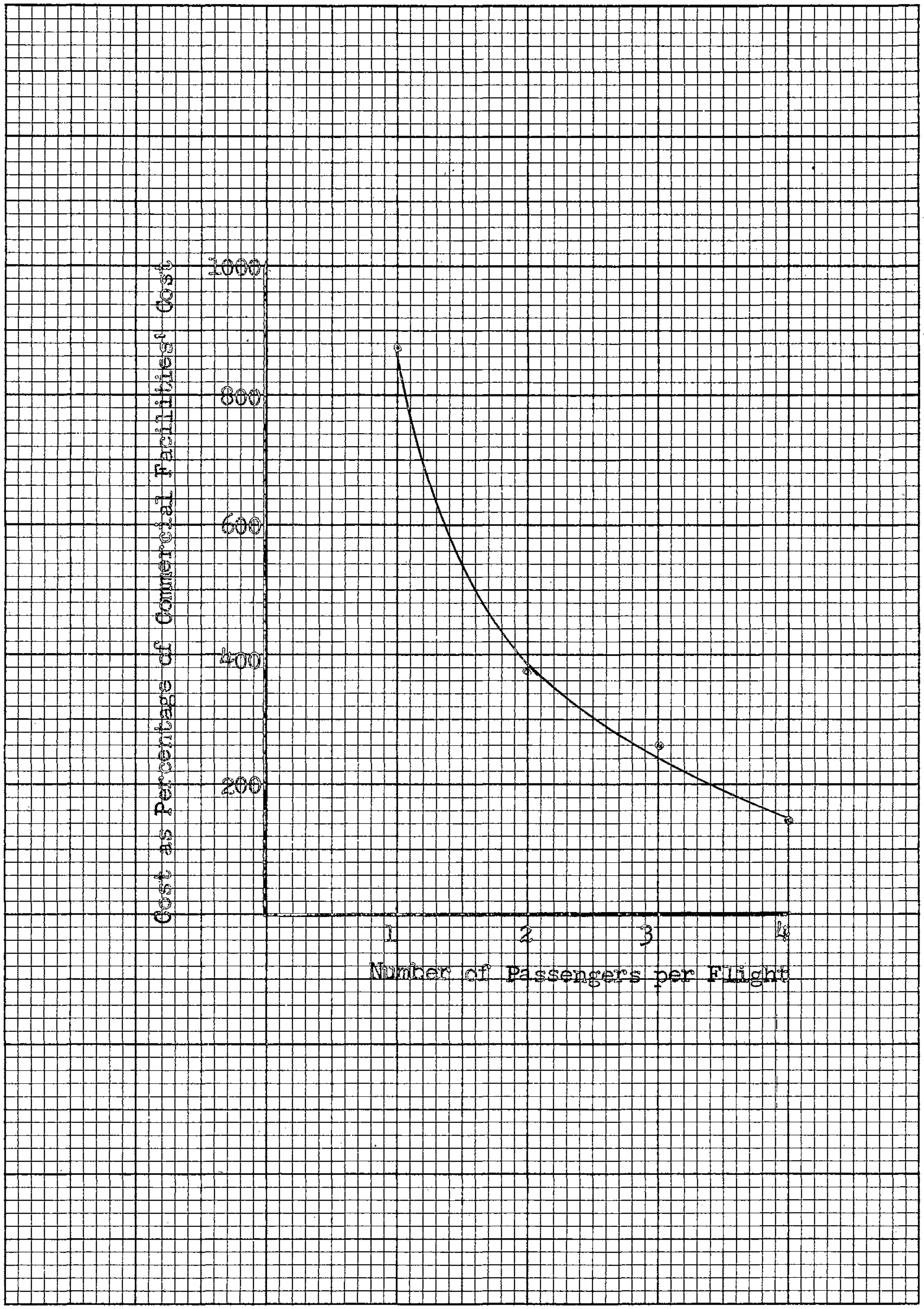

Fig. 7 Cost of Transporting Various Numbers of Passengers With Aircraft "I" Compared to Cost of Commercial Facilities

