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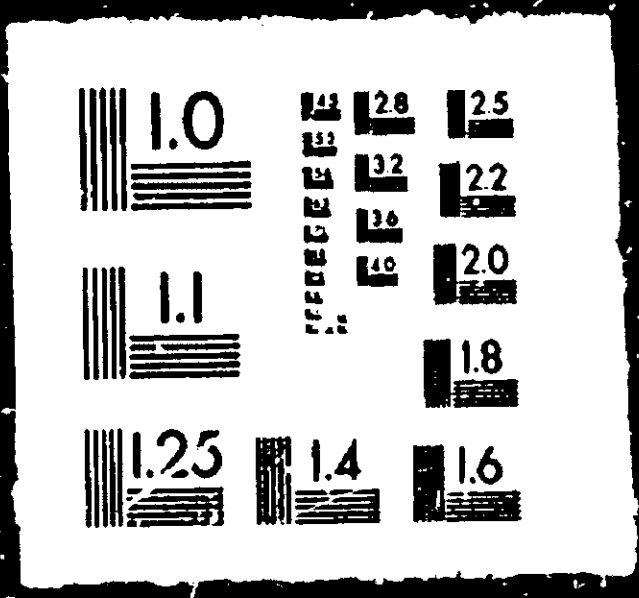

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Special Investigation Report: Design-Induced Landing Gear Retraction Accidents in Beech Baron, Bonanza, and Other Light Aircraft

(U.S.) National Transportation Safety Board
Washington, DC

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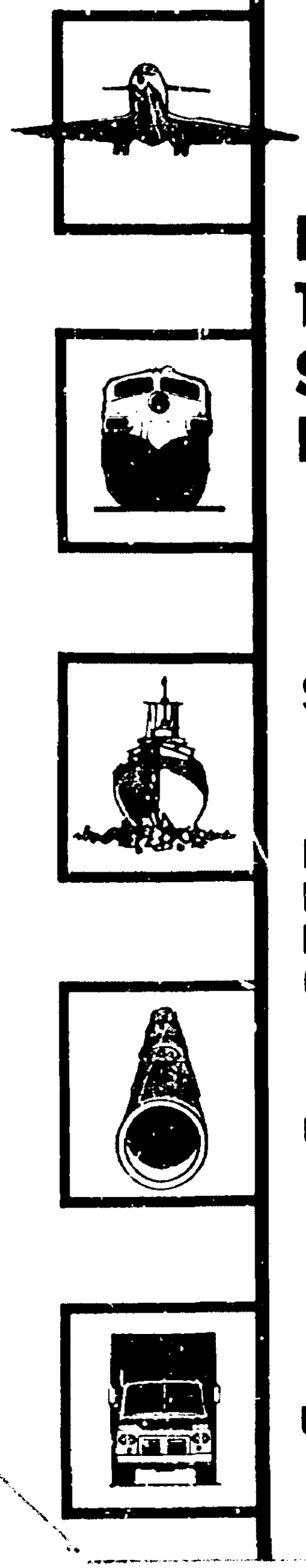

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

SPECIAL INVESTIGATION REPORT

DESIGN-INDUCED LANDING GEAR RETRACTION ACCIDENTS IN BEECHCRAFT BARON, BONANZA, AND OTHER LIGHT AIRCRAFT

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16. Abstract

A detailed review was made of all inadvertent landing gear retraction accidents occurring from 1975 to 1978. The data indicated that Beech Bonanza and Baron-type aircraft, while comprising only one-quarter of the single-engine and light twin-engine fleets, were involved in the majority of these accidents. Pilot comments and a human engineering evaluation of contemporary light aircraft cockpits revealed that these two Beech aircraft had four design features which would tend to increase the probability of inadvertent retraction accidents. Inexpensive methods of correcting these problems are recommended.

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SPECIAL INVESTIGATION REPORT

Adopted: June 24, 1980

DESIGN-INDUCED LANDING GEAR RETRACTION ACCIDENTS IN BEECH BARON, BONANZA, AND OTHER LIGHT AIRCRAFT

SYNOPSIS

A detailed review was made of all inadvertent landing gear retraction accidents occurring from 1975 to 1978. The data indicated that Beech Bonanza and Baron type aircraft, while comprising only one-quarter of the single-engine and light twin-engine fleets, were involved in the majority of these accidents. Pilot comments and a human engineering evaluation of contemporary light aircraft cockpits revealed that these two Beech aircraft have four design features which tend to increase the probability of inadvertent landing gear retraction accidents. Inexpensive methods of correcting these problems are recommended.

BACKGROUND

During this investigation, the Safety Board reviewed its files for every inadvertent landing-gear retraction accident between 1975 and 1978. Information from these files indicated that such accidents typically occurred because the pilot was attempting to put the flaps control "UP" after landing, and moved the landing gear control instead. The inadvertent movement of the landing gear control was often attributed to the pilot's being more accustomed to flying aircraft in which these two controls were in exactly opposite locations.

The review of the Safety Board's automated data base indicated that two aircraft types, the Beech "Bonanza" (Models 33, 35, and 36), and the Beech "Baron" (Models 55, 56, 58, and 95) were involved in most of the inadvertent landing gear retraction accidents which occurred from 1975 to 1978. 1/ The Bonanza and Baron, 2/ however, constitute only about one-quarter of the active light aircraft fleet with retractable landing gear. Inadvertent gear retraction accidents may cause extensive damage to the aircraft ($15,000 to $25,000 per occurrence) and occasionally have resulted in occupant injuries. For these reasons, the Safety Board undertook this special investigation to establish why these two aircraft were experiencing a disproportionately high number of such accidents.

1/ The last year for which complete data are available.
2/ These two aircraft were also marketed under the names "Debonair" and "Travel Air," respectively.

The Safety Board compared the details of Bonanza and Baron's cockpit features to those of other contemporary light aircraft. The comparison indicated that the cockpit design features of the various models of Bonanzas and Barons differed from those of most other contemporary light aircraft -- such as the locations for the landing gear and flap controls. The human engineering problem areas documented in the report resulted largely from the fact that their basic instrument panel design is 35 years old. A great deal of knowledge about the effects of good design in preventing human error has been acquired since these aircraft were originally certificated, and more appropriate standards have been established. However, the current FAA regulations permit the continued manufacture of these aircraft under their previously issued type certificates.

This report examines how cockpit design deficiencies generated the relatively high rate 3/ of inadvertent gear retraction accidents in these two airplanes. In addition, it will show how these deficiencies have contributed to accidents in other types of aircraft because the pilots were more familiar with the nonstandard arrangement in the Bonanzas and Barons. The report also clearly indicates by specific examples the fallacy of continuing to produce new aircraft to certification standards which have been bypassed by technology.

