FAA-AM-78-3

PASSENGER FLOW RATES BETWEEN COMPARTMENTS:
STRAIGHT-SEGMENTED STAIRWAYS, SPIRAL STAIRWAYS, AND PASSAGEWAYS WITH RESTRICTED VISION AND CHANGES OF ATTITUDE

D. W. Pollard
J. D. Garner
J. G. Blethrow
D. L. Lowrey

Civil Aeromedical Institute
Federal Aviation Administration

January 1978

Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Aviation Medicine
Washington, D.C. 20591

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM-78-3		

4. Title and Subtitle	5. Report Date
PASSENGER FLOW RATES BETWEEN COMPARTMENTS: STRAIGHT-SEGMENTED STAIRWAYS, SPIRAL STAIRWAYS, AND PASSAGEWAYS WITH RESTRICTED VISION AND CHANGES OF ATTITUDE	January 1978
	6. Performing Organization Code
7. Author(s) D. W. Pollard, J. D. Garner, J. G. Blethrow, and D. L. Lowrey	8. Performing Organization Report No.
9. Performing Organization Name and Address FAA Civil Aeromedical Institute P.O. Box 25082 Oklahoma City, Oklahoma 73125	10. Work Unit No. (TRAIS) 11. Contract or Grant No. 13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591	14. Sponsoring Agency Code FAA

15. Supplementary Notes

Research leading to preparation of this report was conducted under Tasks AM-B-75/76-PRS-38.

16. Abstract

Data are presented from 210 trials to compare movement up and down spiral and straight-segmented stairways simulating the stairs in multideck transport aircraft, up and down spiral and straight-segmented industrial-type stairways, fore and aft through a passageway enclosed on one side, and fore and aft through a passageway enclosed on both sides. The Civil Aeromedical Institute evacuation simulator was positioned to represent degrees of pitch and roll similar to those encountered in accidents as a result of landing gear failure. Tests were conducted in regular cabin lighting, reduced cabin lighting, reduced cabin lighting with subjects wearing goggles simulating smoke conditions, and artificial smoke conditions.

Results indicate that an enclosed passageway enables more rapid movement from one compartment to another than does a passageway enclosed on only one side. Straight-segmented stairways allowed more efficient movement from one level to another than did spiral stairs. Subjects were more cautious in the tests that involved wearing smoke goggles than in any of the other conditions.

17. Key Words	18. Distribution Statement
Air transport stairs Passageways Passenger movement	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	51	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Dr. Earl Folk, Chief, Biostatistical Staff, Civil Aeromedical Institute, in the experimental design and statistical analysis phase of the research. Acknowledgment also goes to Mr. Oscar Ball, Flight Standards National Field Office, for engineering and technical assistance in the program.

TABLE OF CONTENTS

PASSENGER FLOW RATES BETWEEN COMPARTMENTS: STRAIGHT-SEGMENTED STAIRWAYS, SPIRAL STAIRWAYS, AND PASSAGEWAYS WITH RESTRICTED VISION AND CHANGES OF ATTITUDE

I. Introduction.

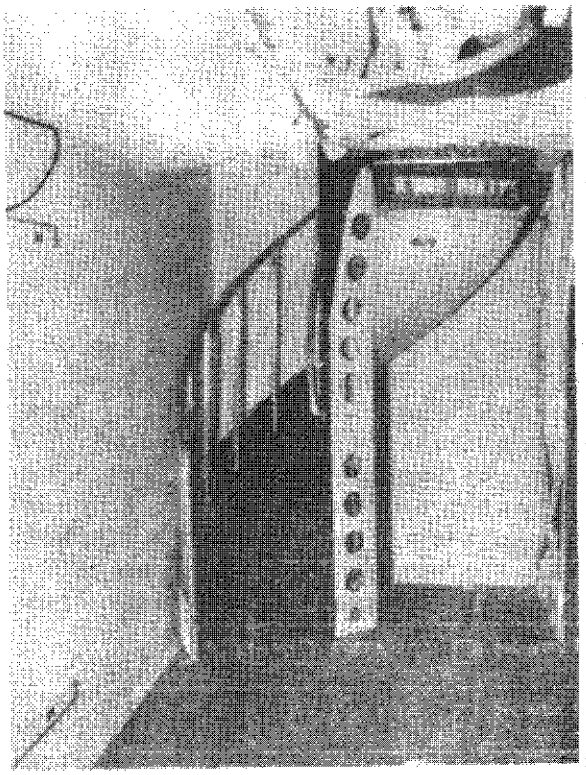
The multideck passenger-carrying aircraft has the inherent problem of passenger movement from one deck to another during emergency evacuations. Stairways are the only equipment offered to facilitate this movement. Some models of the Boeing 747 are equipped with a spiral staircase, and a straight-segmented staircase is installed in the Lockheed L-1011. The aircraft manufacturing companies have satisfactorily demonstrated the adequacy of stairs for emergency evacuation when the number of passengers is limited. However, their adequacy is questionable when the number of passengers is increased, particularly when an emergency evacuation takes place under less than ideal conditions.

Manufacturers and airline companies have requested an increase in the number of passengers that may be carried in both the upper (B-747) and lower (L-1011) decks. Because of these requests, the Federal Aviation Administration Flight Standards Service and the Office of Aviation Medicine cooperatively initiated a research task to provide data to establish numerical performance ratings for the straight and spiral stairways as compared to the single-deck, unobstructed passageway required by Federal Aviation Regulation (FAR) 25.813(a). This FAR states: "There must be a passageway between individual passenger areas, and leading from each aisle to each Type I and Type II emergency exit. These passageways must be unobstructed and at least 20 inches wide."

