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CIVIL AERONAUTICS AUTHORITY
BUREAU OF FEDERAL AIRWAYS
TECHNICAL DEVELOPMENT DIVISION

Washington

Note No. 19

# ANALYSIS OF FATAL ACCIDENTS IN MISCELLANEOUS FLYING

Air Transport Section

January
1939



1649

TABLE OF CONTENTS



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# ANALYSIS OF FATAL ACCIDENTS IN MISCELLANEOUS FLYING

By

James C. Edgerton

## SUMMARY

This report is restricted to miscellaneous flying accidents involving fatalities, in order to reduce the statistical volume and to insure consideration of cases containing maximum details. The period covered is between January 1, 1934 and December 31, 1937. There occurred 690 fatal accidents which are the basis of the data presented, and the analysis of those accidents revealed that the great majority happened by reason of the personnel element. In a substantial number of accidents, violations of regulations were strong contributing factors. It is not shown that the age of pilots nor hours of experience were primary factors. It is the general purpose of this report to determine the basic underlying causes of such accidents so that remedial measures can be recommended.

Tabulations and analyses were made covering all available factors including detailed consideration of the personnel and materiel elements. This report includes the presentation of these factors, a discussion of them, and the conclusions reached.

It is concluded that it is not the materiel of miscellaneous flying which is primarily at fault when the use thereof is kept within proper limits. In a great majority of the accidents considered, the causes were the exercise of poor technique or of poor judgment, or violations of regulations by pilots.

Selected tables are appended in support of this report.

# INTRODUCTION

The study of accidents is a valuable source of information in developing safety in aviation. Up to the present little has been done to make available detailed information derived from correlated miscellaneous accidents. It is the purpose of this report to assemble such accident material from field reports, to determine the basic factors underlying such accidents, and to analyze such factors, in order that practical remedies may be developed.

Civil aviation is divided logically into two component types of operations - scheduled and miscellaneous flying. Both are transportation mediums. Ordinarily, it is thought that scheduled operation is preeminently the medium for the transportation of passengers for hire. As a matter of fact, however, in 1937 alone, 1,295,904 passengers were carried for hire in miscellaneous operations, while 1,147,969 were transported by all American owned and operated, domestic and foreign, scheduled services. During that year, miscellaneous operations covered a distance of 102,996,355 miles as compared to 76,996,163 miles flown in scheduled operations.

The period covered by this report, beginning January 1, 1934 and ending December 31, 1937, was chosen as representative. The reports covering the 690 fatal accidents which occurred during this period are judged to be reasonably accurate, statistically and technically. This opinion is confirmed by the scope of the

statistics contained in Table 1. Consideration is confined to those accidents which occurred within the continental limits of the United States.

## PERTINENT DATA

The subject may be conveniently divided as follows:

(a) Personnel
(b) Aircraft
(c) Supervision
(d) Weather
(e) Terrain (including airports)
(f) Air Navigation Aids
(g) Types of operations
(h) Traffic control
(i) Administration - Regulation

### Personnel

Reference to the number of accidents attributed to personnel, shown in Table 2, will reveal why the relative importance of this factor is emphasized. For the purpose of analysis, personnel is divided into the following groups:

I. Pilots
II. Instructors
III. Inspectors
IV. Airport officials
V. Maintenance personnel

#### Pilots

Table 3 shows that during the four year period all pilots involved in the 690 fatal accidents had accumulated the following averaged number of flying hours:

| Type | Hours |
|---|---|
| Transport | 1,927 |
| Limited commercial | 267 |
| Private | 256 |
| Amateur | 114 |
| Student | 65 |
| Unlicensed | 220 |

This table indicates no trends from year to year over the four year period.

Table 4 is one in which all miscellaneous pilots are grouped together to show the accident frequency within blocks of 50 hours of experience, and similarly, within blocks of 500 hours. It is to be noted that a preponderance of accidents occurred to pilots having less than 250 hours of experience as follows:

| Year | Percentage |
|---|---|
| 1934 | 73 |
| 1935 | 64 |
| 1936 | 51 |
| 1937 | 74 |

or an average of 65.5 per cent.

The percentage of pilots with 100 hours or less of experience, involved in fatal accidents is as follows:

| Year | Percentage |
|---|---|
| 1934 | 48 |
| 1935 | 33 |
| 1936 | 45 |
| 1937 | 50 |

or an average of 44 per cent.

Table 5 shows that, on the average, pilots involved in fatal accidents were of the following ages:

| Type | Years |
|---|---|
| Transport | 32.3 |
| Limited commercial | 27.3 |
| Private | 30.8 |
| Amateur | 26.8 |
| Student | 27.1 |
| Unlicensed | 29.0 |

This table fails to disclose any striking yearly trends.

Table 6 assembles by age groups the data on all pilots covered in the report, and is designed to show fatal accident frequencies in an age trend upward at less than the calendar rate. This trend breaks sharply downward in 1937.

Table 7, which is a composite of the age groups over the four year period, reveals that the consistently highest bracket was the 28-30 year group. Forty-six per cent of the pilots were 30 or more years of age and 59 per cent were 28 years or more. Those below 26 years were involved in only 31 per cent of the fatal accidents. To illustrate the sudden drop in age trend in 1937, this year shows that pilots below 26 years were involved in 41 per cent of the accidents, or an increase for this group of 10 per cent over the previous years.

Because of the very nature of student pilot permits, many of them are inactive. Table 8 is appended to provide the most accurate estimate possible of the number of active ratings in this category.

Table 9 is furnished to show the relative numbers of pilots in each classification and their relationship in percentage. Attention is called to the rapid decrease in the ratio of transport pilots. The

limited commercial and amateur categories also show a decrease. Opposed is the more than proportional increase among private and student pilots.

Table 10 shows the number of fatal accidents in which the pilots of each category were involved.

Table 11 shows in percentage the ratio of the number of fatal accidents among the pilot groups. The annual decrease in the number of accidents over the four year period among transport pilots is in greater proportion than the decrease in the total number of these pilots - a favorable ratio. Limited commercial and private groups showed a net increase - unfavorably. In greater proportion was the unfavorable showing of student and amateur pilots.

Table 12 is designed to show the percentage ratio of pilots in each classification involved in fatal accidents as against the total number of such pilots. It reveals improved net ratios for transport, private and student pilot groups.

Table 13 constitutes an analysis of the detailed causes of accidents the responsibility for which is assigned to personnel. Of 554 cases where personnel was directly the cause of fatal accidents, 356, or 64 per cent, are assignable to poor technique on the part of pilots. The next largest item, with 121 cases, or 22 per cent, is assigned to poor pilot judgment. Among 486 acts of commission or omission which it is believed contributed to the group of fatal accidents considered, by far the largest group, 292, is assigned to violations of regulations.

Airport Officials

Discussed on page 14.