STATISTICS

The Bonanzas comprised only about 30 percent of the single-engine aircraft fleet with retractable gear, but they were involved in 67 percent of the accidents of this type based upon the following information. The FAA records for 1978, 4/ indicate that the various Beechcraft Bonanza models comprised 9,430 aircraft in a fleet of approximately 31,500 active single-engine aircraft with retractable landing gear, and Safety Board data indicate that from 1975 to 1978, these Bonanza were involved in 16 of the 24 inadvertent gear retraction accidents. (See Table 1.)

The Barons comprised only 16 percent of the light-twin fleet, but they were involved in 54 percent of the accidents of this type based upon the following information. The 1978 FAA records showed that the various Beechcraft Baron models comprised 3,441 of the approximately 21,000 active reciprocating engine light twins, and during the 1975 to 1978 period, Safety Board records indicated that the Barons suffered 21 of the 39 inadvertent gear retraction accidents. (See Table 2.)

Therefore, the Bonanza and Baron aircraft have inadvertent gear retraction accident rates that are between two to four times the average rate for aircraft in their respective categories. In fact, they were involved in over 61 percent of all these accidents from 1975 to 1978, while constituting only 25 percent of the active fleet of light aircraft having retractable landing gear. These results are similar to

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3/ These rates were derived for each type aircraft by dividing the number of inadvertent landing gear retraction accidents by the estimated number of those aircraft which were active.

4/ The last year for which complete data were available.

TABLE 1

Retractable Landing Gear Accidents: Beechcraft Bonanza and Other Single Engine Aircraft

Model	Date	Location	Total Pilot Hours in Accident Involved Model	Total Pilot Hours in All Makes and Models	Pilot Admitted Confusing Flaps with Landing Gear	Pilot Stated a Familiarity for a Reversed Arrangement of Gear and Flaps
BEECHCRAFT BONANZA						
BE-33	1/19/75	Elko, NV	120	4564	x	x
BE-35	6/15/75	West Mifflin, PA	50	630	x	–
BE-35	6/19/75	Jackson, OH	220	1056	x	–
BE-35	9/2/75	Minneapolis, MN	111	293	x	–
BE-35	9/7/75	Laramie, WY	870	1173	x	–
BE-36	3/19/76	Camdenton, MO	525	1656	–	–
BE-35	3/21/76	St. Joseph, MO	131	2214	x	–
BE-35	4/13/76	Jacksonville, FL	16	2950	–	–
BE-35	7/3/76	San Carlos, CA	183	406	–	–
BE-35	5/4/77	Jacksonville, FL	30	416	x	–
BE-35	6/4/77	Bessemer, AL	7	4426	x	–
BE-35	8/5/77	Dallas, TX	51	136	–	–
BE-33	8/28/77	Keystone Heights, FL	7	1330	x	–
BE-36	8/30/77	Keystone Heights, FL	228	5176	–	–
BE-35	10/16/77	San Jose, CA	3	337	–	–
BE-35	7/6/76	Meadville, PA	127	368	x	–
PIPER						
PA-24	5/10/76	Greenwood, SC	1220	1240	–	–
PA-24	6/12/76	Muleshoe, TX	665	665	–	–
PA-24	7/13/76	Columbia, SC	550	800	–	–
PA-24	11/23/76	Birmingham, AL	20	4739	–	–
MOONEY						
M-20	7/24/76	Las Vegas, NV	11	887	–	–
M-20	5/20/78	Westerly, RI	187	405	–	–
M-20	7/21/78	Atlanta, GA	430	1075	–	–
CESSNA						
C-210	5/19/77	Amarillo, TX	40	3000	x	–

Table 1.

Table 2.

Retractable Landing Gear Accidents: Beechcraft Barons and Other Twin Engine Aircraft

Model	Date	Location	Pilot Total Hours in Accident Involved Model	Pilot Total Hours in All Makes and Models	Pilot Admitted Confusing Flaps With Landing Gear	Pilot Stated a Familiarity For a Reversed Arrangement of Gear and Flaps
BEECHCRAFT BARON						
BE-55	2/20/75	Kansas City, MO	47	1114	—	—
BE-58	3/5/75	Plymouth, MA	33	12586	X	X
BE-58	6/23/75	Phoenix, AZ	5	6580	X	—
BE-55	1/17/75	Anchorage, AL	99	7567	—	—
BE-58	8/20/75	Blountstown, FL	418	3308	—	—
BE-58	9/25/75	Jacksonville, FL	405	12220	X	—
BE-58	9/29/75	Little Rock, AR	12	872	X	—
BE-55	1/31/76	Fresno, CA	27	8300	—	—
BE-58P	7/20/76	Albuquerque, NM	15	12000	X	X
BE-95	2/3/77	Las Vegas, NV	40	700	X	X
BE-55	5/5/77	Davenport, IA	934	6841	X	—
BE-58	8/7/77	San Antonio, TX	12	1412	X	X
BE-58	11/2/77	Albany, NY	3	10650	X	—
BE-58	12/10/77	Laredo, TX	425	1400	X	—
BE-58	5/22/78	Kalskag, AL	18	14500	X	X
BE-58	5/31/78	Little Rock, AR	294	1205	X	—
BE-55	6/16/78	Walla Walla, WA	45	1232	X	X
BE-55	7/11/78	Albuquerque, NM	140	2300	X	—
BE-58	8/16/78	Hickory, NC	700	8355	X	X
BE-95	9/23/78	Amarillo, TX	100	6000	X	—
BE-55	12/24/78	Crossett City, FL	1200	2200	X	—
MISCELLANEOUS TWIN ENGINE MODELS						
PA-23	6/3/75	Plattsburgh, NY	15	450	X	X
C-421	6/23/75	Chattanooga, TN	100	100	—	—
BE-50	2/11/76	Jacksonville, FL	7	1633	—	—
C-320	4/15/76	Granbury, TX	7	5000	X	X
C-310	7/21/76	New Smyrna Beach, FL	25	904	X	—
AS-600	8/17/76	West Mifflin, PA	466	1592	—	—
C-421	9/12/76	International Falls, MN	74	2000	—	—
PA-23	9/16/76	Demopolis, AL	187	3123	—	—
SA-26	10/20/76	Claire, MI	70	8000	—	—
PA-30	4/6/77	Tuscaloosa, AL	450	2040	—	—
PA-30	4/9/77	Brooksville, FL	57	961	—	—
PA-40	6/22/77	Ashsville, NC	240	12017	—	—
C-310	10/5/77	Cairo, GA	28	2587	—	—
PA-34	4/4/78	Cheyenne, WY	275	3628	—	—
E-4500	7/29/787	Togiac, AL	No Data		—	—
AC-500	7/31/78	Boston, MA	27	3762	—	—
BE(C-45)	8/8/78	Las Vegas, NV	144	9169	—	—
PA-31	10/9/78	Concord, NC	1555	8575	—	—

KEY

AC - Aero Commander
AS - Aerostar
BE - Beech
C - Cessna
E - Evangle
PA - Piper
SA - Swearingen

those reported in an earlier Safety Board Special Study, published in 1967, concerning design-induced pilot error. 5/ That report concluded that the early Bonanzas, while comprising only 22 percent of the fleet with retractable landing gear, accounted for 48 percent of the inadvertent gear retraction accidents. The number of such accidents involving the Bonanzas and Barons, and their individual accident rates, are several times as great as those of most other similar contemporary light aircraft. Figure 1 graphically illustrates these facts. For instance, the significant differences in the rates of occurrence of inadvertent landing gear retraction accidents can be seen by comparing the Bonanza with a similar aircraft, the Cessna 210. The 4,741 Cessna 210's, which comprised 15 percent of the single-engine, retractable gear fleet in 1978, only had 4 percent (1 accident) of the inadvertent landing gear retraction accidents occurring to single-engine aircraft during the 1975 to 1978 period. In contrast, the Bonanzas, comprising about 30 percent of the fleet, experienced 67 percent of these accidents (21 accidents) -- an accident rate about 10 times as high as that of the Cessna 210.

