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HUMAN FACTORS IN GENERAL AVIATION ACCIDENTS

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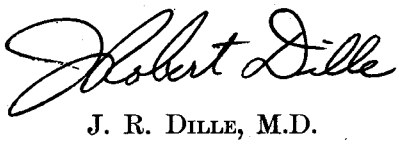

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HUMAN FACTORS IN GENERAL AVIATION ACCIDENTS

On September 17, 1908, Lt. Thomas Selfridge was killed, and Orville Wright was seriously injured, in the crash of the Army's first airplane. A Board of Inquiry determined that Lt. Selfridge suffered a fatal skull fracture when his head struck part of the airplane structure on impact. Attention was called to the need for the crew and passenger to wear safety belts and crash helmets in certain types of operations. Military aircraft accident investigations have been relatively complete since the first year of Army aviation.

Since 1956 the Armed Forces Institute of Pathology has provided the necessary aviation toxicology and pathology support to the Civil Aeronautics Board and the Civil Aeronautics Administration/Federal Aviation Agency. In practice, this valuable service has been confined mostly to air carrier accidents.

A Federal Aviation Agency Manual of Procedure on accident investigation, published in October 1959, called for Regional Flight Surgeon cooperation with the Flight Safety Foundation's Aviation Crash Injury Research division to determine what caused death or serious injury in survivable aircraft accidents, or prevented it in accidents with severe destructive forces. Interest was specifically disclaimed for the pilots' background, competency, or physical condition.

In July 1961, Albers [5] published the first outline for Aviation Medical Examiners' participation in light aircraft accident investigation. In 1964, Harper and Albers [4] published the first statistics on the incidence of positive blood alcohol levels in pilots killed in general aviation accidents.

Aviation Medical Examiner participation in accident investigation has increased rapidly. There has been 100% coverage the past two years in the Southwest Region.[2] The goal is medical investigation of all aircraft accidents with serious or fatal injuries to: 1) determine if human factors were primary or contributory causes of each accident; 2) establish the cause of death; 3) study injuries and correlate them with structure, equipment, and safety devices and recommend human engineering design improvements when indicated; and 4) identify the victims.

The results of this program the past year in the nine states in the Western Region have been reviewed and tabulated for this report.

FATAL ACCIDENTS

During the twelve months ending October 31, 1965, there were 122 fatal general aviation accidents, with 236 fatalities, in which the wreckage was located within one week and the Western Regional Flight Surgeon's office was notified. The distribution of these accidents is shown in Figure 1. Autopsies were requested for all of the pilots and were performed in 86 of the accidents. A blood alcohol determination was also requested on each pilot and was obtained in 83 of the accidents Failures were attributable to accidents with marked disintegration, delays in communications, and remote locations. Burial was at the scene in one accident included in this study.

Medical Conditions. No accidents were found to be definitely due to an existing medical condition resulting in partial or complete incapacitation; it is the probable cause in one, however.

An intern, who reported occasional bouts of nervous gastritis during medical school and internship, was felt to be qualified for a Third Class Medical Certificate by the AME. The AME later learned that this physician had not completed his internship, apparently due to psychiatric problems, and reported this to the Regional Flight Surgeon. A letter was sent to the physician-airman directing him to return his medical certificate. This letter was found in his pocket at the time of his fatal accident ten days later. A pistol was also found in the wreckage. During the investigation it was found that six instructors had refused to endorse his Student Pilot Certificate and one had been threatened with a gun to endorse it, he was known to be