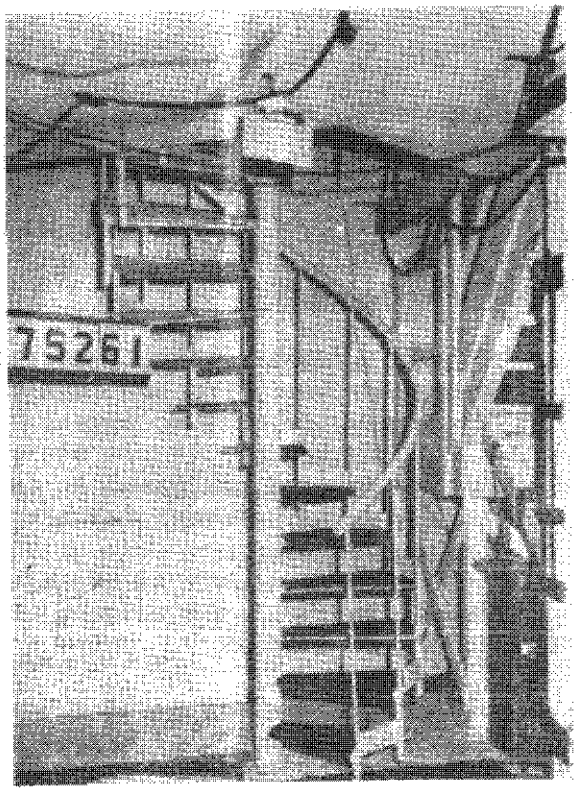
This project was divided into two phases. Phase I provided preliminary data for comparison of passenger flow rates on stairways and through a passageway under normal lighting and attitude (0^{o} pitch and roll) conditions (1). Details of this study are presented in Appendix A. This phase confirmed that further research would be necessary to achieve definitive conclusions with operational equipment. Therefore, Phase II was conducted and is discussed in this report.

II. Method.

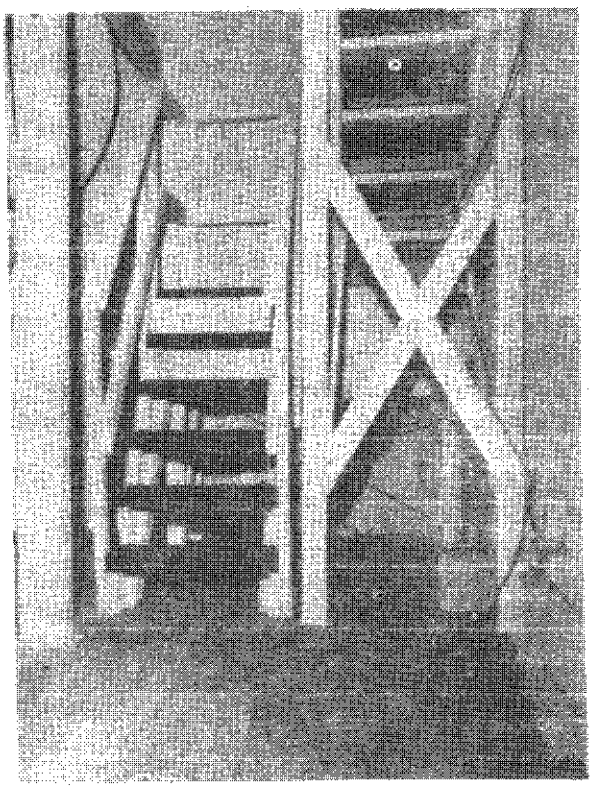
Because of differences in experimental procedure and equipment, Phase II consists of two main experiments. The primary purpose of Experiment 1 was to obtain data on the effects of pitch and roll on passenger movement on spiral stairways, on straight stairways, and in passageways under emergency lighting conditions (0.05 fc). Experiment 2, conducted during the last 3 test days, provided data for the added condition of reduced visibility and for changes in equipment.



(a)



(b)



(c)