Maintenance Personnel

Discussed on page 15.

## Aircraft

Table 14 is included to show the probable accident causes divided into basic groups. To aircraft or materiel failures (including power plants) are assigned 100 cases where such failures are believed to have contributed directly to fatal accidents. In 37 additional cases it was found that aircraft failures contributed in some degree to fatal accidents.

Table 16 is included to show the average age of aircraft - 56.8 months, and the average hours since overhaul - 321. In neither case do these figures necessarily apply to the power plant. It will be noticed that the average annual age fails considerably to increase in proportion to the actual elapsed time. It will be noted also that an improvement is indicated in the composite annual hours since overhaul. Because of the paucity of statistics, too much credence should not be given to this latter item.

Table 17 constitutes a detailed analysis of structural failures on an annual basis. This analysis includes both direct and contributory causes. Attention is called to the fact that out of 61

structural failures, 50 are believed to be attributable to wings and wing fittings. The remaining 11 failures are divided among eight separate structural items.

Table 18 is a detailed analysis of reported power plant failures, presented by years. It is unfortunate that 22 out of the 39 cases must be listed as "undetermined" either because of an incomplete field report or for undiscoverable reasons. It should be noted that the remaining 17 cases are quite uniformly spread over 11 power plant items, leaving no predominant factor.

## Supervision

Table 15 indicates that in no case was the direct responsibility for any fatal accidents attributable to supervisory personnel, although this element contributed in many of the accidents studied. This subject is discussed on page 20.

## Weather

From Table 14 it is found that over the four year period adverse weather conditions were directly responsible for 23 of the fatal accidents and contributed to an additional 23.

## Terrain

Discussed on page 18.

## Air Navigation Aids

Discussed on page 18.

## Types of Operations

Table 19 shows the various types of non-scheduled operations for the last half of the year 1937, which is typical of the entire period covered in the report. Of the 112 fatal accidents which occurred

during this six months period, only 18 can be assigned strictly to commercial operations, including rating. Student solos accounted for 28 (30 per cent) of the remaining 94.

Traffic Control

Discussed on page 20.

Administration - Regulation

Table 14 indicates that in the case of five fatal accidents, violations of regulations were assigned as direct causes. On the other hand, violations of regulations contributed to 292 such accidents.

Table 20 discloses a more flagrant type of violation of regulations involving unlicensed and student pilots carrying passengers. Of the 292 violations, 125, or 42 per cent, were in this category. It will be noted that over the four year period there was a considerable decrease in this type of violation. Violations by students involving not only passenger carrying, but also aerobatics, show a marked increase over the period considered.

Table 21 supplies a breakdown of the types of licenses issued to cover the aircraft involved in this analysis. It is of interest to note that identified or unrated aircraft were involved in 18 per cent of the total number of accidents considered. Thus the aircraft with unrated airworthiness constituted 18 per cent of all the aircraft included in this report. As of April 1, 1937, identified and unlicensed aircraft constituted 18 per cent of all aircraft engaged in miscellaneous flying.

Summarization

Table 1 is supplied to furnish in condensed form some of the more basic data. Most of the items have already been discussed briefly, with the exception of the 1,129 fatalities which occurred as a result of the 690 accidents.

## DISCUSSION

Views are expressed herewith concerning the various factors contributing to the accidents in this analysis.

### Personnel

Table 2, a composite of accident causes, shows that 79 per cent of all basic accident causes were assigned to the personnel element. On the strength of this showing, a preponderance of attention is directed toward this element.

### Pilot Hours

Too much credence should not be placed in individual statements by pilots of their hours of experience, for obvious reasons. They are not so susceptible of proof as statements of airline pilot hours.

A study of Table 3 reveals a ratio of hours of experience between the pilot groups such as might be expected, except for student and unlicensed pilots. The average of 65 hours for student pilots is surprisingly high. The extremes range from 1 to 450 hours. Table 22 indicates that the high average of 65 hours is in true proportion, as it clearly shows that this average is not overbalanced by an undue proportion of student pilots in the high brackets. Out of a total of

161 student pilots listed in Table 22 involved in fatal accidents, only 44, or 27 per cent, had more than 70 hours. These students were licensed for a period of two years. If it is assumed that on the average each student soloed in eight hours, there remains a period of roughly 60 hours of unsupervised solo flying. Undoubtedly many faults of omission and commission were developed during this period.

The Air Commerce Regulations effective during the period covered by this report provided that a student pilot must have 25 hours of solo flying to attain the grade of Amateur Pilot, and 50 hours of solo flying to become a Private Pilot. With the severe restrictions imposed upon student pilots during this period, it is difficult to understand how 130, out of a total of 180 students involved, who were eligible in hours flown, failed to avail themselves of the Amateur Pilot rating; or how 55, who had sufficient time, failed to take advantage of the Private Pilot status - unless they feared some weakness in themselves which might militate against them if discovered by a Bureau of Air Commerce inspector. This supposition seems even better founded in the case of the unlicensed (unrated) pilots, 101 of whom were involved in fatal accidents, with an average accumulation each of 220 hours.

Of all the pilots considered, 44 per cent had less than 100 hours of experience, and there were 23 per cent with less than 50 hours. Although 50 hours, and even 100 hours, do not constitute a great deal of experience it would seem that a pilot with that amount of flying time should be able to keep out of trouble. Inexperience cannot

therefore be ascribed as a major accident cause.

Pilot Ages

Table 7, which is a composite table of age groups over the four year period, shows that the age bracket from 28 to 30 years is the highest in number of fatal accidents for the 4 year period. As advancing age is generally supposed to develop stability of character, these seem surprising data. It is unfortunate that these figures can not readily be compared with those of all pilots licensed (certificated) by the former Bureau of Air Commerce, and by the present Civil Aeronautics Authority. The assumption can be tentatively drawn, however, that the age of miscellaneous pilots is not a vital factor in any predisposition to accidents.

Pilot Waivers

An analysis of the waivers of minimum requirements pertaining to physical condition, granted to a few of the pilots involved in this study, failed to reveal any case where such a waiver could be classified as a basic accident cause.

Stalls and Spins

Of the 690 accidents considered, 426 involved stalls or spins, or both. In 356 of these cases, the exercise of poor technique by the pilot was given as the direct cause of the accidents. This large proportion indicates, however, that some improvement in the handling qualities of the aircraft, if possible, would return appreciable dividends in added safety.

Instruction and Inspection of Pilots

The relationship of the non-scheduled pilot to accidents may be considered from two standpoints. The first is his training and general aptitude. The second covers his reactions to discipline and his general behavior after having proved himself as a pilot. On Table 13, it will be noted that this first element covers "Poor Judgment" and "Poor Technique", while the second covers "Disobedience", "Carelessness" and "Violations".