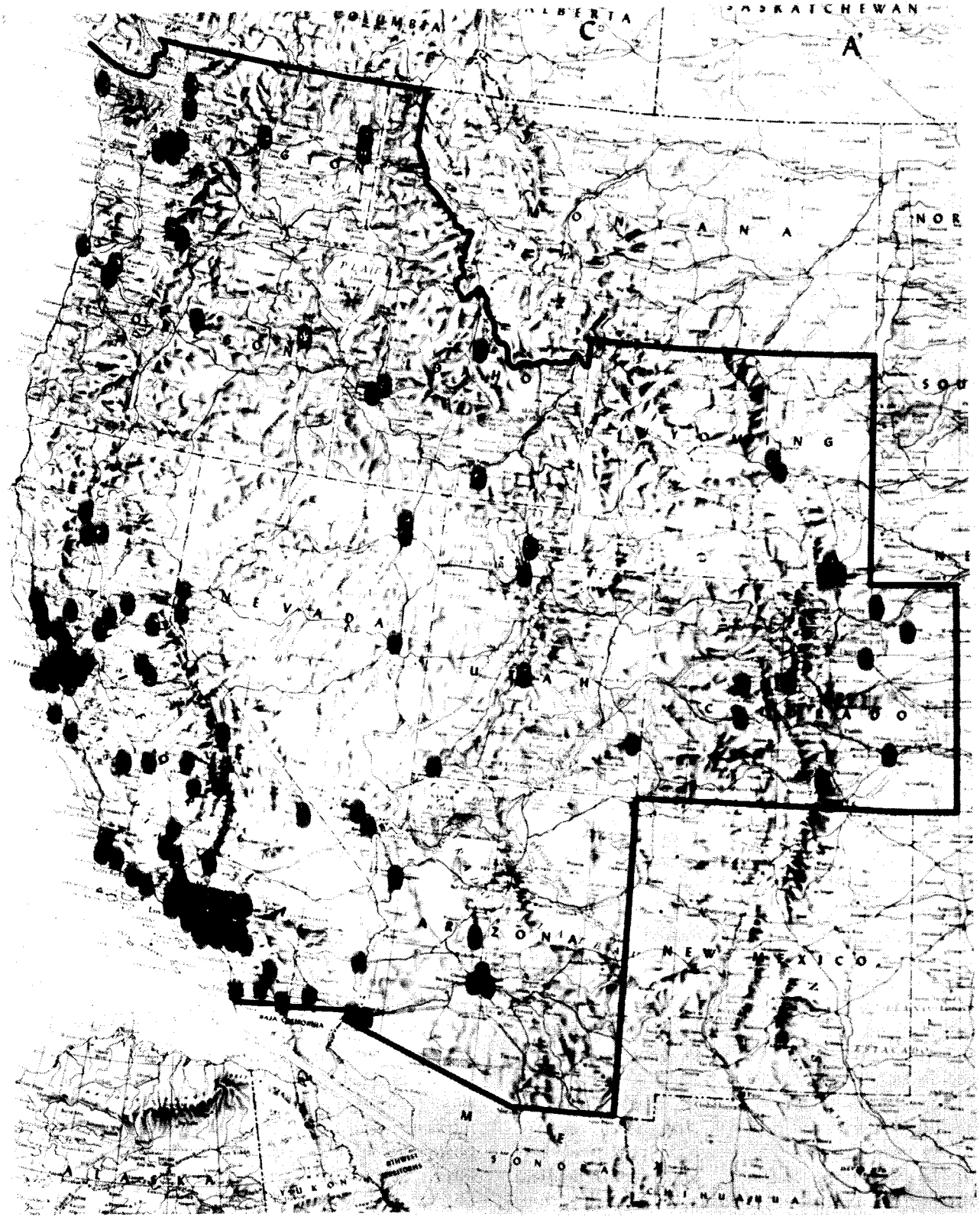

FIGURE 1. The distribution of fatal general aviation accidents in the Western Region during a twelve month period.

carrying passengers with only a Student Pilot Certificate, and two persons, including the airport operator, had urged him not to depart on his fatal flight. A wing structure failed due to excessive stresses during this flight.

A 54 year old Canadian pilot and his wife were killed in the crash of their PA–24. The glucose level on sanguinous fluid from the thoracic cavity was 36 mg %. Correspondence with Canadian Department of National Health and Welfare physicians revealed that a diagnosis of "diabetes mellitus controlled by diet alone" had been made on this pilot. Reports were submitted by his internist every six months verifying continued control by diet; the last report was submitted the month prior to the accident.