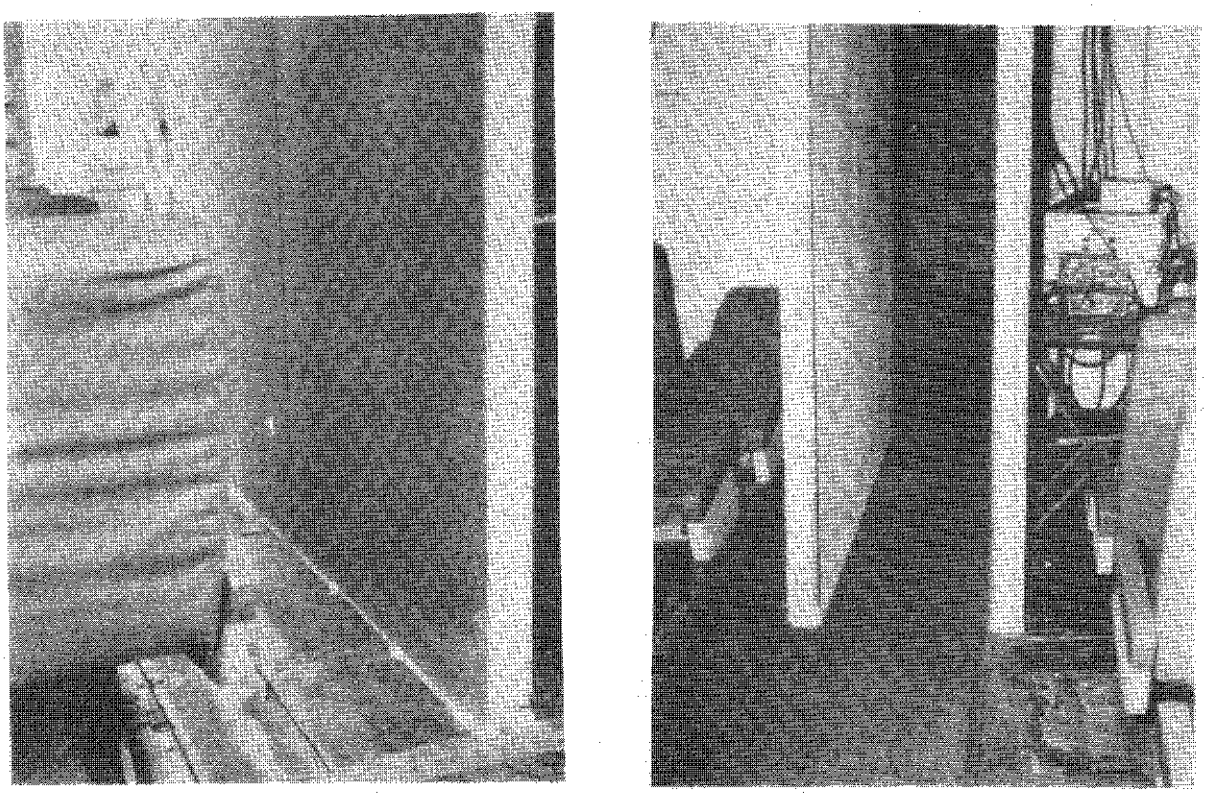
(d)

FIGURE 1. Stairways used in Phase II tests: (a) spiral stairway similar to that used between decks of a Boeing 747; (b) industrial spiral stairway; (c) right-ascending turn, straight-segmented stairway; and (d) left-ascending turn, straight-segmented stairway.

III. Equipment.

Six major pieces of equipment were used: a carpeted spiral stairway similar to that used between decks of a Boeing 747 (Unit A) Figure 1a); a carpeted industrial spiral stairway (Unit B) (Figure 1b) (also used during Phase I); two straight-segmented stairways (Units C and D) (Figures 1c and 1d); and two passageways (Units E and F) (Figures 2a and 2b). This equipment is described in Table 1. Engineering drawings are presented in Appendix E.

Notable differences in equipment were: the stairs used during the first 5 days of testing (A and C) are right ascending and have 13 steps while those used during days 6 and 7 (B and D) are left ascending and have 14 steps; the industrial-type spiral stairs (B) have a more abrupt wedge shape; there is a pole going through the center of the spiral stairs and a bannister on the outer circumference; passageway E is paneled on the right side and has aircraft seats on the left side; and passageway F is paneled on both sides.



(a) (b)

FIGURE 2. (a) Passageway with seats on one side; (b) passageway enclosed on both sides.

TABLE 1. Description of Equipment

Unit	No. Steps	Step Rise (in)	Step* Depth (in)	Step Width (in)	Rail/Pole Distance (in)	Height (in)	Test Days Used	Figure/Reference Appendix
A SPIRAL STAIRWAY, similar to aircraft stairs, carpeted, 234° right-ascending turn.	13	7.73	9.50	27.13	22.5	100.49	1,2,3,4,5	Figures 1a, 6/A-1
B SPIRAL STAIRWAY, similar to industrial stairs, carpeted, 280° left-ascending turn.	14	7.00	9.00	21.75	20.0	98.0	6,7	Figures 1b, 7/A-2
C STRAIGHT STAIRWAY, two segments of six steps each plus 7.5 in to top, carpeted, 180° right-ascending turn.	12 → + 1 → 13	7.75 7.50	9.75	23.25	20.25	100.50	1,2,3,4,5	Figures 2, 6
D STRAIGHT STAIRWAY, two segments of seven steps each, carpeted, 180° left-ascending turn	14	7.00	9.00	23.25	20.0	98.0	6,7	Figures 2, 7
E PASSAGEWAY, aircraft seats on the left, 96 in long and 20 in wide, paneled on one side.							1,2,3,4,5	Figure 3b
F PASSAGEWAY, paneled on both sides, 96 in long and 20 in wide							6,7	Figure 3a

*Measured at midpoint of step.

The goggles worn by subjects on Test Days 5 and 6 to simulate smoke conditions were industrial eye-protective goggles manufactured by Willson and called Vue-Guard Goggles (Figure 3). These goggles comply with the Occupational Safety and Health Administration (OSHA) American National Standards Institute 87.1 (1968) for safety goggles. They have a flat surface, they can be worn with regular eyeglasses, and the distance from the surface to the eye averages 28 mm. Test personnel laminated the transparent surfaces of the goggles with gray, almost opaque material called "60% Black" that is made by Bourges in the United States. This produced a goggle that gave a 17-percent transmission as measured by a Gamma-Scientific Inc. photometer. On the Gardner PG.5500 Hazemeter a 55-percent haze factor was recorded in the right lens sample and a 57-percent haze factor was recorded in the left lens sample of randomly selected pairs of goggles. This haze factor required the subjects to feel for the passenger seats to find them.