The exercise of poor judgment, and, especially, of poor technique, by pilots as the direct or contributory cause of accidents, reflects upon the character of flying instruction received or the type of supervision employed, or both. These twin subjects will be discussed later in this report.

Acts involving disobedience, carelessness, or the violation of regulations by pilots, which become the direct or contributory causes of miscellaneous fatal accidents, can be classified in two parts - either willfulness or ignorance. Both are supervisory elements. "Carelessness", which directly caused 63 fatal accidents, leads the other two items. Carelessness is often synonymous with overconfidence.

As it has already been stated, violations of regulations contributed to 292 of the fatal accidents covered by this report. Of the total number of pilots involved in accidents in each group, it is found that the following percentages violated regulations:

| Types | Per Cent |
|---|---|
| Unlicensed (unrated) | 54 |
| Student | 50 |
| Amateur | 46 |
| Private | 45 |
| Limited Commercial | 41 |
| Transport | 24 |

We find from Table 20 such violations as 63 fatal accidents where students were carrying passengers, in four cases for hire, and in 21 cases doing aerobatics with passengers. In 30 such accidents we find that unrated pilots were carrying passengers, in 17 of which cases they were doing aerobatics with passengers.

It is through instructors that the most fruitful contact with student pilots is afforded. It is the instructor who must instill the proper technique and form the habits leading to the exercise of good judgment, and the development of a wholesome respect for the duties of a pilot. Such instruction should do much to eliminate the marked inclination toward the violation of regulations and the carelessness in pilot performance revealed by this study. The method of rating and selecting instructors and their maintenance at the level commensurate with their importance in aviation appears to deserve the closest attention. Likewise it is important to devise and promulgate an adequate system of training which will broaden the base of instruction.

Airport Officials

Most of the flights covered by this report involved airport flying, which means that they were under at least casual observation. It seems reasonable to assume that the pilot faults which resulted in the majority of fatal accidents involved had been in many cases in

evidence prior to the fatal termination. For example, an individual is usually either habitually careful or careless, and is either prone to violate established rules or is normally cooperative. These characteristics are familiar facts to those at the home airport. Suitable means for enlisting the cooperation of airport officials would be helpful in this respect.

There were indications in many of the accidents studied that airport officials permitted flights in which it must have been apparent that violations were occurring. With 42.8 per cent of the 292 violations attributable to unlicensed (unrated) and student pilots carrying passengers, there were undoubtedly many such cases which occurred under the observation of airport officials. Where there are violations as glaringly obvious as this, means should be devised of making such officials a party to the violation.

Maintenance Personnel

Maintenance personnel are not shown by this study to have been directly responsible for any of the fatal accidents involved, although in some of the 100 cases of aircraft failure which were directly responsible for fatal accidents and 37 additional cases where aircraft failures were contributory, airplane maintenance undoubtedly was a decisive factor. Unfortunately, statistics can not reveal the facts. As aircraft mechanics are already rated for competence, it must be assumed that their work is satisfactory pending a more thorough survey of this phase of miscellaneous flying.

Aircraft

Out of 61 failures of aircraft structure resulting in a similar number of fatal accidents over the four year period, 50 are attributable to wings and wing fittings. Lack of accurate data makes it impossible to state whether this extremely large proportion resulted from maneuvers which exceeded a reasonable factor of safety, or whether there was actually a failure in structure as the preponderant cause. It is reasonable to assume, however, that the proportion of wing failures was excessive, especially in view of the fact that the remaining 11 failures were divided equally among almost as many of the other aircraft structural and control groups. The failures included a few cases of dry rot in wing members, fabric failures, fatigue of wing fittings, aileron failures, and failures due to excessive vibration.

On the basis of meager data it was found that the average number of hours between overhauls on the aircraft involved was 321 hours of elapsed flying time. An improvement was shown over the four year period, since in 1934 the average was 455 hours, as against 298 hours in 1937.

The average age of aircraft taken over the 4 year period was 56.8 months, the annual increase being considerably less than the calendar rate. A study of the accidents involved fails to reveal any decided age factor as a basic accident cause. This is striking in view of the fact that aircraft ages ranged from a few days to 18 years. This age element should receive more careful study on the basis of a broader statistical foundation, as it is evident that structural fatigue, dry rot and similar age failures are factors which must eventually be

related to the age of aircraft.

Power plant failures contributing to 39 accidents serve to reveal an unfortunate lack of data from the field. Out of the 39 cases, 22 must be listed as undetermined. There will always be a substantial proportion in this category, but it is believed that they can be limited by arranging a more thorough method of developing facts. The remaining 17 cases are divided very evenly among all the component parts of the power plant. On the basis of available data it is indicated that power plant failure is a minor factor in miscellaneous fatal accidents.

Weather

This study reveals the fact that adverse weather conditions provide a major accident factor, having been the direct cause of 23 fatal accidents and contributory to an additional 23. A majority of these accidents occurred in the course of cross-country flying. In most cases, adverse conditions developed suddenly which found the pilots involved lacking both the experience and the proper radio equipment, avigation and flight instruments to extricate themselves.

As long as miscellaneous fliers depend upon contact avigation, it is inevitable that a certain proportion will continue to be caught by adverse weather. One remedy lies in more thorough education in all phases, including instrument flight instruction, and the equipping of aircraft with the proper instruments and radio apparatus. Another is the recognition by pilots of their own limitations.

The chief obstacle to such a program is economic, as instrument training is tedious and costly. Then too, to equip one of the popular

low-priced airplanes with the proper radio and equipment requires an outlay of money out of proportion to the original cost of the aircraft itself. Further, the design of such aircraft limits them in carrying the additional weight. This is a condition which will probably be improved only with increased aircraft production and use.

It is true also that much miscellaneous flying is performed away from the airways. Aerological services are now organized mainly to serve the airways. Potentialities of miscellaneous flying are such that some consideration of the development of aerological services to serve such off-airway operations would be helpful.

Terrain

A majority of the fatal accidents covered in this report occurred upon or in the immediate vicinity of airports and can be classed properly as airport flying. In view of the fact that the aircraft involved in most of these airport accidents were of a single-engine type and had a low landing speed, it must be assumed that most of the airports involved were adequate in size. It must be further assumed, therefore, that the nature of the terrain, particularly that of the airports proper, cannot be considered a major factor in miscellaneous accidents. Rather, it is indicated that it is the use made of such airport facilities by the miscellaneous pilots involved which is the major concern. The presence of obstructions in the vicinity of airports, although a minor factor, is sufficiently prominent from this study to warrant corrective measures.

Air Navigation Aids

It has already been shown that the adjuncts to instrument flying are economically difficult of attainment for the majority of

private pilots. This fact makes our system of radio aids of no practical use for aircraft not properly equipped. The average pilot who engages in such flying, when faced with adverse conditions such as night flying complicated by adverse weather, must depend upon lighting aids. If severe weather conditions develop before he reaches an airport, his safety depends largely upon his ability to maintain a course in cross-country flying utilizing the airway light beacons, the efficiency of which depends on the degree of visibility. The thought is advanced that lighting aids must be continued, developed and amplified as an adjunct to miscellaneous flying.