Two pilots were found to have severe narrowing of one or more coronary arteries but no evidence of infarction. One of these, a commercial pilot with over 20,000 hours, also had a 30 mg % blood alcohol level. In two other accidents, the pathologists reported coronary atherosclerosis, and, in another, focal myocardial chronic inflammation with fibrosis was reported.

A review of the medical records revealed that 25 wore corrective lenses, two had deficient color vision, one had hypertension and diabetes mellitus treated by diet, one housewife-student pilot had a history of emotional instability, one was obese with gout, one had no speech or hearing, one had weakness of one leg, one had a systolic heart murmur after exercise, two had had previous surgery for kidney stones and three admitted a history of peptic ulcer.

Nineteen had had previous aircraft accidents.

Drugs. A pilot who flew straight into a hillside soon after take-off under VFR conditions was found to be carrying Pro-banthine with phenobarbital, Librium and Kolantyl. His wife, who survived the accident, stated that he was symptomatic and took medications but did not know when he had last taken any of those he carried. He had a known history of peptic ulcer with profuse hemorrhage but had been issued a Third Class Medical Certificate valid for six months after he submitted a report that he had no ulcer, was asymptomatic and was on no medications. No ulcer crater, evidence of hemorrhage, or pills were found in the gastrointestinal tract at autopsy; no barbiturates, aldehydes, alkaloids, or alcohol were found in the blood.

Liberal quantities of professional samples of twelve drugs, a pair of contact lenses, an empty contact lens container and a large bottle of wetting solution were found together at the scene of a BE–18 accident in which the physician-AME-pilot and eight laymen were killed. Except for three Eskatrol capsules, all of the medications were comfort items which were understandable for the sole physician to be carrying on a week-end outing with fifty others. A Second Class Medical Certificate with a contact lens provision had been issued despite a waiver limited to third class certificates. No evidence of any physical condition or drug effect was found at autopsy. Of chief concern in this accident was the failure of two physicians and the coroner's representative to note the prominent array of at least 200 pills and capsules, many of which, like Tuss-Ornade, were contained in brightly-colored packages of twos.

Two ATR pilots involved in fatal general aviation accidents due to human factors were found to have positive liver barbiturate levels. One, with over 8000 hours, had a near-fatal accident shortly before the fatal accident, had a liver barbiturate level of 0.4 mg %, and was reported to be on Dexamyl No. 2 for appetite control. The other, with over 3000 hours, was found to have a liver barbiturate of 0.7 mg %, of which 0.4 mg % was phenobarbital. No further information was obtained regarding the identification or purpose of the medication in this case.

Ethyl Alcohol. The blood ethyl alcohol levels of the 17 pilots involved in fatal accidents found to have levels $\geq$ 30 mg % are shown in Table 1.

TABLE 1. Blood ethyl alcohol levels in pilots involved in fatal general aviation accidents.

Blood ethyl alcohol level	*Number of fatal accidents*
30–49 mg %	4
50–99 mg %	4
100–149 mg %	1
150–199 mg %	3
200–249 mg %	0
250–300 mg %	5

There would seem to be little doubt of a causal role in those with levels over 250 mg %. One (4:45 a.m.; 278 mg %) was known locally to drink and fly at night; one (270 mg %) had the nickname of "Boozer"; and another (300 mg %) had received four speeding tickets the past year.

One-third of all of the accidents occurred at night; two-thirds of those involving alcohol occurred at night.

A businessman-student pilot, who crashed a Cessna 310 into his estranged wife's bar in a murder-suicide attempt, had a blood alcohol level of 90 mg % and was known to be flying passengers at night with only a student permit in an aircraft that needed some engine maintenance. No decrement in performance was noted prior to take-off or during the flight to his predetermined crash site. The influence of this alcohol level upon his action is, of course, not known.