Activity under reduced lighting was recorded on Milliken 500 cameras (provided with numeric timing) operating at 24 frames/s, augmented with a Javelin Model 220 night-viewing device.

FIGURE 3. Subject wearing goggles used to simulate visibility in smoke.

IV. Environment.

The tests were conducted in the Civil Aeromedical Institute (CAMI) evacuation simulator (Figure 4). The first six trials each day were run

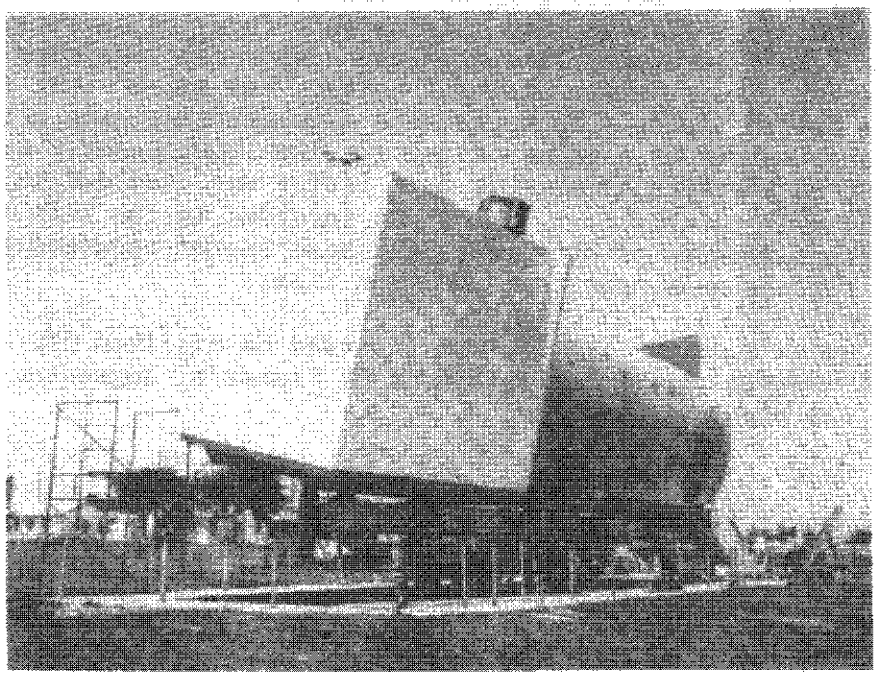


FIGURE 4. Evacuation simulator.

under normal lighting conditions of 50 fc at armrest level and 40 fc at floor level. All other trials were conducted in reduced light of 0.05 fc measured on the Photo Research Corporation millicandela foot-candle meter, with measurements taken at the midpoint of each equipment item (each spiral or straight stairway and each passageway). Further measurements of light levels were taken through the cabin and found to be more than 0.02 fc. This is at or above the light level required by the airworthiness standard for emergency lights, as stated in FAR 25.812(c) and (d):

> (c) General illumination in the passenger cabin must be provided so that when measured along the center-line of main passenger aisle(s), and cross aisle(s) between main aisles, at seat armrest height and at 40-inch intervals, the average illumination is not less than 0.05 ft-candle and the illumination at each 40-inch interval is not less than 0.01 ft-candle. A main passenger aisle(s) is considered to extend along the fuselage from the most forward passenger emergency exit or cabin occupant seat, whichever is farther forward, to the most rearward passenger emergency exit or cabin occupant seat, whichever is farther aft.

(d) The floor of the passageway leading to each floor-level passenger emergency exit, between the main aisles and the exit openings, must be provided with illumination that is not less than 0.02 ft-candle measured along a line that is within 6 in of and parallel to the floor and is centered on the passenger evacuation path.

The evacuation simulator is air conditioned and was maintained for these tests at a temperature of approximately 72° F.

V. Subjects.

Paid test subjects were provided by contract with the University of Oklahoma, Office of Research Administration. The majority of the subjects were inexperienced in evacuations at the start of the tests. The subject population of 23 to 26 subjects per test was obtained in an attempt to match the description of a representative passenger load described in FAR 25.803(c)(5), which states:

(5) A representative passenger load of persons in normal health must be used as follows:
(i) At least 30 percent must be female.
(ii) Approximately 5 percent must be over 60 years of age, with a proportionate number of females.
(iii) At least 5 percent but no more than 10 percent must be children under 12 years of age prorated through that age group.

Pertinent data on the subjects are summarized in Table 2.

TABLE 2. Subject Description

Test Day	Group	No. of Subjects M	F	Total	Mean Age (yr)	Mean Height (in)	Mean Weight (lb)
1	A	12	14	26	29.25	67.00	143.69
2	B	11	13	24	24.79	65.50	133.08
3	C	16	10	26	29.23	67.00	150.38
4	D	15	10	25	25.44	68.33	149.92
5	E	11	12	23	27.74	67.33	146.00
6	F	15	10	25	23.76	64.85	148.08
7	G	13	12	25	26.72	66.85	146.44

The mean age for all subjects was 26.76 yr, the mean height was 67 in, the mean weight was 145.37 lb, and the average male/female ratio for all tests was 13/11. Appendix B contains additional subject information. The normal population, based on a civilian adult population aged between 18 and 79, has a height of 65.5 in and a mean weight of 155 lb (1).