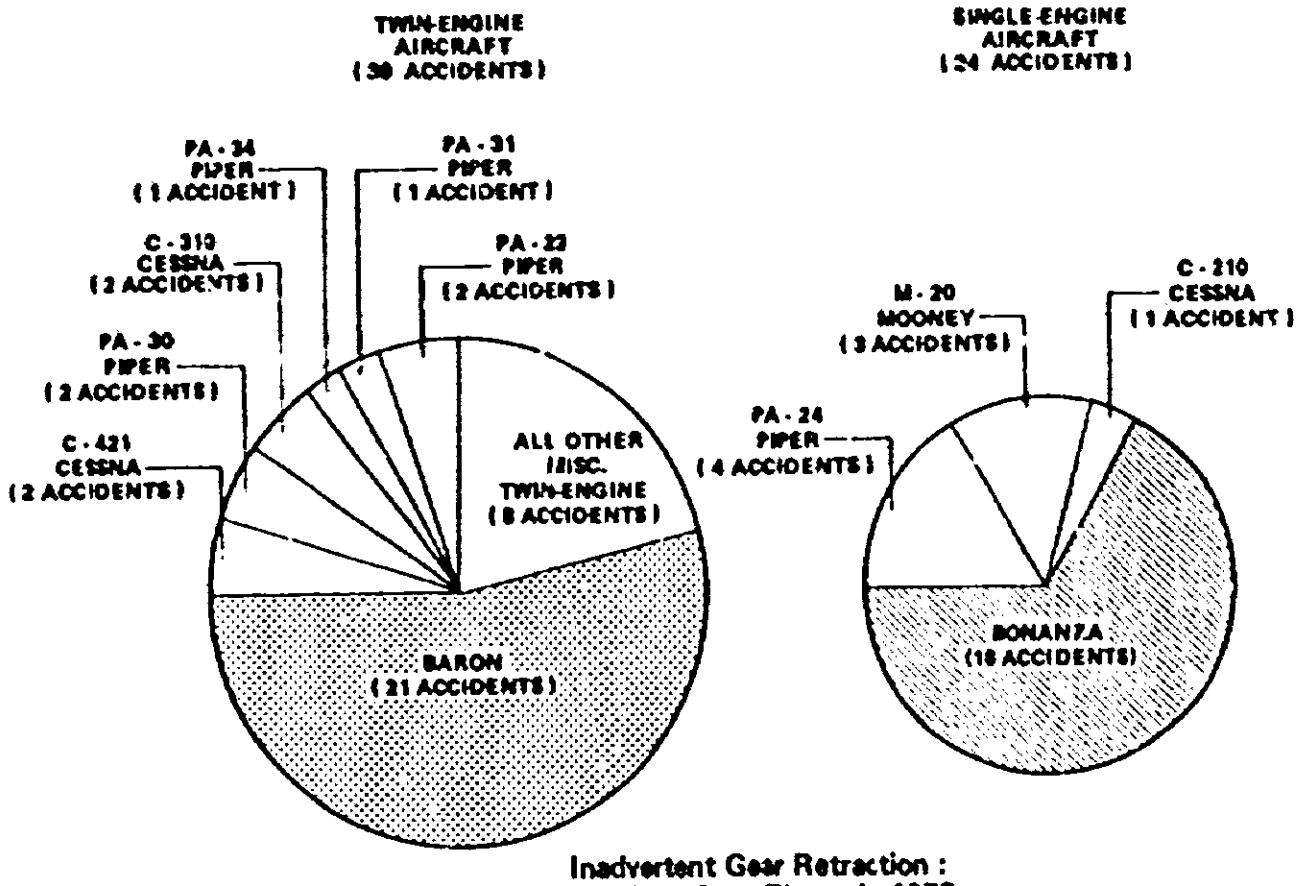
Similarly, the accident rate of the Baron can be compared to the Piper PA-23 Aztec, a similar light twin. The 3,459 active PA-23's comprised about 16 percent of the 1978 light-twin fleet, but suffered only 8 percent (2 accidents) of the inadvertent landing gear retraction accidents occuring to light twins from 1975 to 1978. In contrast, the Baron, also comprising 16 percent of the twin fleet, experienced 67 percent of such mishaps (16 accidents) -- an accident rate of about 8 times that of the PA-23.

The Safety Board's review of its accident files for the 63 accidents from 1975 to 1978 revealed several facts. Tables 1 and 2 indicate that there is little correlation between pilot experience, either in total hours or hours in type, and the occurrence of these accidents. This is illustrated by comparing the hours of the Bonanza and Baron pilots with the hours of the pilots having such accidents in other single- and twin-engine aircraft. The data from Tables 1 and 2 indicate that in 63 percent of the Bonanza accidents and in 81 percent of the Baron accidents, the pilots specifically admitted that they confused the landing gear and flaps controls. In many cases, they mistakenly retracted the gear while intending to raise the flaps after landing. Such explanations usually were not offered by the pilots having this type of accident in the other aircraft.