Types of Operations

Table 19, covering the last half of 1937, has been prepared as typical of the non-scheduled operations engaged in during the entire four year period. It shows that miscellaneous flying can be divided roughly into 12 general categories. These 12 can again be grouped under airport, cross-country and special flying. Of these three, airport flying, with 60 per cent of the total, comprises the largest operation. Cross-country flying is the next largest with only 28 per cent, and special operations constitute 12 per cent. Airport flying for pleasure comprised 34 per cent of the total for the period covered and must be considered as the most significant of the entire category. Similarly, the next largest item, with 10 per cent, were solos by student pilots while engaged in airport flying. These two types of operations, constituting 44 per cent of the total, strongly indicate the need for closer supervision of such airport operations.

Traffic Control

There was a sufficient number (seven) of collisions between aircraft in flight and between aircraft while taking off or landing, to indicate strongly the desirability of traffic control for miscellaneous flying. The fact that this problem developed early in the 4 year period, when traffic density was at a minimum, points the way to future needs. The numerical time ratio of such accidents indicates the growing efficiency of present traffic control methods.

Administration - Regulation

Table 20 indicates that there are too many cases where student pilots especially, display overconfidence and exhibit a tendency to "show off" before others. Approximately 30 per cent of all the accidents covered in this report are due to these factors, and as a result, there is an imposing list of passenger fatalities. The only control possible lies in better training and stricter supervision of student flying. It would seem that some student pilots have not been properly impressed with the limitations of present day flying, and further that they have been allowed to develop faulty technique and judgment, unchecked. There are too many student pilots to be kept under constant check by the inspectors. Additional responsibility could probably be lodged with the instructors and a system of accountability developed.

A great many cases were discovered, chiefly among student pilots, of aerobatics being performed over crowds and populated areas with fatal results. The fact has already been cited that in 297 fatal accidents there were violations of regulations involved. A campaign

of education might be helpful in this respect. It could be directed toward impressing upon students in particular a more wholesome attitude toward flying. Some of them apparently need to be impressed with the idea that flight regulations are set up for their benefit and that over-confidence has no place in aviation.

## TABLE 1 - ACCIDENT SUMMARIZATION

| | | |
|---|---|---|
| 1. | Accidents ..... | 690 |
| 2. | Fatalities - total ..... | 1189 |
| 3. | Transport pilots involved ..... | 234 |
| 4. | Limited Commercial pilots involved ..... | 34 |
| 5. | Private pilots involved ..... | 146 |
| 6. | Student pilots involved ..... | 180 |
| 7. | Amateur pilots involved ..... | 11 |
| 8. | Unlicensed pilots involved ..... | 101 |
| 9. | Accidents involving violations ..... | 297 |

TABLE 2 - COMPOSITE ACCIDENT CAUSES

| Year | Personnel | Structural | Power Plant | Weather | Undetermined | Totals |
|---|---|---|---|---|---|---|
| 1934 | 150 | 18 | 8 | 3 | 5 | 184 |
| 1935 | 127 | 18 | 13 | 3 | 10 | 171 |
| 1936 | 127 | 11 | 11 | 9 | 6 | 164 |
| 1937 | 150 | 14 | 7 | 8 | 8 | 187 |
| | 554 | 61 | 39 | 23 | 29 | 706* |

*706 pilots were involved in the 690 fatal accidents, due to seven accidents involving more than one aircraft.

## TABLE 3 - AVERAGE HOURS BY PILOT GROUPS

| Pilot Classification | 1934 | 1935 | 1936 | 1937 | Averages-Hours |
|---|---|---|---|---|---|
| Transport ..... | 1961 | 1752 | 2139 | 1850 | 1927 |
| Limited Commercial ..... | 314 | 367 | 143 | 247 | 267 |
| Private ..... | 364 | 204 | 290 | 168 | 256 |
| Amateur ..... | 15 | 143 | 57 | 244 | 114 |
| Student ..... | 60 | 102 | 55 | 46 | 65 |
| Unlicensed ..... | 115 | 185 | 358 | 224 | 220 |

## TABLE 4 - PILOT HOURS FLOWN VS. ACCIDENT FREQUENCY

### Pilot Experience Groups of 50 Hours

| Hours | 1934 | 1935 | 1936 | 1937 | Average Hours All Years |
|---|---|---|---|---|---|
| 0 - 50 ..... | 27 | 22 | 26 | 46 | 30.2 |
| 50 - 100 ..... | 38 | 16 | 21 | 37 | 28.0 |
| 100 - 150 ..... | 14 | 16 | 13 | 20 | 15.7 |
| 150 - 200 ..... | 7 | 9 | 8 | 8 | 8.0 |
| 200 - 250 ..... | 13 | 10 | 9 | 10 | 10.5 |
| 250 - 300 ..... | 6 | 3 | 4 | 5 | 4.5 |
| 300 - 350 ..... | 4 | 10 | 6 | 9 | 7.2 |
| 350 - 400 ..... | 2 | 4 | 1 | 0 | 1.7 |
| 400 - 450 ..... | 9 | 4 | 5 | 1 | 4.7 |
| 450 - 500 ..... | 1 | 7 | 0 | 5 | 3.2 |
| 500 - 550 ..... | 2 | 4 | 6 | 3 | 3.7 |
| 550 - 600 ..... | 1 | 2 | 0 | 1 | 1.0 |
| 600 - 650 ..... | 2 | 3 | 2 | 2 | 2.2 |
| 650 - 700 ..... | 0 | 0 | 0 | 2 | 0.5 |
| 700 - 750 ..... | 3 | 0 | 0 | 1 | 1.0 |
| 750 - 800 ..... | 1 | 0 | 0 | 0 | 0.2 |
| 800 - 850 ..... | 3 | 2 | 3 | 3 | 2.7 |
| 850 - 900 ..... | 0 | 1 | 0 | 6 | 1.7 |
| 900 - 950 ..... | 2 | 1 | 0 | 4 | 1.7 |
| 950 - 1000 ..... | 1 | 0 | 1 | 1 | 0.7 |
| | 136* | 114* | 105* | 164* | 129.7 |

*Number of pilots with hour data available.