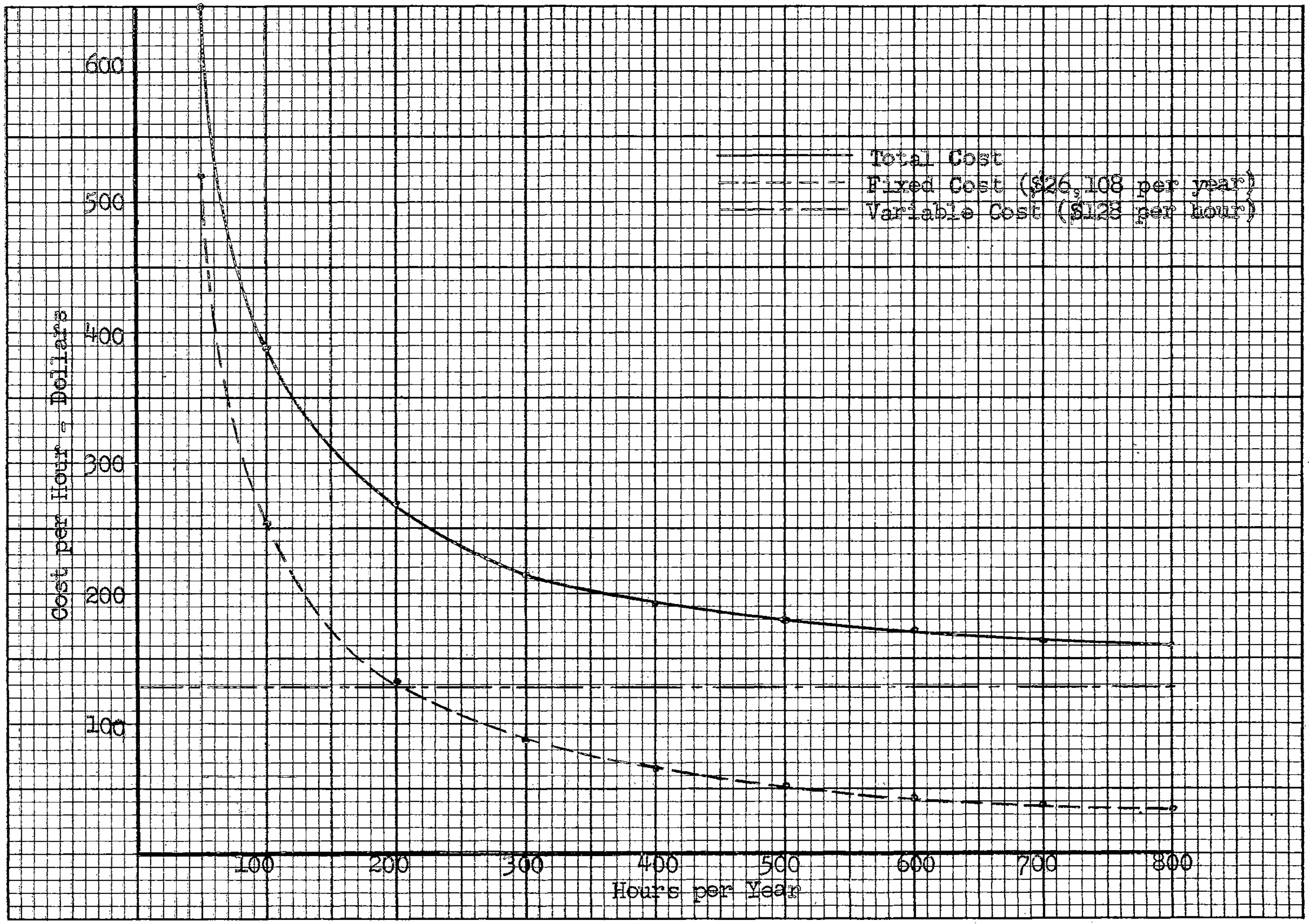

Fig. 8 Variable, Fixed, and Total Costs per Hour for Hours of Operation per Year for Aircraft "B"