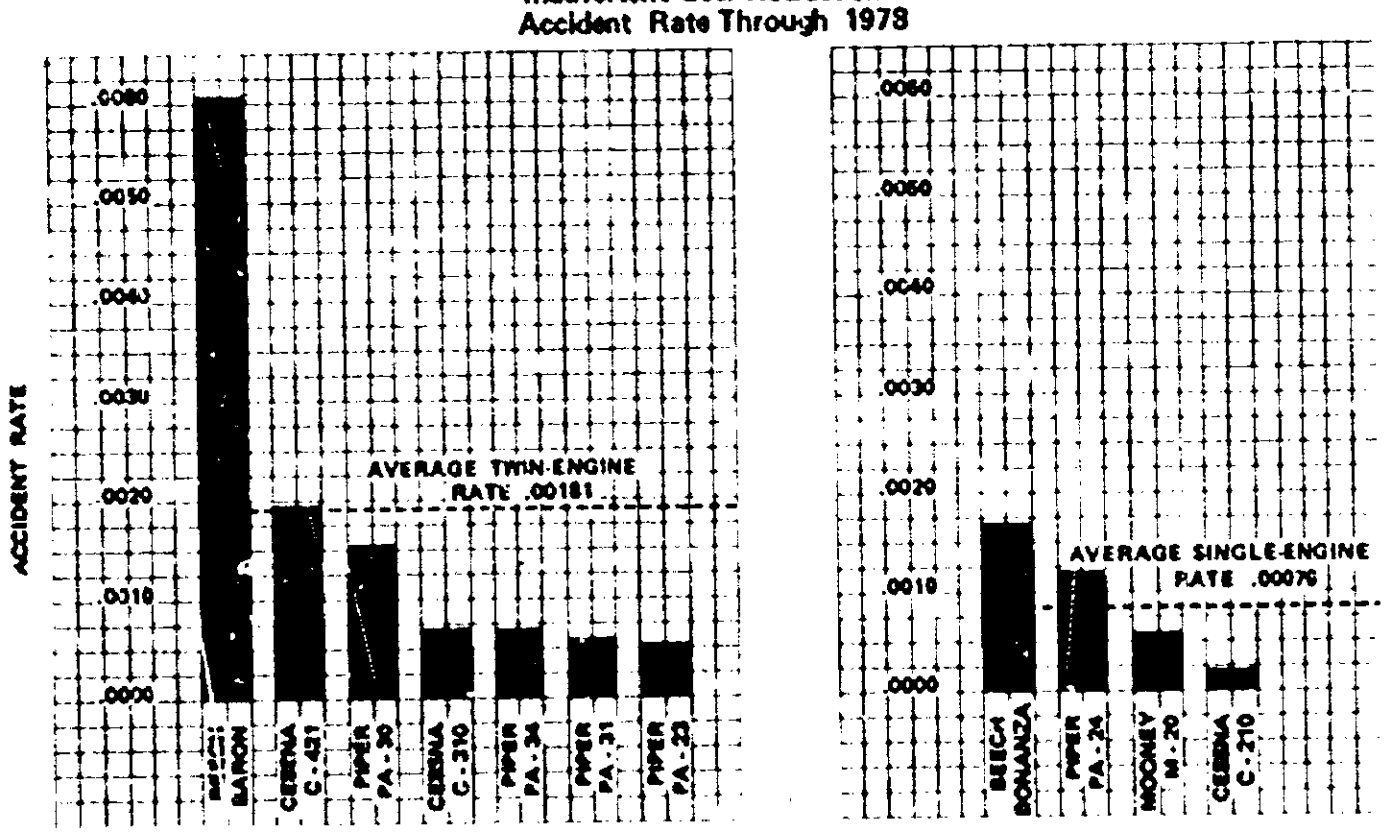
An analysis of the NTSB data also revealed various circumstances which may have contributed to many of these accidents. Some pilots were either in stressful situations (such as in danger of running off the runways) or they were distracted (such as by a tower controller's request to clear the active runway), or they may have been inattentive (such as when returning from a fatiguing flight).

5/ "Aircraft Design-Induced Pilot Error," NTSB Special Study PB 175629, July 1967.

Number and Rate 1/ of Inadvertent Landing Gear Retraction Accidents in Popular Light Aircraft 2/ 1975 - 1978



Inadvertent Gear Retraction : Accident Rate Through 1978



1/ These rates were derived for each type aircraft by dividing the number of inadvertent landing gear retraction accidents by the estimated number of those aircraft which were active.

2/ Aircraft models with more than 500 active aircraft in 1978.

Figure 1.—Number and Rate of Inadvertent Landing Gear Retraction Accidents in Popular Light Aircraft, 1975-1978.

HUMAN FACTORS ENGINEERING CONSIDERATIONS

Design-Induced Errors

There are numerous documents which describe the use of human engineering design features to decrease design-induced pilot error accidents. For example, a classic 1947 study, 6/ which surveyed hundreds of military pilots, found that confusing the flaps and landing gear controls was the second most frequent type of pilot-error control problem. The previously noted Special Study, "Aircraft Design-Induced Pilot Error," was a comprehensive document detailing many of these problems, including the increased number of inadvertent gear retraction accidents resulting from certain aircraft design features.

The accidents reviewed during this special investigation illustrate the need for rigid adherence to procedures, constant vigilance, and total familiarity with the cockpit layout on the part of the pilot. However, they also illustrate how design deficiencies can add to a pilot's burden and increase the likelihood of an accident. The following pilot statements were extracted from Safety Board accident files:

Bonanza, Elko, Nev., January 19, 1975:

> "When I reached to retract the flaps, I hit the gear switch instead. I also own a PA-30 in which the switches are in reverse to the Beech."

Baron, Plymouth, Mass., March 5, 1975:

> "I have thousands of hours in aircraft in which the flap switch is located where the gear switch is on the B-58 which was a contributing factor."

Baron, Las Vegas, Nev., January 1, 1977:

> "During rollout, at about 35/40 kts, pilot (me) retracted gear thinking it was the flap switch. Pilot used to flying Cessna 210 and flap switch is located where gear switch is located on Baron. Dumb pilot error."

Baron, San Antonio, Texas, August 7, 1977:

> "More careful familiarization with the instrument panel set up. This aircraft had a reverse set up for flaps and gear handles than the operator was used to."

Baron, Hickory, N.C., August 16, 1978:

> "Reached to retract flaps as for short field procedures, however, flap switch on Baron is reversed with landing switch on Cessna and Queen Air, pilot retracted landing gear instead of flaps."

6/ "Analysis of Factors Contributing to 460 'Pilot-Error' Experiences in Operating Aircraft Controls," by P.E. Fitts and R.E. Jones, USAF Aero Medical Laboratory, Memorandum Report, July 1947.

Piper PA-23, Platts, New York, June 3, 1975:

"Speed on rollout down to about 30K. Pilot went for flaps and got gear handle."

"Pilot has over 100 hours recently in 310 with some landings in this type. Recently transitioned to Aztec. Position of gear and flap levers are reversed on these models. Standardization of position in aircraft might help to remove part of the hazard of transition."

Cessna 320, Granbury, Texas, April 4, 1976:

"I have been flying a Bonanza and the gear and flap switch positions on Bonanza are exactly opposite to Cessna 320."

"Require all manufacturers to place important controls consistently. Can you imagine a Cadillac and a Lincoln with brake and throttle in opposite positions?"