The subjects met in the CAMI lobby, where they completed consent forms (Appendix B); recorded their height, weight, and age; and left their personal possessions, especially sharp objects. After listening to taped instructions (for text see Appendix B), they were assigned subject numbers that established the order in which subjects approached test equipment for the tests; donned jackets with large, readily identifiable numbers; and were led to the evacuation simulator. When subjects were in the simulator, they were given the countdown procedures (5-4-3-2-1; start at the sound of the bell; move as swiftly as possible while observing personal safety and the safety of others; and move as far away from the end of the test device as possible). They were allowed to hear the bell that would ring throughout each individual test. The subjects were told to clear the end of the test unit (stairway or passage) following each trial to allow room for those following them. When goggles were used, additional instructions were given on the use of the goggles. After the first six trials, conducted in normal light, the subjects were allowed to wear the goggles and become familiar with them. Then, before each trial, the subjects wore the goggles for 120 s to allow time for visual light/dark adaption.

VI. Procedure.

The average of times from stopwatches operated by three independent observers was recorded as the time for each trial. The first subject, positioned at the threshold of the stairs or entrance to the passageway with the other subjects in line behind him, started when the bell sounded. A countdown procedure coordinated the sound of the bell, the starting of the watches, and the start of the subject movement. Time ended when the last subject in the group placed his weight off the stairs or out of the passageway. Subjects were given 15-min rest periods following Trials 6 and 12, a 45-min lunch period following Trial 18, and another rest period of 15 min following Trial 24. Following Trial 30, the subjects returned to the CAMI lobby, where they signed pay forms and were dismissed.

The trial sequence is shown in Table 3. To establish a baseline of data on each test day the subjects were given six trials in normal light. They were required to go up and down each set of stairs and fore and aft through the passageways during these preliminary trials. After the first six trials, the lights were dimmed to 0.05 fc for the remainder of the trials.

During the first 4 test days the subjects were required to move up and down the spiral stairs (A) (Figure 1a), up and down the straight-segmented stairs (C) (Figure 1c), and fore and aft through the passageway (E) (Figure 2a) with the simulator pre-positioned in the pitch and roll attitudes laterally. These attitudes were 0^{o} pitch and 0^{o} roll, 12^{o} roll left and 0^{o} pitch, 12^{o} roll right and 0^{o} pitch, 7^{o} pitch and 12^{o} roll right, and 7^{o} pitch

TABLE 3. Summary of Test Sequence

	Equipment Used in Each Test Aircraft-Type Spiral Right-Ascending Stairs (A) Straight-Segmented, Right-Ascending Stairs (C) Passageway, Aircraft Seats on Left Side (E)					Equipment Used in Each Test Industrial Left (B) Straight Left (D) Enclosed (F)	
					Smoke-Simulating Goggles		Smoke-Simulating Goggles
Day	1	2	3	4	5	6	7
Trial*	1-6	31-36	61-66	91-96	121-126	151-156	181-186
Attitude**	0° 0°	0° 0°	0° 0°	0° 0°	0° 0°	0° 0°	0° 0°
Trial*	7-12	37-42	67-72	97-102	127-132	157-162	187-192
Attitude**	0° 0°	7° 12°R	0° 12°L	7° 0°	7° 12°L	7° 12°R	7° 12°R
Trial*	13-18	43-48	73-78	103-108	133-138	163-168	193-198
Attitude**	7° 0°	0° 12°L	7° 12°L	0° 0°	0° 0°	0° 0°	0° 0°
Trial*	19-24	49-54	79-84	109-114	139-144	169-174	199-204
Attitude**	0° 12°R	7° 0°	7° 12°L	0° 0°	0° 0°	0° 0°	0° 0°
Trial*	25-30	55-60	85-90	115-120	145-150	175-180	205-210
Attitude**	7° 12°L	0° 0°	7° 0°	0° 12°R	7° 12°L	7° 12°R	7° 12°L

*Normal Lighting 0.50 fc
Emergency Lighting 0.05 fc
**Attitude = nose down pitch degree/degree of roll L (left) or R (right)

and 12^{o} roll left. These attitudes were selected because they approximate the pitch and roll an aircraft might assume with a right, left, or nose gear collapse or a combination of one main gear and nose gear collapse. The sequence of trials was established to balance the variables of learning and fatigue. Appendix D contains information about each test day's protocol.

On Day 5 a baseline was established and the subjects donned goggles to restrict visibility. Six trials were conducted with the simulator positioned at 7^{o} nose down and 12^{o} roll left; 12 trials were conducted at 0^{o} pitch and roll; then the simulator was returned to the 7^{o} nose down and 12^{o} left roll for the remaining six trials. The subjects were required to go up and down each set of stairs (A and C) and fore and aft through the passageway (E) during each set of six trials.

The attitude 12^{o} left roll and 7^{o} nose down was selected because data collected during the first 4 test days showed this to be the most difficult attitude for subjects to negotiate the equipment. The stairways (A and C) are both right-ascending and the passageway (E) has aircraft seats on the left side.

The test procedure was the same for Days 6 and 7; however, there were equipment differences. On both days, spiral staircase B (industrial type, left ascending) (Figure 1b), the straight stairway (left ascending) (Figure 1d), or the passageway F (enclosed on both sides) (Figure 2b) were used. Goggles were donned after a baseline was established on Day 7.

VII. Results.

The "seconds per passenger" (s/pax), a unit of measurement commonly used by the airline industry when discussing passenger flow rates, is computed by dividing the amount of time needed for all individuals to complete the task by the number of individuals. Means were obtained for all trials in each attitude on each piece of equipment.