TABLE 4 - PILOT HOURS FLOWN VS. ACCIDENT FREQUENCY (CONTD)

Pilot Experience Groups of 500 Hours

| Hours | 1934 | 1935 | 1936 | 1937 | Average Hours All Years |
|---|---|---|---|---|---|
| 0 - 500 ..... | 121 | 101 | 93 | 141 | 114.0 |
| 500 - 1000 ..... | 15 | 13 | 12 | 23 | 15.7 |
| 1000 - 1500 ..... | 8 | 7 | 8 | 6 | 7.2 |
| 1500 - 2000 ..... | 6 | 6 | 9 | 5 | 6.5 |
| 2000 - 2500 ..... | 2 | 5 | 2 | 2 | 2.7 |
| 2500 - 3000 ..... | 5 | 4 | 7 | 3 | 4.7 |
| 3000 - 3500 ..... | 8 | 4 | 4 | 3 | 4.7 |
| 3500 - 4000 ..... | 1 | 4 | 1 | 0 | 1.5 |
| 4000 - 4500 ..... | 2 | 1 | 1 | 3 | 1.7 |
| 4500 - 5000 ..... | 2 | 1 | 1 | 1 | 1.2 |
| 5000 - 5500 ..... | 2 | 2 | 1 | 1 | 1.5 |
| 5500 - 6000 ..... | 0 | 0 | 0 | 0 | 0.0 |
| 6000 - 6500 ..... | 0 | 1 | 1 | 0 | 0.5 |
| 6500 - 7000 ..... | 0 | 0 | 1 | 0 | 0.2 |
| 7000 - 7500 ..... | 0 | 0 | 0 | 0 | 0.0 |
| 7500 - 8000 ..... | 0 | 0 | 1 | 0 | 0.2 |
| 8000 & over ..... | 2 | 0 | 1 | 2 | 1.2 |
| | 174 | 149 | 143 | 190 | 164.0 |

TABLE 5 - AVERAGE AGES - BY PILOT GROUPS

| Pilot Classification | 1934 | 1935 | 1936 | 1937 | Average Age |
|---|---|---|---|---|---|
| Transport ..... | 32.4 | 31.6 | 33.3 | 31.9 | 32.3 |
| Limited Commercial ..... | 25.7 | 29.7 | 28 | 26 | 27.3 |
| Private ..... | 32 | 29 | 32.4 | 30 | 30.8 |
| Amateur ..... | 29 | 28 | 21 | 29.5 | 26.8 |
| Student ..... | 27 | 26.7 | 28.3 | 26.7 | 27.1 |
| Unlicensed ..... | 28 | 28 | 31.5 | 28.7 | 29.0 |
| Composite Average ..... | 29.0 | 28.8 | 29.1 | 28.8 | 28.9 |

## TABLE 6 - PILOT AGES VS. ACCIDENT FREQUENCY BY YEARS

1934

| Arranged per Age Factor | | | Arranged per Accident Factor | |
|---|---|---|---|---|
| Age | No. of Accidents | No. of Accidents | Age |
| 16 - 18 | 1 | 25 | 24 - 26 |
| 18 - 20 | 3 | 21 | 30 - 32 |
| 20 - 22 | 13 | 20 | 26 - 28 |
| 22 - 24 | 14 | 19 | 28 - 30 |
| 24 - 26 | 25 | 16 | 34 - 36 |
| 26 - 28 | 20 | 16 | 38 - 40 |
| 28 - 30 | 19 | 14 | 22 - 24 |
| 30 - 32 | 21 | 13 | 20 - 22 |
| 32 - 34 | 12 | 12 | 32 - 34 |
| 34 - 36 | 16 | 7 | 36 - 38 |
| 36 - 38 | 7 | 4 | 40 - 42 |
| 38 - 40 | 16 | 3 | 18 - 20 |
| 40 - 42 | 4 | 3 | 44 - 46 |
| 42 - 44 | 2 | 3 | 46 - 48 |
| 44 - 46 | 3 | 2 | 42 - 44 |
| 46 - 48 | 3 | 2 | 50 - 52 |
| 48 - 50 | 0 | 1 | 16 - 18 |
| 50 - 52 | 2 | | |
| | 181 | 181 | |

TABLE 6 - PILOT AGES VS. ACCIDENT FREQUENCY BY YEARS (CONTD)

1935

| Arranged per Age Factor | | Arranged per Accident Factor | |
|---|---|---|---|
| Age | No. of Accidents | No. of Accidents | Age |
| 16 - 18 | 1 | 30 | 28 - 30 |
| 18 - 20 | 5 | 21 | 26 - 28 |
| 20 - 22 | 9 | 19 | 30 - 32 |
| 22 - 24 | 8 | 12 | 24 - 26 |
| 24 - 26 | 12 | 12 | 36 - 38 |
| 26 - 28 | 21 | 10 | 38 - 40 |
| 28 - 30 | 30 | 9 | 20 - 22 |
| 30 - 32 | 19 | 9 | 32 - 34 |
| 32 - 34 | 9 | 9 | 34 - 36 |
| 34 - 36 | 9 | 8 | 22 - 24 |
| 36 - 38 | 12 | 5 | 18 - 20 |
| 38 - 40 | 10 | 5 | 40 - 42 |
| 40 - 42 | 5 | 3 | 42 - 44 |
| 42 - 44 | 3 | 2 | 44 - 46 |
| 44 - 46 | 2 | 2 | 46 - 48 |
| 46 - 48 | 2 | 1 | 16 - 18 |
| | 157 | 157 | |

## TABLE 8 - PILOT AGES VS. ACCIDENT FREQUENCY BY YEARS (CONTD)

### 1936

| Arranged per Age Factor | | Arranged per Accident Factor | |
|---|---|---|---|
| Age | No. of Accidents | No. of Accidents | Age |
| 16 - 18 | 2 | 18 | 24 - 26 |
| 18 - 20 | 1 | 18 | 28 - 30 |
| 20 - 22 | 10 | 14 | 26 - 28 |
| 22 - 24 | 13 | 13 | 22 - 24 |
| 24 - 26 | 18 | 12 | 30 - 32 |
| 26 - 28 | 14 | 12 | 32 - 34 |
| 28 - 30 | 18 | 11 | 34 - 36 |
| 30 - 32 | 12 | 10 | 20 - 22 |
| 32 - 34 | 12 | 10 | 38 - 40 |
| 34 - 36 | 11 | 6 | 36 - 38 |
| 36 - 38 | 6 | 5 | 40 - 42 |
| 38 - 40 | 10 | 5 | 44 - 46 |
| 40 - 42 | 5 | 4 | 50 - 52 |
| 42 - 44 | 1 | 3 | 46 - 48 |
| 44 - 46 | 5 | 2 | 16 - 18 |
| 46 - 48 | 3 | 1 | 18 - 20 |
| 48 - 50 | 1 | 1 | 42 - 44 |
| 50 - 52 | 4 | 1 | 48 - 50 |
| 52 - 54 | 1 | 1 | 52 - 54 |
| 54 - 56 | 1 | 1 | 54 - 56 |
| 56 - 58 | 1 | 1 | 56 - 58 |
| 61 | 1 | 1 | 61 |
| | 150 | 150 | |