The frequency of accidents and alcohol involvement by occupational groups is shown in Table 2.

TABLE 2. Occupational groups of pilots involved in fatal aircraft accidents, with and without alcohol involvement.

Occupational group	*No. of fatal accidents*	*No. (and %) with blood alcohol level > 30 mg %*
Professional	16	0 (0%)
Businessmen	35	6 (17%)
Commercial pilots	21	4 (19%)
Mechanics	7	3 (43%)
All others	43	4 (9%)

A commercial pilot with over 20,000 hours was fatally injured in a crash at 6:51 a.m. during low-level flight. He had a blood alcohol level of 130 mg %.

The reported flying time of pilots involved in fatal accidents, with and without significant blood alcohol levels, is shown on Table 3. The relationship of age of the airman population, those involved in fatal accidents in this series, and those with alcohol involvement in this series are shown in Figure 2. The amount of flying time, by age group, is not known.

TABLE 3. Relationship of fatal accident involvement, alcohol and reported total flying time.

Total flying hours reported at time of last physical exam.	*No. of pilots*	*No. with blood alcohol > 30 mg %*
0–40	19 (15.6%)	2 (11.8%)
41–100	11 (9%)	2 (11.8%)
101–200	5 (4.1%)	0 (0%)
201–500	16 (13.1%)	0 (0%)
501–1000	15 (12.3%)	4 (23.5%)
> 1000	37 (30.3%)	6* (35.3%)
Unknown	19 (15.6%)	3 (17.6%)

* Includes 1 with 14,000 hrs., 2 with over 20,000 hrs.

Carbon Monoxide. Carbon monoxide levels were routinely requested. Only four positive levels in three accidents were reported. Levels of 10% and 13% in two accidents were not considered significant. The direct and distractive effects on a father and son with levels of 27.5% and 40%, respectively, are felt to have caused one accident which was fatal to both occupants.

Agricultural Chemicals. Three pilots were killed during aerial application flying. One had evidence of severe exposure to organic phosphorus insecticides, evidence of some exposure to chlorinated hydrocarbon insecticides, and narrowing of the left anterior descending coronary artery to 10% of normal at one level. Another had a low normal cholinesterase level and no flying time seven months before his fatal accident. A third with reported "blackouts" had evidence of brain damage from head trauma two years before. A cholinesterase determination was requested, but was not obtained, in the last case.

All three were flying the same type agricultural aircraft. This particular aircraft has no higher accident rate than other "ag" aircraft but fatality rates are four times higher than other types.[1]

Miscellaneous. A commercial pilot with over 7500 hours was found to have crashed in nearly level flight 57 miles off course. Investigation revealed that he had been drinking the night before and had obtained little, if any, sleep before his 5:00 a.m. departure. It is felt that the pilot went to sleep in flight.

Discussion. Increased visits by physicians to accident sites to determine the availability and use of protective equipment, and crash-injury correlations, are a major remaining need for successful human factors investigations of general aviation accidents.

An increased awareness of, and searching for, the physical and chemical presence of drugs and toxic materials are also indicated. The two possible human factors accidents involving very experienced pilots with reported liver barbiturate levels are of particular interest. A relationship of the liver to blood levels near unity can be assumed when barbiturates are taken in divided doses. The amounts of d-amphetamine and amobarbital in one of the preparations reportedly taken are sufficient, *individually*, to increase judgment error.[6] The levels involved in these cases are not sufficiently elevated to permit one to draw any conclusions, however. This may be be-