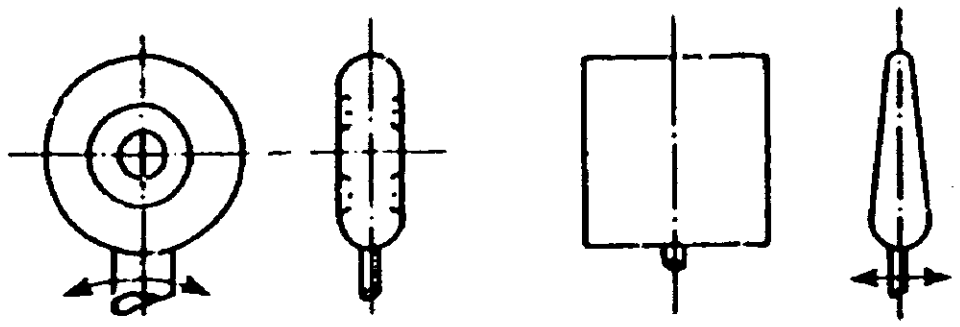
Regulatory Requirements

Regulatory requirements for the location and shape coding of controls were first adopted October 1, 1959, by Amendment 3-5 to the Civil Air Regulations, which revised Section 3.364. These regulations were essentially identical to the current Federal Aviation Regulations adopted in September 28, 1964, which require that the location and shape-coding of controls be standardized as follows: 14 CFR 23.777 states: "Wing flap and auxiliary lift device controls must be located--(1) Centrally, or to the right of the pedestal or powerplant throttle control centerline; and (2) Far enough away from the landing gear control to avoid confusion." The landing gear control gear must be located to the left of the throttle centerline or pedestal centerline. Regulation 14 CFR 23.781 states: "Cockpit controls must conform to the general shapes (but not necessarily the exact sizes or specific proportions) in the following figure." (See figure 2.)

The Bonanza was first type-certificated in 1945 and later recertificated in 1956. Also in 1956, the nonpressurized Barons were first type certificated. At that time, the Civil Air Regulations did not specify location or shape of the landing gear and flap controls. In 1959, the regulations were amended but the Bonanza and nonpressurized Barons were not required to meet the amended regulations and therefore continued to be produced under the earlier type certificates. The pressurized Barons were certificated in 1974 under 14 CFR 23, and therefore had to meet the requirements for the location and shape of these controls.

DESIGN DEFICIENCIES

An examination of cockpits of the Bonanza and Baron revealed four design deficiencies with regard to their landing gear and flap controls which can lead to design-induced pilot errors. These deficiencies include: (1) A lack of adequate "shape-coding" of these control knobs to permit the pilot to differentiate between



LANDING GEAR CONTROL KNOB FLAP CONTROL KNOB

Figure 2.—Currently "required" control knob shapes 14 CFR 23.781.

them on the basis of feel alone; (2) an arrangement of these two controls in nonstandard locations which increases the probability that the pilot will actuate one control while intending to actuate the other; (3) the location of the horizontal bar on which the control wheels are mounted so that it obscures the pilot's view and obstructs his reach of these two controls; and (4) the lack of a guard or latch mechanism over the landing gear control to prevent the pilot from activating this control unless the guard/latch is moved first. (See figures 3 through 8.)

While various other types of modern light aircraft may have one of these four problems, the Bonanzas and Barons are the only aircraft produced in recent years with multiple combinations of these design deficiencies. (See Table 3.)

Table 3.

Design Deficiencies for Different Bonanza and Baron Models

Design Deficiency	Bonanza[1/] (pre-1963)	Bonanza (post-1963)	Baron (Nonpressurized)	Baron (pressurized)
Inadequate Shape-Coding	X			
Nonstandard Location	X	X	X	
Obscuration of Controls	X	X	X	X
Lack of Guard Latch		X	X	X

1/ No longer in production.

Figure 3.—Identically shaped tab-type control switches of early model Bonanzas (circa 1948). Note: Landing gear switch is in the neutral position in left photo and in the raised position at in right photo.

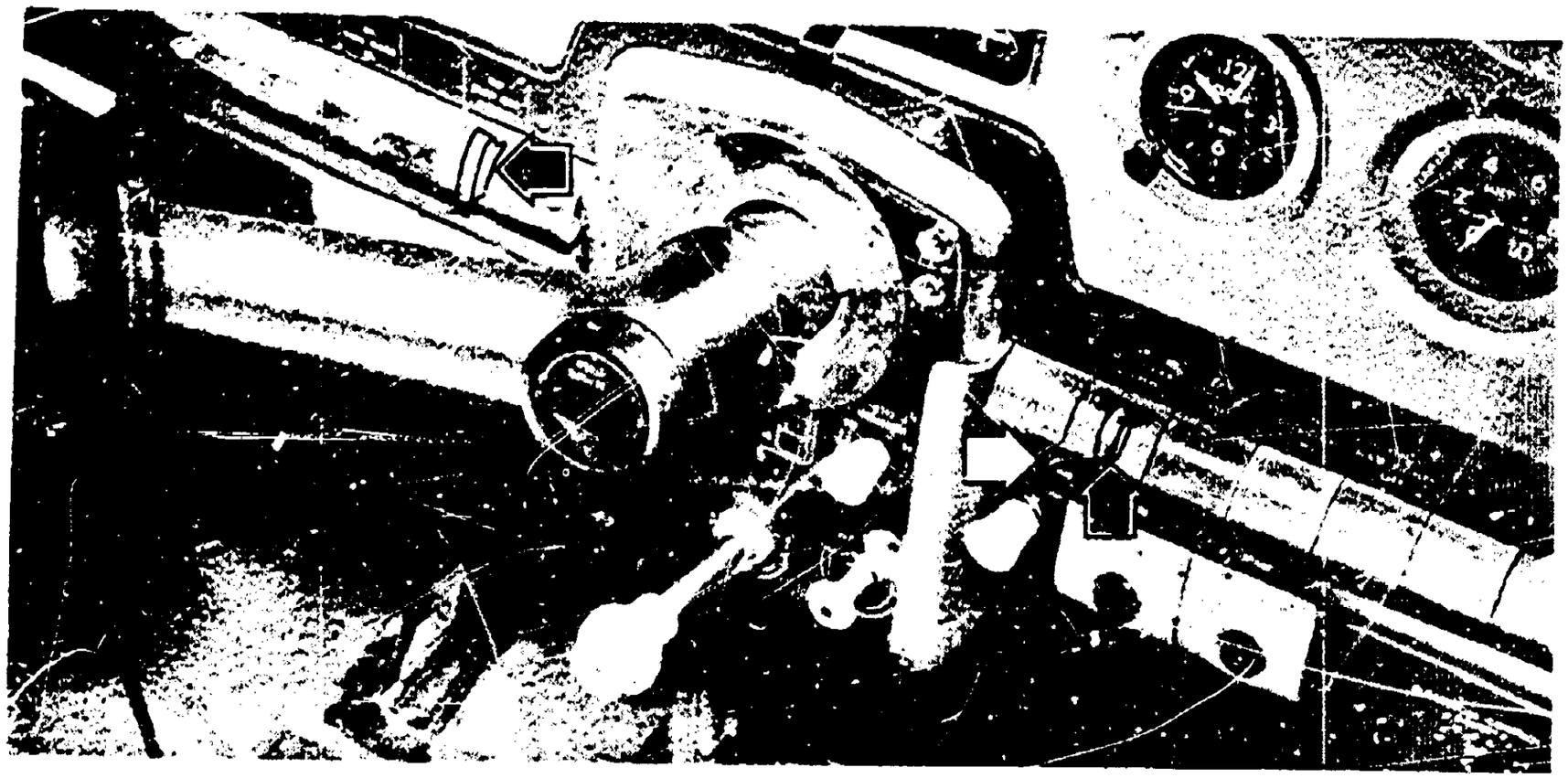


Figure 4.—Bonanza (circa 1955) with tab-type switches incorporating small protrusions on flap control and landing gear control on left and right, respectively. (See black arrows.) The safety latch for the landing gear switch is indicated by the white arrow.