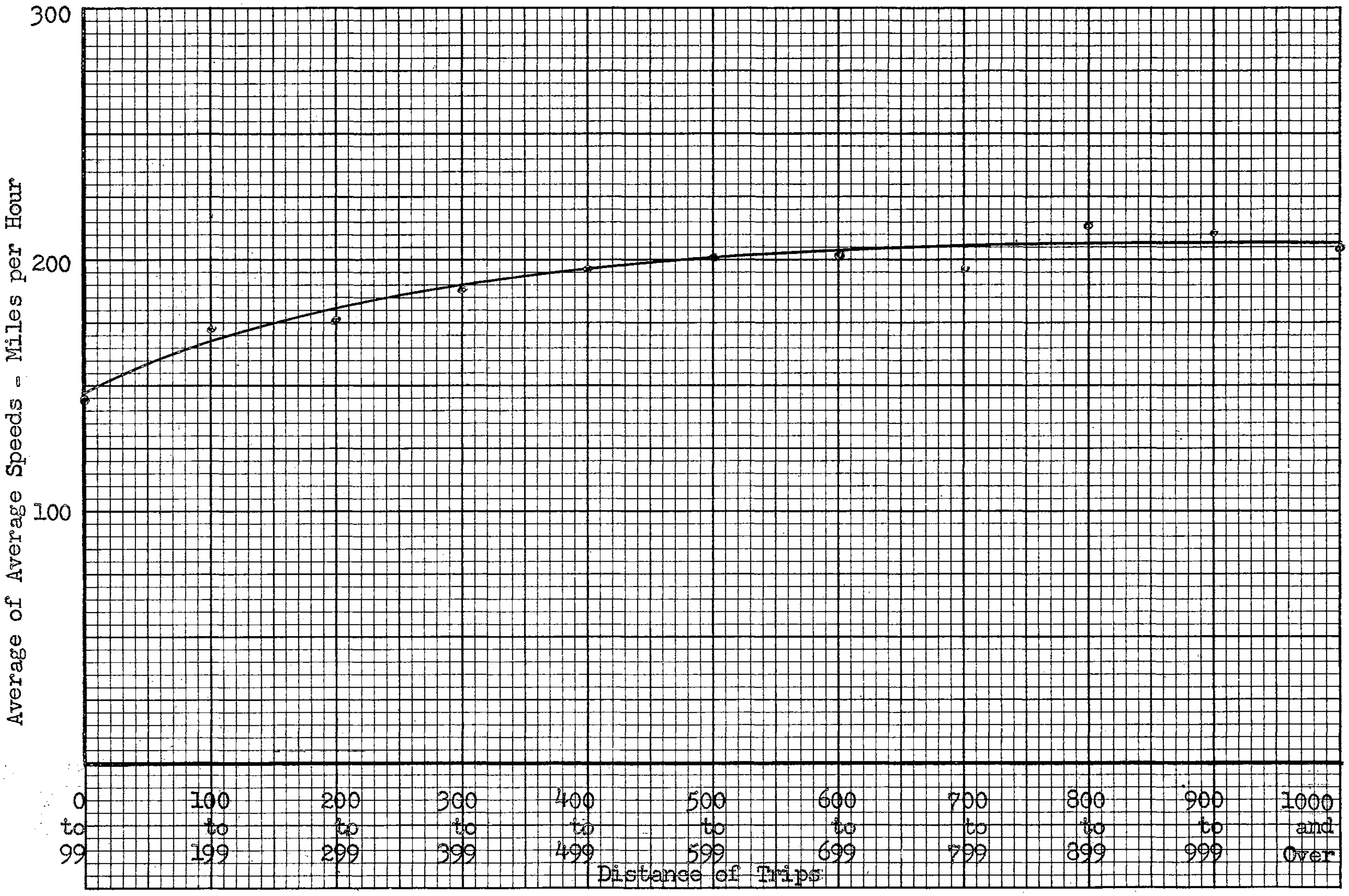

Fig. 9 Average of Average Speeds for Trips of Different Distances in Aircraft "B"