TABLE 3 - PILOT AGE VS. ACCIDENT FREQUENCY

1937

| Arranged per Age Factor | | Arranged per Accident Factor | |
|---|---|---|---|
| Age | No. of Accidents | No. of Accidents | Age |
| 16 - 18 | 4 | 23 | 22 - 24 |
| 18 - 20 | 12 | 20 | 28 - 30 |
| 20 - 22 | 18 | 19 | 24 - 26 |
| 22 - 24 | 23 | 18 | 20 - 22 |
| 24 - 26 | 19 | 15 | 30 - 32 |
| 26 - 28 | 11 | 12 | 18 - 20 |
| 28 - 30 | 20 | 11 | 26 - 28 |
| 30 - 32 | 15 | 11 | 32 - 34 |
| 32 - 34 | 11 | 11 | 34 - 36 |
| 34 - 36 | 11 | 11 | 42 - 44 |
| 36 - 38 | 10 | 10 | 36 - 38 |
| 38 - 40 | 6 | 6 | 38 - 40 |
| 40 - 42 | 5 | 5 | 40 - 42 |
| 42 - 44 | 11 | 4 | 16 - 18 |
| 44 - 46 | 2 | 2 | 44 - 46 |
| 46 - 48 | 2 | 2 | 46 - 48 |
| 48 - 50 | 2 | 2 | 48 - 50 |
| 50 - 52 | 2 | 2 | 50 - 52 |
| | 184 | 184 | |

## [redacted] - PILOT AGES VS. ACCIDENT FREQUENCY

Four Years - 1934, 1935, 1936, 1937

| Age | No. of Accidents | No. of Accidents | Age |
|---|---|---|---|
| 16 - 18 | 8 | 87 | 28 - 30 |
| 18 - 20 | 21 | 74 | 24 - 26 |
| 20 - 22 | 50 | 67 | 30 - 32 |
| 22 - 24 | 58 | 66 | 26 - 28 |
| 24 - 26 | 74 | 58 | 22 - 24 |
| 26 - 28 | 66 | 50 | 20 - 22 |
| 28 - 30 | 87 | 49 | 34 - 36 |
| 30 - 32 | 67 | 44 | 32 - 34 |
| 32 - 34 | 44 | 42 | 38 - 40 |
| 34 - 36 | 49 | 35 | 36 - 38 |
| 36 - 38 | 35 | 21 | 18 - 20 |
| 38 - 40 | 42 | 19 | 40 - 42 |
| 40 - 42 | 19 | 17 | 42 - 44 |
| 42 - 44 | 17 | 12 | 44 - 46 |
| 44 - 46 | 12 | 10 | 46 - 48 |
| 46 - 48 | 10 | 8 | 50 - 52 |
| 48 - 50 | 3 | 8 | 16 - 18 |
| 50 - 52 | 8 | 3 | 48 - 50 |
| 52 - 54 | 1 | 1 | 52 - 54 |
| 54 - 56 | 1 | 1 | 54 - 56 |
| 56 - 58 | 1 | 1 | 56 - 58 |
| 61 | 1 | 1 | 61 |
| | 674* | 674* | |

*Ages were not available for the remaining 32 pilots.

TABLE 8 - STUDENT LICENSES

| Year | Total Student Licenses Issued | Inactive Student Licenses (Estimated) | Active Student Licenses (Estimated) |
|---|---|---|---|
| 1934 | 11,994 | 8,156 | 3,833 |
| 1935 | 14,572 | 9,909 | 4,663 |
| 1936 | 17,675 | 12,019 | 5,656 |
| 1937 | 21,770 | 14,804 | 6,966 |

TABLE 9 - TOTAL NUMBER OF PILOTS IN EACH RATING AND

PERCENTAGE INVOLVED IN FATAL ACCIDENTS

| Year | Transport | Limited Commercial | Private | Amateur | Student | Totals |
|---|---|---|---|---|---|---|
| 1934 ..... | 7,068 | 1,006 | 5,110 | 679 | 3,838 | 17,701 |
| Percentage . | 39.9 | 5.7 | 28.9 | 3.8 | 21.7 | 100.0 |
| 1935 ..... | 6,450 | 909 | 5,961 | 746 | 4,663 | 18,729 |
| Percentage . | 34.4 | 4.9 | 31.8 | 4.0 | 24.9 | 100.0 |
| 1936 ..... | 6,408 | 880 | 7,154 | 668 | 5,656 | 20,766 |
| Percentage . | 30.8 | 4.2 | 34.4 | 3.3 | 27.3 | 100.0 |
| 1937 ..... | 6,411 | 971 | 8,604 | 631 | 6,966 | 23,583 |
| Percentage . | 27.2 | 4.1 | 36.6 | 2.6 | 29.5 | 100.0 |

TABLE 10 - ACCIDENTS BY PILOT CLASSIFICATIONS

| Year | Transport | Limited Commercial | Private | Student Amateur | Unlicensed | Total |
|---|---|---|---|---|---|---|
| 1934 ..... | 68 | 9 | 30 | 49 | 37 | 193 |
| 1935 ..... | 63 | 7 | 36 | 34 | 23 | 163 |
| 1936 ..... | 57 | 7 | 39 | 41 | 16 | 160 |
| 1937 ..... | 46 | 11 | 41 | 67 | 25 | 190 |
| | 234 | 34 | 146 | 191 | 101 | 706* |

*706 pilots were involved in the 690 fatal accidents, the discrepancy being due to seven accidents involving more than one aircraft.

## TABLE 11 - FATAL ACCIDENTS

## RATIO OF ACCIDENTS BETWEEN PILOT GROUPS

| Year | Transport | Limited Commercial | Private | Amateur | Student | Unlicensed | Totals |
|---|---|---|---|---|---|---|---|
| 1934 ..... | 68 | 9 | 30 | 1 | 48 | 37 | 193 |
| Percentage . | 35.2 | 4.7 | 15.5 | 0.5 | 24.9 | 19.2 | 100.0 |
| 1935 ..... | 63 | 7 | 36 | 1 | 33 | 23 | 163 |
| Percentage . | 38.7 | 4.3 | 22.1 | 0.6 | 20.2 | 14.1 | 100.0 |
| 1936 ..... | 57 | 7 | 39 | 2 | 39 | 16 | 160 |
| Percentage . | 35.6 | 4.4 | 24.4 | 1.2 | 24.4 | 10.0 | 100.0 |
| 1937 ..... | 46 | 11 | 41 | 7 | 60 | 25 | 190 |
| Percentage . | 24.2 | 5.8 | 21.6 | 3.6 | 31.6 | 13.2 | 100.0 |
| | 234 | 34 | 146 | 11 | 180 | 101 | 706 |