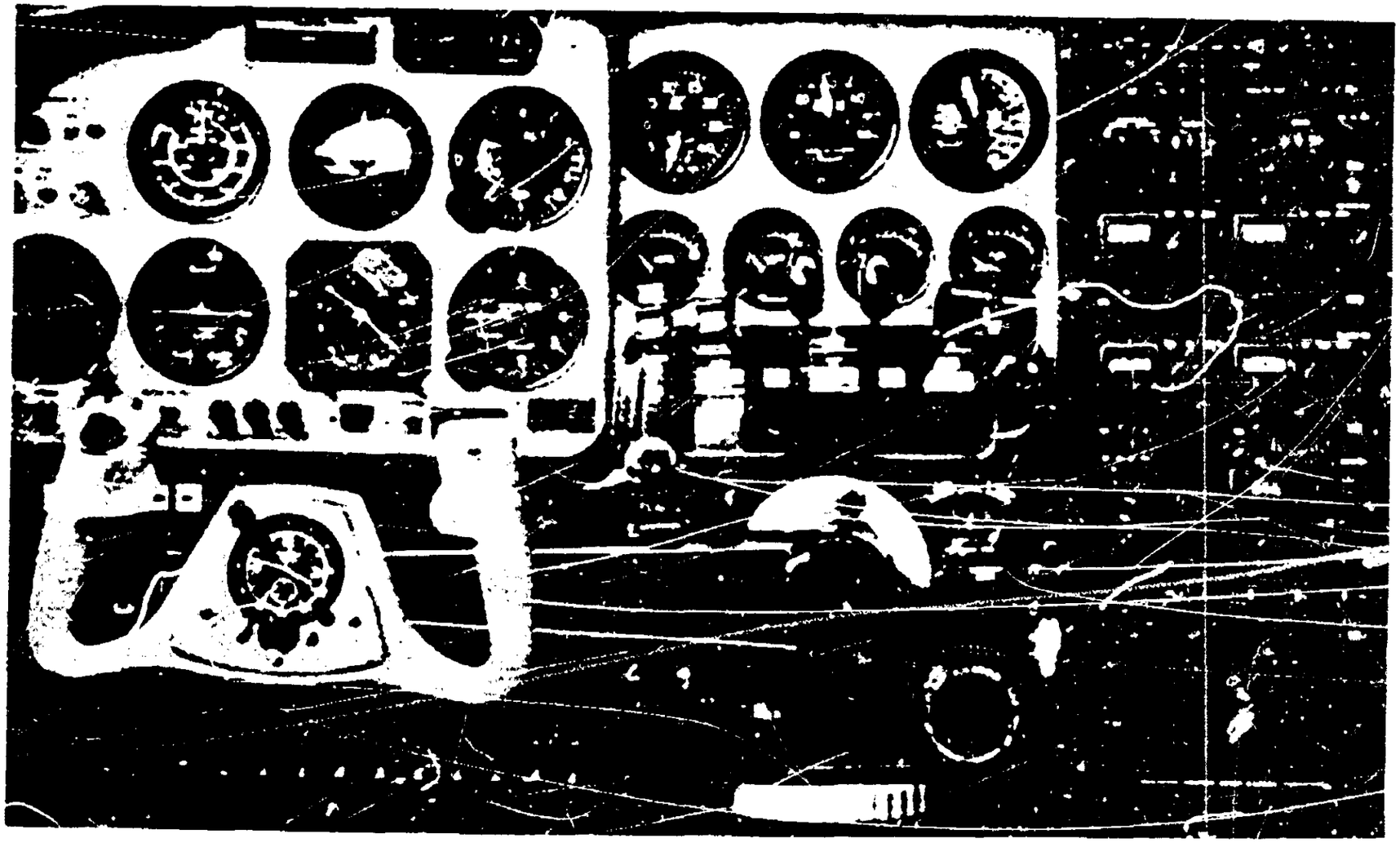


Figure 5.—Single control wheel mounted on a "throw-over" bar (late model Baron).