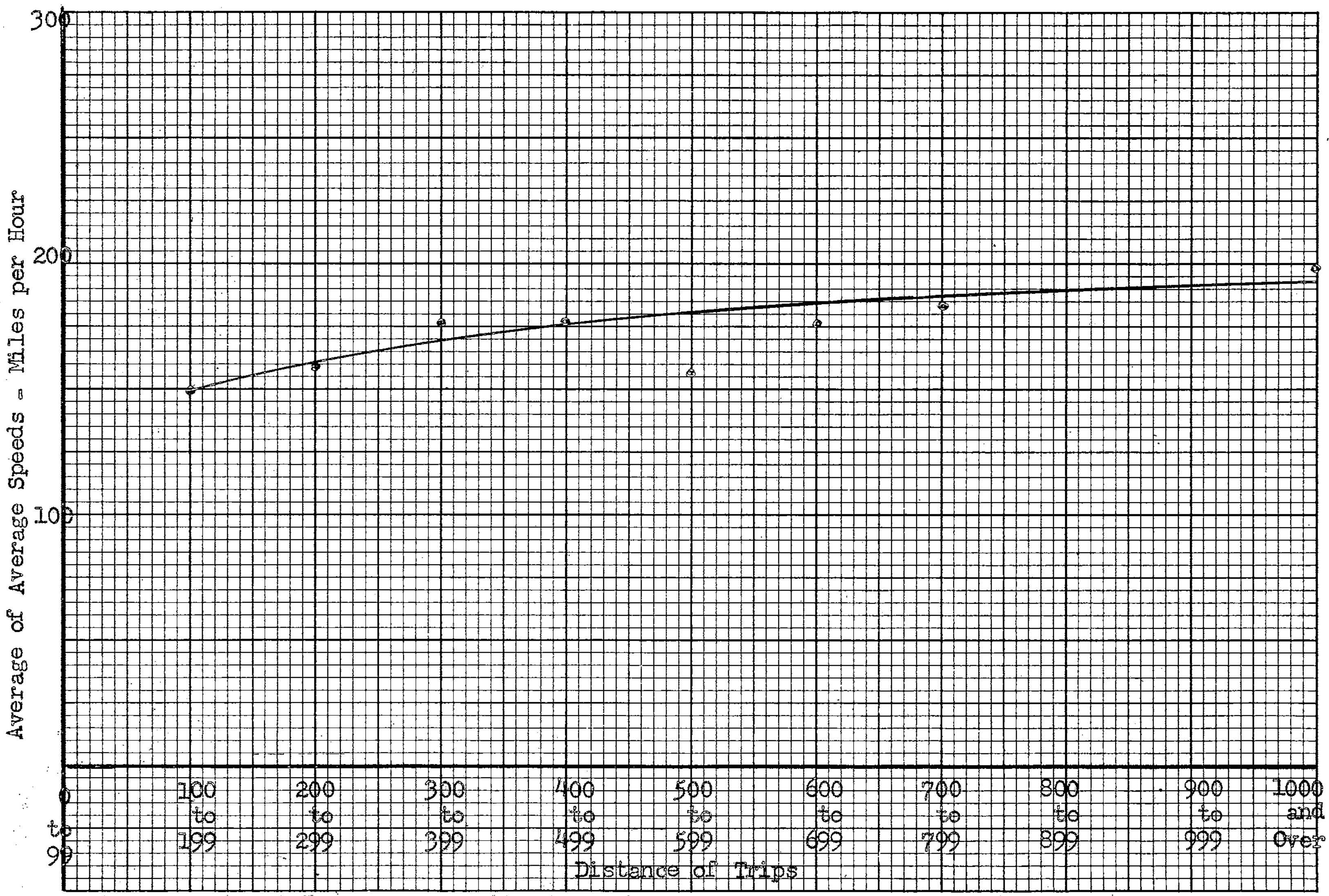

Fig. 10 Average of Average Speeds for Trips of Different Distances in Aircraft "C"

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5. "U. S. Air Distance Table," Rand McNally Cosmopolitan World Atlas, Centennial ed., New York, Rand McNally and Co., 1956, p. 197.

6. U. S. Department of Commerce, Coast and Geodetic Survey, "United States Aeronautical Planning Chart," revised 1957.

APPENDIX

Three companies furnished operating expense statements for aircraft. These statements are reproduced in order that the relationships of the various component parts of the total costs may be seen. The statements were edited to remove company names and some intermediate costs leaving only the total costs for the aircraft from the dates of acquisition to dates of the statements.