Statistical ratios comparing passenger movement between stairways and passageway in all attitudes tested are contained in Appendix C. Figure 5 summarizes the baseline data for all test days and provides a comparison of equipment efficiency under normal lighting conditions, with an attitude of 0^{o} pitch and 0^{o} roll, before the learning and fatigue variables are considered.

Figures 5 through 10 present data on passenger flow rates as related to the test variables.

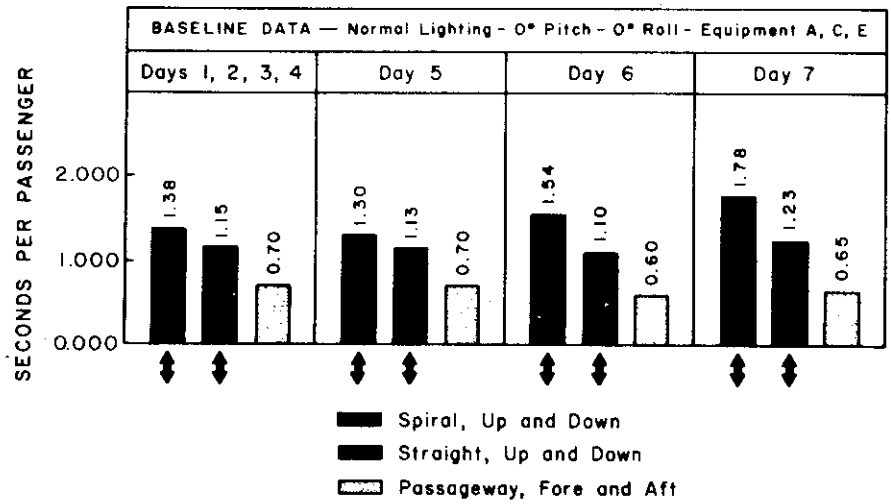


FIGURE 5. Passenger flow rates.

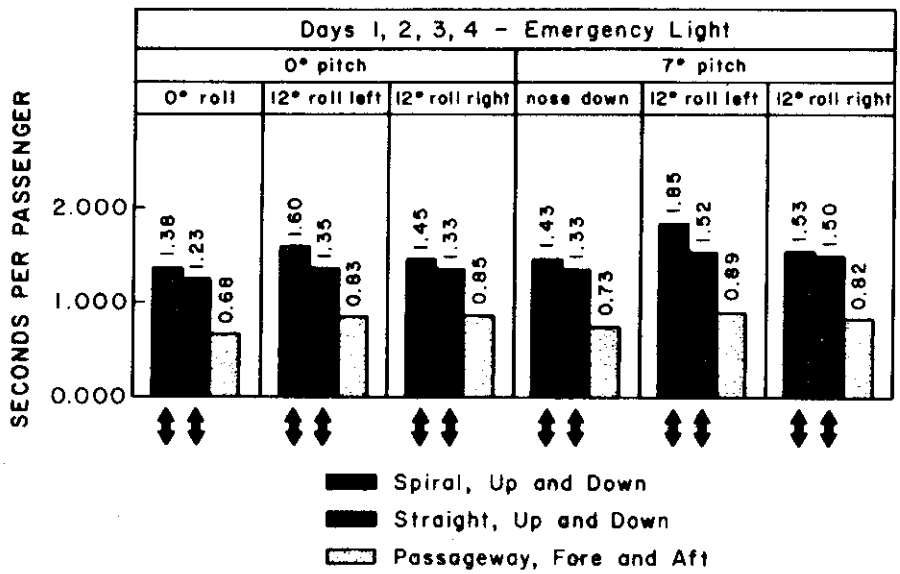


FIGURE 6. Comparison of attitude variable.

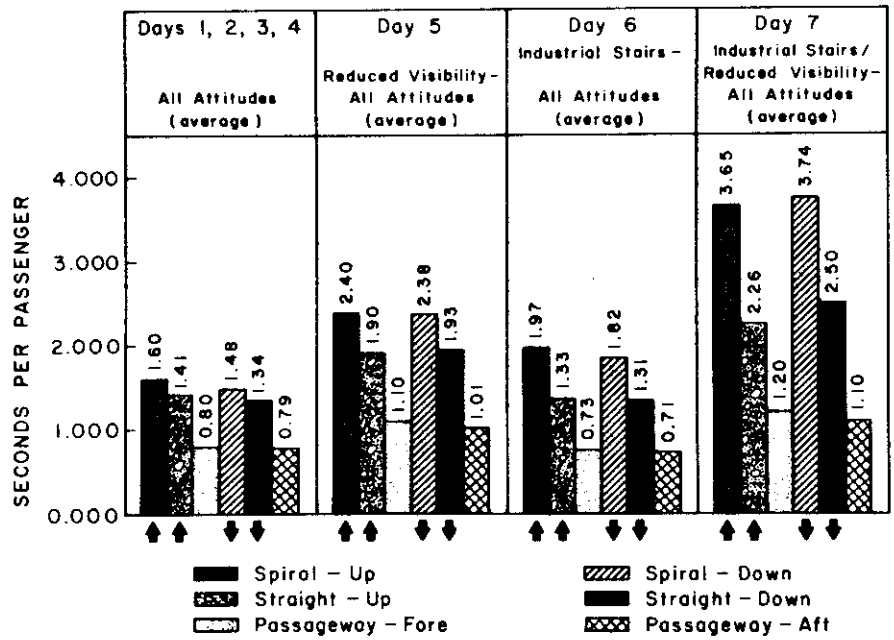


FIGURE 7. Comparison of passenger flow on all test equipment (up vs. down and fore vs. aft).