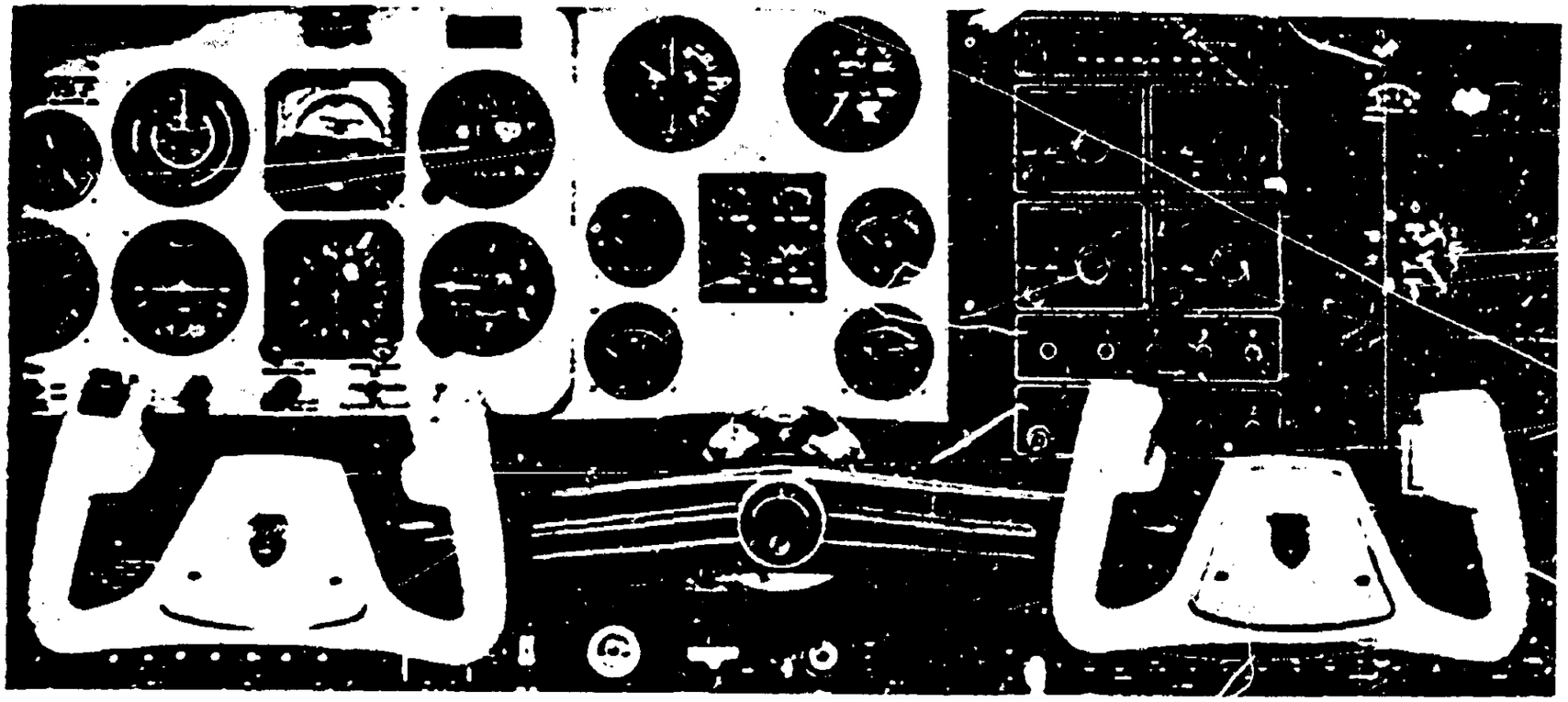


Figure 6.—Dual control wheels on bar (late model Bonanza).

Figure 7.—Pilot reaching underneath the control wheel bar to locate obscured landing gear control switch.

Figure 8a.—Pilot's view of landing gear and flap switches partially obscured by the control wheel bar.

Figure 8b.--Pilot's view of landing gear and flap switches obscured by control wheel bar.

Inadequate Shape-Coding.--The significance of shape-coding to reducing pilot error was clearly recognized in the 1947 study cited above by Fitts and Jones which recommended shape-coding to prevent such errors. Classic research studies 7/have shown: (1) How certain knob shapes can be distinguished solely on the basis of touch, and (2) how by using symbolic shape associations which are similar to the function of the control (i.e. wheel-shaped knob for landing gear) the probability of misuse can be minimized.

The lack of shape-coded control knobs has been documented on the early Bonanzas by the Safety Board special study cited previously. In describing these tab-type switches this report stated that ". . . the landing gear control and wing flap control are included in a row of similar switches or more precisely, nearly identical switches." (See figures 3 and 4.) The accident rate of the Bonanza was more than twice the average rate for all aircraft with retractable landing gears. When Beech redesigned the Bonanza cockpit in 1963, they did incorporate full shape-coding on these controls, but they deleted the latch which had been incorporated on previous models.

Nonstandardized Control Location.--The significance of standardized locations to reducing pilot error was also clearly described in the 1947 Fitts and Jones study. As with shape-coding, this document recommended standardizing the location of these controls to prevent errors. A 1977 FAA study 8/ states that ". . . increased standardization of cockpit systems can reduce cockpit workload, reduce the potential for habit interference when transitioning to another type aircraft, and provide for application of the best and most error-resistant designs."

The detrimental effects of a nonstandardized control arrangement are illustrated by the contrasting accident rates of the Bonanza and the Cessna 210, which has a standard control arrangement. As shown by statistics, the Bonanza's inadvertent landing gear retraction accident rate is 10 times higher than that of the Cessna 210.

Obscuration of Controls.--The problem of inadvertent gear retraction on the Bonanza and Baron aircraft is compounded further by a design feature of the flight control system which is unique to these two aircraft. The system utilizes a large horizontal cross-bar on which the control wheel (or wheels) is mounted. The two versions of this control system are (1) the single control wheel with a "throw-over" mechanism which allows the wheel to be placed in front of either the left or the right front seat (see figure 5), and (2) the dual control model where wheels are available to both seats (see figure 6).

7/ W.O. Jenkins "Tactile Discrimination of Shapes for Coding Aircraft-Type Controls." U.S. Army Air Force, Aviation Psychology Program, Research Report 19, 1947.

8/ "General Aviation (FAR 23) Cockpit Standardization Analysis" by R.J. Ontiveros, R.M. Spangler, and R.L. Sulzer, FAA, NAFEC Report No. RD-77-191, March 1978.

There are two problems associated with this control system: (1) the horizontal bar is large enough to block the pilot's view of the gear and flap control switches forcing the pilot to rely on his sense of feel to identify the desired control, and (2) the pilot must reach around the bar to activate these controls. (See figures 7 and 8.) Both of these problems are more of a hindrance to pilots of small stature and when the wheel is relatively far forward. The control switches are relatively small in comparison to those on many other aircraft. This also tends to decrease the pilot's ability to differentiate those controls by feel.

The pressurized Baron (53P), which was certificated in 1974 and meets 14 CFR 23 requirements with respect to landing gear and flap control location and shape-coding, was involved in only one landing gear retraction accident during the 1975 to 1978 period. Ironically, the pilot attributed his mistake in part to the fact that he was more familiar with the nonstandard control arrangement of the unpressurized Baron and Bonanza. However, he also pointed out that his view of these controls was blocked by the wheel-mounting mechanism.

Lack of a Landing Gear Control Guard Latch.--The advantages of incorporating a latch or guard on the landing gear control can be seen by comparing the accident rate of the Baron with that of a similar aircraft, the Piper PA-23 Aztec. 9/ The PA-23 is the only other light twin currently being produced with a nonstandard gear and flap control arrangement. However, the landing gear control on this aircraft is protected from inadvertent actuation by a separate mechanical guard latch, and as noted earlier, its inadvertent landing gear retraction accident rate is only one-tenth that of the Baron.

PROBLEM SOLUTIONS

The increased potential for inadvertent landing gear retraction accidents on the Baron was recognized by FAA in 1973, when the agency retrofitted its own Barons with a special guard over the landing gear control. This guard must be raised before the gear control can be put in the "UP" position. (See figure 9.) This FAA-developed device is a simple spring-loaded guard that is attached to the instrument panel. 10/ The cost of the parts (a modified toggle switch guard and attaching screws) was minimal. The largest expense was the labor involved. FAA mechanics suggested that this was due to the prototype nature of the modification, which required removal of the control wheel bar and instrument panel cover.

If these guards were to be installed on a large number of aircraft, a well designed, easy to operate, customized guard could be developed. Ideally, this device could be installed without the removal of the yoke and instrument panel, thus the total cost of the device and its installation should be minimal. The landing gear controls on the early (pre-1963) models of the Bonanza could be easily modified by attaching a wheel-shaped knob to the existing switch or by replacing the existing switch with one incorporating a wheel-shaped feature. The cost of such a modification also should be minimal. On newly manufactured Bonanzas and nonpressurized Barons, the cost of installing such a guard and relocating the flap and landing gear controls to the standard configuration (as on the pressurized Baron) would be minimal, because these controls are simple electrical toggle switches which can be located in a variety of places.