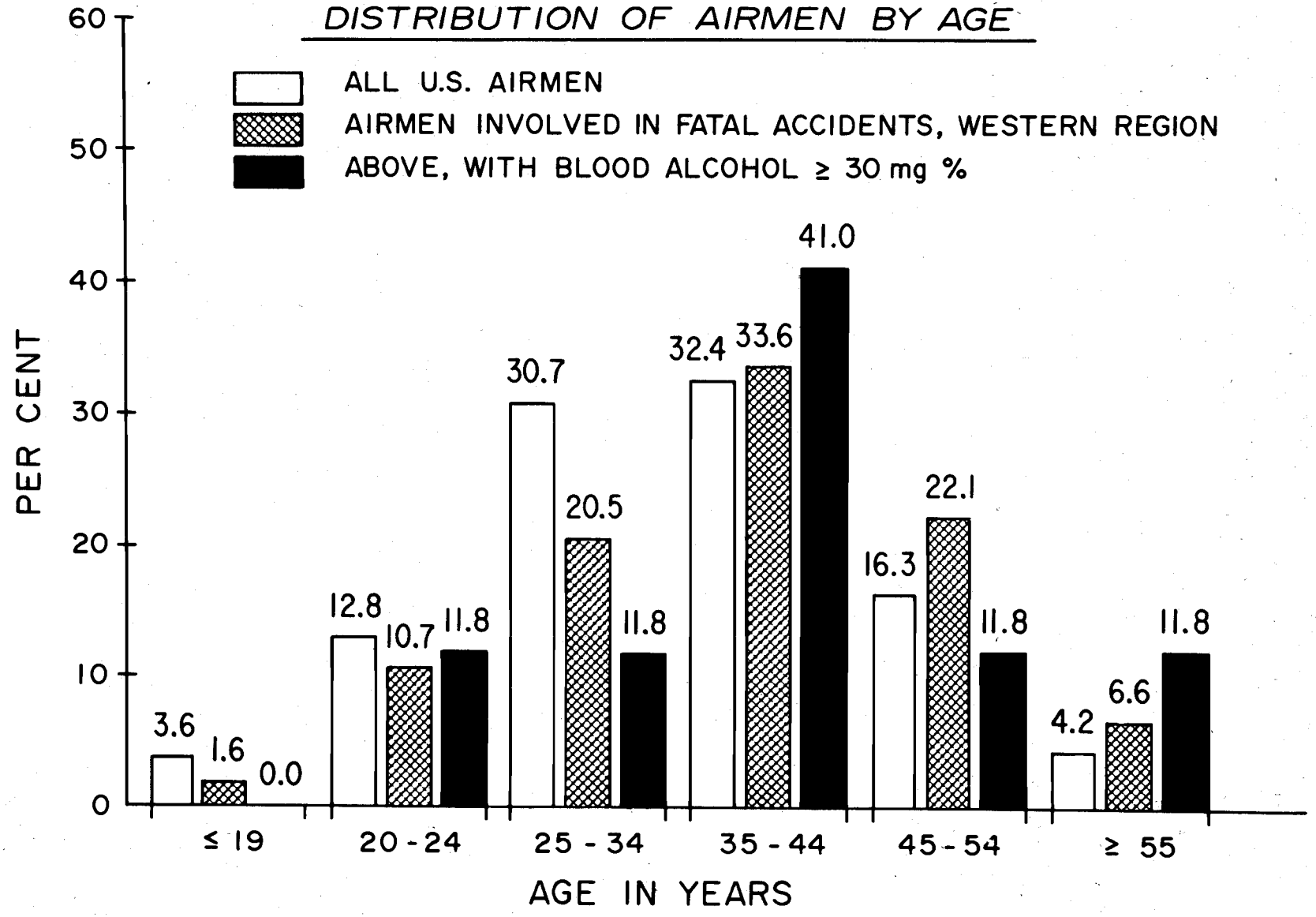

FIGURE 2. The age distributions of all U.S. airmen, those involved in fatal accidents in the Western Region in twelve months, and those in this series with a blood alcohol level ≥ 30 mg %.

cause of the sustained release form of the preparation, to the time since the drug was taken or to a combination of these two factors.