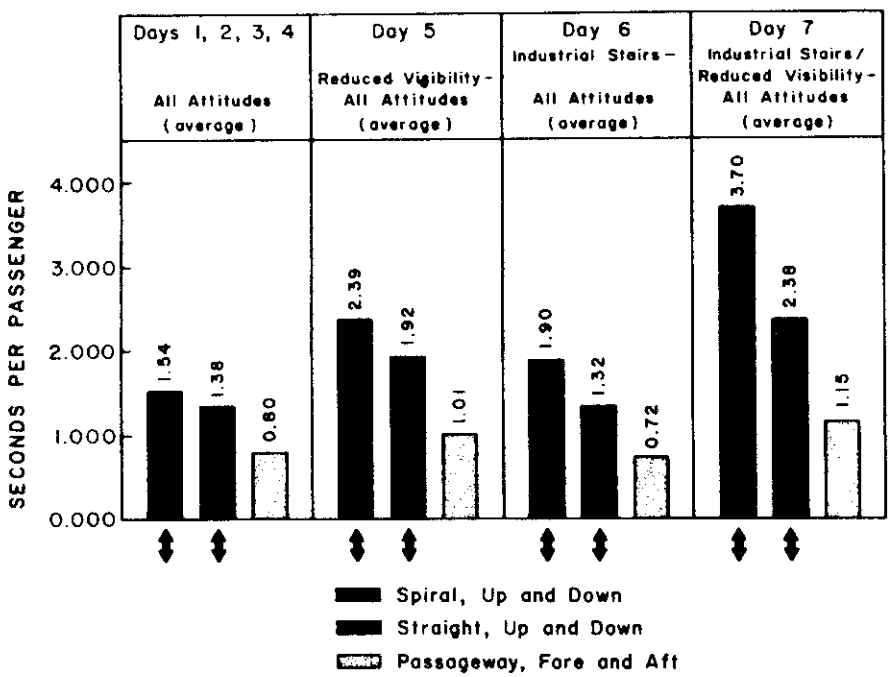


FIGURE 8. Comparison of passenger flow on all test equipment.

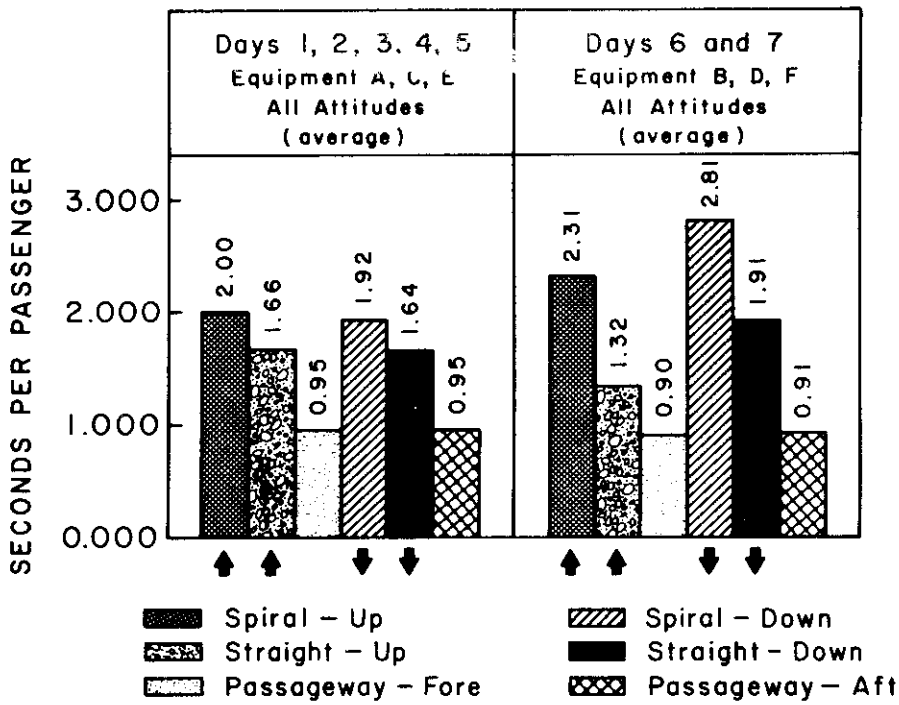


FIGURE 9. Summary of equipment efficiency for all tests.