## TABLE 12 - NON-SCHEDULE FATAL ACCIDENTS

RATIO OF TOTAL RATED PILOTS TO FATAL ACCIDENTS

| Year | Breakdown | Transport** | Limited Commercial | Private | Amateur | Student*** | Totals |
|---|---|---|---|---|---|---|---|
| | ACB totals* | 7,068 | 1,006 | 5,110 | 679 | 3,838 | 17,701 |
| 1934 | Inv. in accidents | 68 | 9 | 30 | 1 | 48 | 156 |
| | Ratios | 0.0096 | 0.0089 | 0.0058 | 0.0014 | 0.0125 | 0.0088 |
| | ACB totals* | 6,450 | 909 | 5,961 | 746 | 4,663 | 18,729 |
| 1935 | Inv. in accidents | 78 | 7 | 37 | 1 | 33 | 156 |
| | Ratios | 0.0121 | 0.0077 | 0.0062 | 0.0013 | 0.0070 | 0.0082 |
| | ACB totals* | 6,408 | 880 | 7,154 | 668 | 5,656 | 20,766 |
| 1936 | Inv. in accidents | 57 | 7 | 39 | 2 | 39 | 144 |
| | Ratios | 0.0089 | 0.0079 | 0.0054 | 0.0029 | 0.0069 | 0.0069 |
| | ACB totals* | 6,411 | 971 | 8,604 | 631 | 6,966 | 23,583 |
| 1937 | Inv. in accidents | 46 | 11 | 41 | 7 | 60 | 165 |
| | Ratios | 0.0071 | 0.0113 | 0.0047 | 0.0110 | 0.0086 | 0.0069 |

* ACB refers to the Air Commerce Bulletin which contains official statistics.
** Less airline pilots.
*** Estimated to be active student pilots.

TABLE 13 - CAUSES OF ACCIDENTS ATTRIBUTED TO PERSONNEL

| Year | | Poor Judgment | Poor Technique | Disobedience | Carelessness | Violations | Total Causes |
|---|---|---|---|---|---|---|---|
| 1934 | Direct | 18 | 109 | 3 | 18 | 2 | 150 |
| | Contrib. | 34 | 3 | 20 | 3 | 87 | 147 |
| 1935 | Direct | 24 | 87 | 3 | 12 | 1 | 127 |
| | Contrib. | 15 | 5 | 22 | 6 | 74 | 122 |
| 1936 | Direct | 38 | 76 | 0 | 12 | 1 | 127 |
| | Contrib. | 27 | 6 | 4 | 5 | 74 | 116 |
| 1937 | Direct | 41 | 84 | 3 | 21 | 1 | 150 |
| | Contrib. | 19 | 11 | 8 | 6 | 57 | 101 |
| | Direct | 121 | 356 | 9 | 63 | 5 | 554 |
| | Contrib. | 95 | 25 | 54 | 20 | 292 | 486 |

TABLE 14 - COMPOSITE DATA - CAUSES OF FATAL ACCIDENTS

| | Personnel | | | | | Miscellaneous | | |
|---|---|---|---|---|---|---|---|---|
| Year | Poor Judgment | Poor Technique | Disobedience | Carelessness | Violations | Aircraft | Weather | Undetermined |
| 1934 | | | | | | | | |
| Primary | 18 | 109 | 3 | 18 | 2 | 26 | 3 | 5 |
| Contrib. | 34 | 3 | 20 | 3 | 87 | 15 | 12 | 3 |
| 1935 | | | | | | | | |
| Primary | 24 | 87 | 3 | 12 | 1 | 31 | 3 | 10 |
| Contrib. | 15 | 5 | 22 | 6 | 74 | 10 | 3 | 4 |
| 1936 | | | | | | | | |
| Primary | 38 | 76 | 0 | 12 | 1 | 22 | 9 | 6 |
| Contrib. | 27 | 6 | 4 | 5 | 74 | 4 | 8 | 6 |
| 1937 | | | | | | | | |
| Primary | 41 | 84 | 3 | 21 | 1 | 21 | 8 | 8 |
| Contrib. | 19 | 11 | 8 | 6 | 57 | 8 | 0 | 4 |
| Totals | | | | | | | | |
| Primary | 121 | 356 | 9 | 63 | 5 | 100 | 23 | 29 |
| Contrib. | 95 | 25 | 54 | 20 | 292 | 37 | 23 | 17 |

TABLE 15 - ACCIDENT SYNOPSIS - MISCELLANEOUS FLYING

Jan. 1, 1934 - Dec. 31, 1937

| | PROBABLE ACCIDENT CAUSES | | | | FATALITIES RESULTING |
|---|---|---|---|---|---|
| | Personnel Inefficiency | | Other Causes | | |
| Year | Pilots | Others | Aircraft | Miscellaneous | Passengers and Pilots |
| 1934 ..... | 150 | 0 | 26 | 8 | 323 |
| 1935 ..... | 127 | 0 | 31 | 13 | 258 |
| 1936 ..... | 127 | 0 | 22 | 15 | 269 |
| 1937 ..... | 150 | 0 | 21 | 16 | 279 |
| | 554 | 0 | 100 | 52 | 1,129 |

TABLE 16 - AIRCRAFT - HOURS SINCE OVERHAUL AND AVERAGE AGE

| Year | Average Age (In Months) | Hours since Overhaul |
|---|---|---|
| 1934 | 54 | 455 |
| 1935 | 53½ | 378 |
| 1936 | 58 | 152 |
| 1937 | 62 | 298 |
| Average | 56.8 Average | 321 |

TABLE 17 - STRUCTURAL FAILURES - CONTRIBUTING CAUSES

| Failures | 1934 | 1935 | 1936 | 1937 | Totals |
|---|---|---|---|---|---|
| Wings and Fittings | 15 | 14 | 9 | 12 | 50 |
| Rotors ..... | 1 | - | - | - | 1 |
| Flaps ..... | - | 1 | - | - | 1 |
| Controls ..... | - | 1 | - | 1 | 2 |
| Control Cables ... | - | - | 1 | 1 | 2 |
| Safety Belts ..... | 1 | 1 | - | - | 2 |
| Struts ..... | - | 1 | - | - | 1 |
| Pilot Seat ..... | - | - | 1 | - | 1 |
| Undetermined ..... | 1 | - | - | - | 1 |
| | 18 | 18 | 11 | 14 | 61 |

TABLE 18 - POWER PLANT FAILURES - CONTRIBUTING CAUSES

| Failures | 1934 | 1935 | 1936 | 1937 | Totals |
|---|---|---|---|---|---|
| Carburetor ..... | - | 1 | - | - | 1 |
| Fuel System ..... | - | 1 | 1 | - | 2 |
| Water in fuel ..... | - | 1 | - | - | 1 |
| Propeller ..... | - | 1 | 1 | - | 2 |
| Cooling System ..... | - | - | 1 | 1 | 2 |
| Valves ..... | - | - | 2 | - | 2 |
| Engine ..... | - | - | - | 2 | 2 |
| Undetermined ..... | 5 | 9 | 5 | 3 | 22 |
| Engine loaded ..... | 1 | - | - | 1 | 2 |
| Cutting out ..... | 1 | - | - | - | 1 |
| Overheating ..... | 1 | - | - | - | 1 |
| Backfire ..... | - | - | 1 | - | 1 |
| | 8 | 13 | 11 | 7 | 39 |