9/ The early models of the PA-23 were marketed under the name "Apache."
10/ "Landing Gear Switch Guard Installation," Technical Assistance Engineering Order, No. 72-20-2, FAA Aeronautical Center, November 1972.

CONCLUSIONS

The Safety Board concludes that the number of inadvertent landing gear retraction accidents in the Beech Bonanza and Baron is unnecessarily high in comparison to other contemporary general aviation aircraft. The Board also concludes on the basis of various pilot statements, a review of the human factors research literature, and a detailed analysis of the cockpit features of these aircraft that these accidents result largely from various combinations of four design deficiencies — inadequate shape-coding, nonstandard location of controls, obscuration of controls, and lack of a guard latch on the landing gear control.

Newly manufactured Baron and Bonanza aircraft could readily be made to comply with the requirements of 14 CFR 23.777 with respect to standardized control locations. Guards or latches on landing gear controls also should be installed on all newly manufactured Barons and Bonanzas (including the pressurized Baron). This is necessary because of the obscuration of these switches by the control-wheel bar and because the flap and gear switch locations could be both standard or nonstandard, depending on the model and the model year. The Board also believes that simple landing gear control guards should be retrofitted on previously produced Barons and late model Bonanzas, and a wheel-shaped control should be added to earlier model Bonanzas. The Board believes that the costs of these simplistic modifications would be reasonable.

Finally, the Safety Board believes that the practice of permitting aircraft to be built for an unlimited time under the standards to which they were originally designed should be reconsidered. A detailed discussion of this topic is beyond the scope of this investigation. However, the Board is vitally concerned about this practice. This situation is not unique to the problem or to the types of aircraft discussed in this report. The Board intends to examine such questions in depth in the future.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require after a specified date that all newly manufactured Beechcraft Baron and Bonanza models conform to 14 CFR 23.777 with respect to landing gear and flap control locations and that they have an adequate latch or guard to minimize inadvertent landing gear retraction. (Class II, Priority Action) (A-80-56)

Require that after a specified date, previously manufactured Beechcraft Baron and Bonanza aircraft which do not conform to the landing gear and flap control arrangements outlined in 14 CFR 23.777, be equipped with an adequate guard or latch mechanism to prevent inadvertent actuation of the landing gear controls. (Class II, Priority Action) (A-80-57)

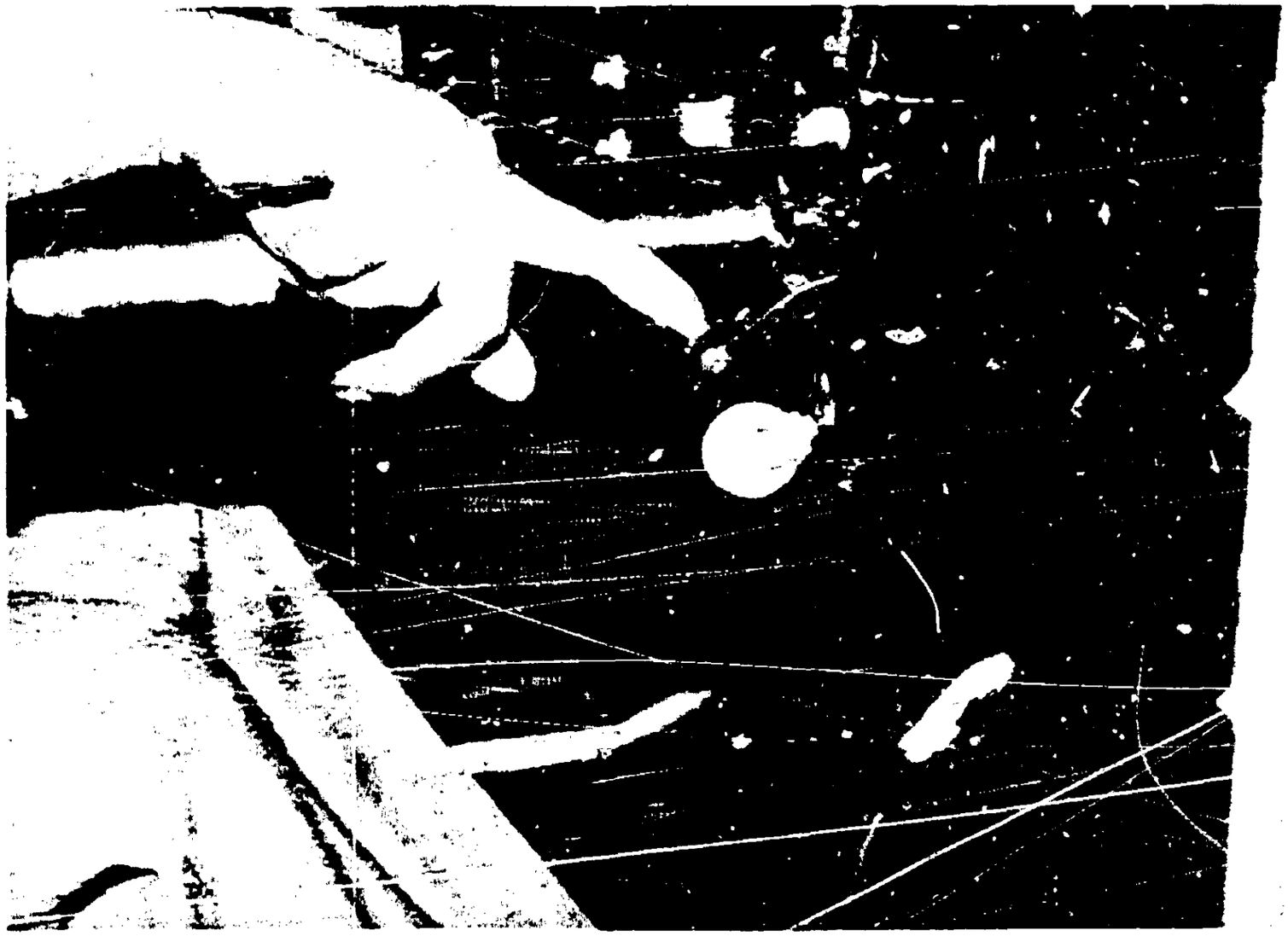


Figure 9.—FAA-designed guard for landing gear control switch (being lifted).

Require that after a specified date, the landing gear control switch on the pre-1963 model Beechcraft Bonanzas be modified to incorporate a wheel-shaped knob as outlined in 14 CFR 23.781. (Class II, Priority Action) (A-80-58)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

[illegible] DRIVER, Vice Chairman, and FRANCIS H. McADAMS, Member, did not participate.

June 24, 1980

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