OPERATING EXPENSE STATEMENT

FOR LOCKHEED 12 AIRPLANE

	Cost	Cost Per Mile (78,777 Miles)
DIRECT OPERATIONS & MAINTENANCE		
Fuel and Lubricants	$ 6,464.89	$.082065
Operating Supplies	340.73	.004325
Engine & Propeller Repairs	5,244.46	.066574
Storage & Rental	1,584.44	.020113
Hull, Wing & Cabin Repairs	810.67	.010291
Insurance & Special Fees	1,735.08	.022025
Miscellaneous	826.50	.010492
Total	$17,006.77	$.215885
INDIRECT MISCELLANEOUS		
Salaries - Crew	$13,550.42	$.172010
Expenses - Crew	1,943.17	.024667
Miscellaneous	1,773.99	.022519
Total	$17,267.58	$.219196
GRAND TOTAL	$34,274.35	$.435081

NOTE: Depreciation is not in above statement. It is reported as approximately $25 per hour.

AERO COMMANDER

STATEMENT OF AIRCRAFT OPERATIONS

MARCH 25, 1957 TO DECEMBER 31, 1957

	AMOUNT	PER HOUR
Hours Flown	198 Hours	
Pilot Expense	$ 9,379.06	$ 47.37
Aircraft Expenses		
Gasoline and Oil	3,664.34	18.51
Maintenance		
Operating Supplies	251.27	1.27
Maintenance and Repair	1,959.47	9.90
Insurance	4,911.06	24.79
Hangar Expense	908.08	4.59
Miscellaneous	816.48	4.12
Total Operating Expenses	$21,889.76	$110.55
Depreciation	17,380.51	87.78
Total Operating Costs	$39,270.27	$198.33

D18S BEECH

ACCUMULATED AIRPLANE EXPENSES

MAY 22, 1956 TO FEBRUARY 28, 1958

Passenger Miles 448,106
Miles Flown 179,178

Operating Labor - Wages of Pilot and Co-Pilot	$ 28,532
Travel Expenses of Pilot and Co-Pilot	8,850
Operating Supplies - Gas and Oil	17,615
Maintenance and Repair Labor - Company Mechanics	4,824
Maintenance and Repair Materials	9,806
Employee Benefits - Pilot, Co-Pilot, Mechanics	5,775
Sundries - Galley supplies, uniforms, etc.	1,028
Taxes and Insurance	4,695
Hangar, Storage, and Airport Fees	4,309
Allocated Overhead	9,110
Depreciation	18,023
Total	$112,567

VITA

Clinton Ellis Murphy

Candidate for the Degree of

Master of Science

Thesis: A COST COMPARISON OF THE USE OF BUSINESS AIRCRAFT FOR PASSENGER SERVICE VERSUS COMMERCIAL AIRLINE SERVICE

Major Field: Industrial Engineering and Management

Biographical:

Personal data: Born at Pandora, Texas, September 28, 1917, son of Franklin W. and Ida Flora Murphy.

Education: Attended grade school in Eastland, Cisco, Mineral Wells and Graham, Texas; attended Mark Twain Junior High School and Thomas Jefferson High School in San Antonio, Texas, graduated from high school in 1935; received the Bachelor of Science degree with a major in Natural Gas Engineering from Texas College of Arts and Industries in May, 1941; completed the requirements for the Master of Science degree with a major in Industrial Engineering and Management in August, 1958.

Professional: During the time interval from 1941 to 1951, five and a half years were spent in various engineering capacities in the natural gas distribution industry; four years were spent in the military service, two of them in the European Theater of Operations, most of service in administrative and staff positions, separated from the service with the rank of captain in the Ordnance Department on duty with the United States Army Air Corps; the remaining half year was devoted to a small retail business venture; entered public school teaching in 1951 and taught high school Physics until January, 1953; returned to natural gas industry in engineering capacity until January, 1955; then reentered the teaching profession; since September, 1955 has been on faculty of Texas College of Arts and Industries, is now an Assistant Professor of Engineering; is a Registered Professional Engineer in Texas. Member of: Texas Society of Professional Engineers; National Society of Professional Engineers; Texas Association of College Teachers; and American Society for Engineering Education.