The alcohol involvement in this series is lower than in other published studies [3, 4] but nevertheless remains an area needing corrective action. The accident rates by age group and flying experience are similar to those reported by Gibbons and Plechus.[3]

Of particular concern is the frequency with which family, friends, and local officials knew the habits, and physical and mental conditions, of the pilots and tolerated the situation. Abstainers who accompanied inebriated pilots on their fatal flights exercised particularly poor judgment. We are also aware of underreporting of significant medical history by physicians who do not understand or accept our medical standards.

Statistical evaluation of each pilots' medical history, physical condition, autopsy results, toxicologic findings, use of protective equipment, crash-injury condition, experience, time of day, phase of flight, weather, type of aircraft, etc., is performed for all fatal and non-fatal accidents by the Accident Studies Branch, Aeromedical Applications Division, and has not been attempted for this series.

NON-FATAL ACCIDENTS

Medical Conditions. Late in this series the medical records were obtained and reviewed for accident repeaters and pilots involved in accidents which, from the initial reports, seemed likely to be due to human factors. No statistical correlation of medical conditions and accidents was planned or attempted at the regional level. The first week of this extended program, three accidents with possible medical significance occurred in a period of three days. A 36 year old male with amblyopia, left eye, struck the ground with the left wing of his Aeronca Champion on landing. The same day, a 39 year old male with 20/50 uncorrectable distant vision, left eye, made a hard landing in a Cessna 182 with substantial damage. Two days later, a 65 year old male with bilateral aphakia, struck high bushes which swung his TA–1 into a ditch when he landed on a gravel road for refueling.

Ethyl Alcohol. A flight surgeon-pilot crashed at 5:00 a.m. shortly after buzzing his residence. The aircraft traveled over 1000 feet from the point where it struck the ground, and the pilot is calculated to have traveled 408 feet from the point where he was thrown from the airplane. His injuries consisted of a superficial head wound, a concussion with amnesia for a three week period, and fractures of the left foot. He was refused additional drinks at a local bar 6 and ½ hours before the accident, was reportedly observed to stagger and fall between his car and the airplane at 4:45 a.m., and told the deputy sheriff at the accident site that he was drunk. No blood or breath alcohol level was determined.

One pilot who called "mayday" over the San Francisco area was sentenced to three days in jail and fined $22 for operating an aircraft under the influence of alcohol.

Only one blood alcohol level was obtained on a pilot involved in a non-fatal accident. He was a spray pilot with a 130 mg % blood alcohol level who explained that he and many such pilots drank to keep the organic phosphorus insecticides from making their pupils small and reducing their vision.

Agricultural Chemicals. The major attention in the investigation of non-fatal accidents was given to aerial application accidents. Two "ag" pilots, who each had two accidents within a two week period, were found to have reduced plasma cholinesterase levels. They each struck wires one time and the ground the other. Three other pilots had single accidents and were found to have reduced cholinesterase levels. One struck large cables suspended between 100 foot steel towers on his seventeenth pass over a field and stated that he "did not know they were there".

Discussion. The human factors investigation of non-fatal accidents is still a relatively untapped area which shows promise for considerable important data which could help prevent future accidents. The incidence of various unsafe acts (inadvertent landing gear retraction, for example) by type of aircraft, pilot experience, time, and phase of flight is being determined. The correlations of these acts with various physical defects reported on periodic physical examinations are also being determined. Accident repeaters have been identified for evaluation of their physical condition but there have been no significant findings to date in this study. Emotional and behavioral factors, which may play an important role, are rarely identifiable from reports of routine physical examinations.

The role of drugs and alcohol in non-fatal accidents is virtually unknown. Blood alcohol levels on survivors are difficult to obtain.

Crash-injury correlations and the use of protective equipment in non-fatal accidents with injuries can be coded for analysis but there is practically no medically-oriented gathering of this data.

Increased participation in the investigation of these accidents by Regional Flight Surgeons and Aviation Medical Examiners is indicated to determine the adequacy of current medical standards, identify areas needing emphasis in airman education (or regulation), and attain maximum aviation safety. Coding of the data in the regional offices will better identify missing facts and promising leads.

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