TABLE 19 - TYPES OF OPERATIONS - 1937 (last half)

(Typical of Three Year Period)

| Types | Number of Cases |
|---|---|
| Airport Flying: | |
| Pleasure | 38 |
| Student Dual | 8 |
| Student Solo | 22 |
| Cross Country Flying: | |
| Taxi Service | 5* |
| Student Dual | 3 |
| Student Solo | 7 |
| Business Service | 1* |
| Pleasure | 16 |
| Special Flying: | |
| Sightseeing | 3* |
| Exhibition | 3* |
| Crop Dusting | 3* |
| Competition - Racing | 3* |
| | 112 |

*Commercial operations, including racing.

## TABLE 20 - TYPES OF FLAGRANT VIOLATIONS

### FATAL ACCIDENTS

| Violation | Number of Violations 1934 | 1935 | 1936 | 1937 |
|---|---|---|---|---|
| Students carrying passengers ..... | 21 | 11 | 15 | 6 |
| Students carrying passengers for hire ... | 3 | 0 | 0 | 1 |
| Students carrying passengers and stunting ..... | 5 | 4 | 4 | 8 |
| Unlicensed pilots carrying passengers in NC aircraft ..... | 13 | 8 | 6 | 3 |
| Unlicensed pilots carrying passengers and stunting in NC aircraft ..... | 7 | 4 | 4 | 2 |
| | 49 | 27 | 29 | 20 |

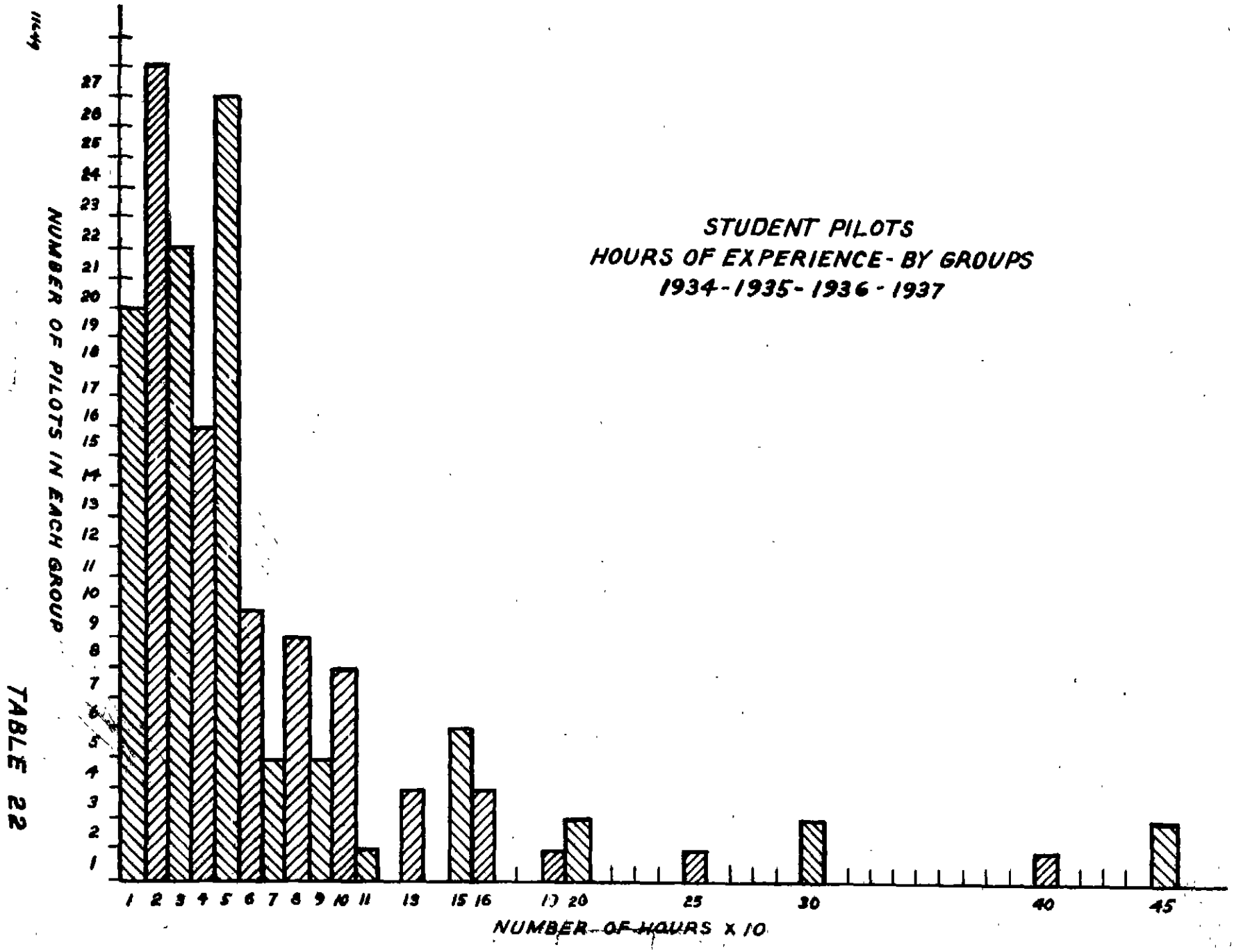
Total - 125

## TABLE 21 - LICENSES ISSUED TO AIRCRAFT INVOLVED IN FATAL ACCIDENTS

| Licenses | Number Issued | | | | |
|---|---|---|---|---|---|
| | 1934 | 1935 | 1936 | 1937 | Total |
| NC ..... | 141 | 132 | 125 | 141 | 539 |
| NR ..... | 5 | 8 | 6 | 7 | 26 |
| NS ..... | 1 | 0 | 2 | 0 | 3 |
| I ..... | 39 | 22 | 26 | 39 | 126 |
| X ..... | 4 | 1 | 1 | 0 | 6 |
| | 190 | 163 | 160 | 187 | 700 |

NC - Commercially licensed aircraft
NR - Restricted use aircraft
NS - Aircraft used solely for government purposes
I - Identified only - airworthiness not rated
X - Experimental

TABLE 22


STUDENT PILOTS
HOURS OF EXPERIENCE - BY GROUPS
1934 - 1935 - 1936 - 1937
NUMBER OF PILOTS IN EACH GROUP
1 2 3 4 5 6 7 8 9 10 11 13 15 16 17 20 25 30 40 45
NUMBER OF HOURS X 10