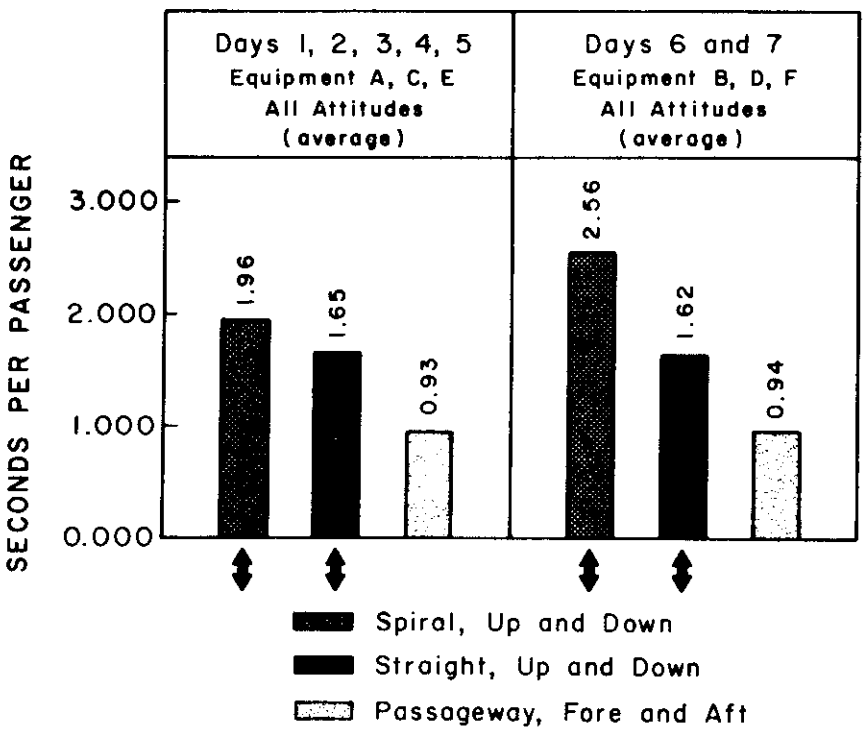


FIGURE 10. Comparison of passenger flow rates.

VIII. Discussion.

As indicated by the graphs in Figures 5-10, the spiral stairways (A and B) were the least efficient equipment in all attitudes with only one exception, the 7° nose down pitch, 12° right roll attitude where the flow rate for climbing the spiral stairs (A) was slightly faster than for climbing the straight-segmented stairs. It was also noted that more stumbling, tripping, and falling occurred on both sets of spiral stairs, with more being noticed on the industrial-type spiral stairs (B) than on the aircraft-type stairs (A).

The industrial-type stairs used on Test Days 6 and 7 were less efficient than the aircraft-type spiral stairs used on the other test days. Part of this difference may be due to the difference in the shape and size of the individual steps (Figure 11). However, another facet of the efficiency level may have been that the industrial-type stairs had a hand railing on only one side with no handhold on the center pole. Subjects were noticed either holding the center pole with both hands or holding the railing with both hands. Observers also noted that subjects appeared to have more difficulty in using the industrial-type steps and their feet were sliding from the front edge of some of the steps. It was also noted that some subjects had difficulty finding the last step.

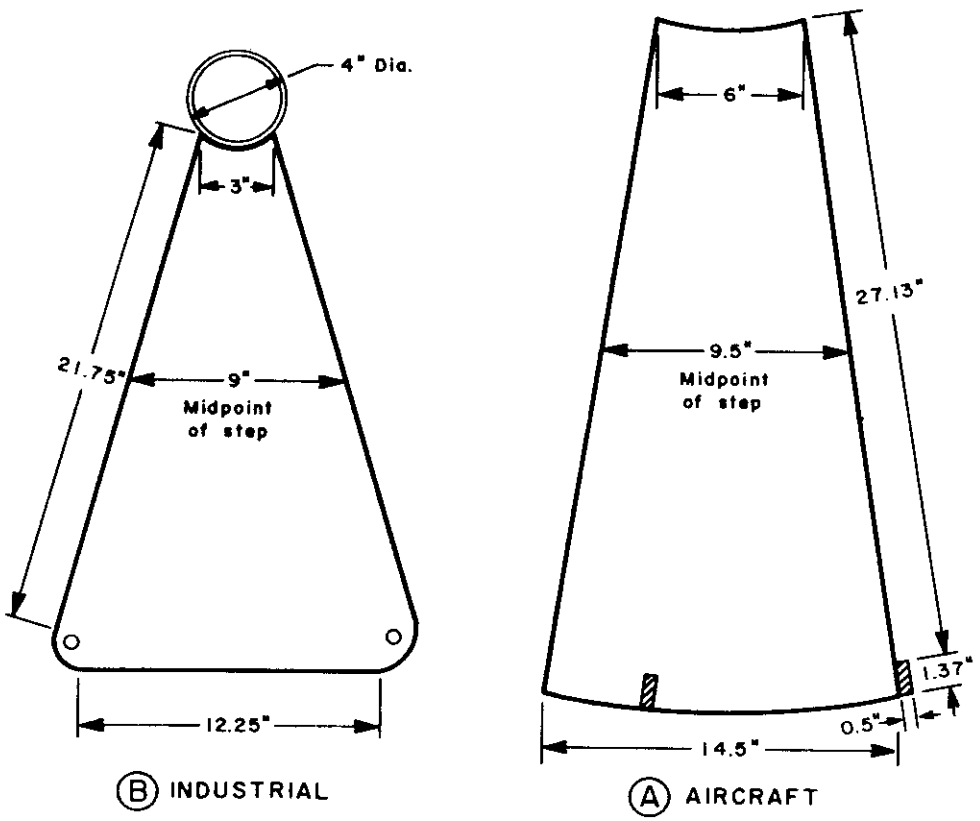


FIGURE 11. Diagram showing comparison of a Boeing 747 staircase step with an industrial spiral staircase step.

The straight-segmented stairs allowed more efficient movement than either of the spiral stairs, with the exception noted above. The effect of learning may account for this efficiency because straight-segmented stairs are encountered more often in daily life and thus the subjects may have had more practice in using this type of stairs. In addition, these stairs have rectangular-shaped steps and accommodate the foot more readily than the wedge-shaped steps characteristic of spiral stairways. Fewer incidents of falling, slipping, and stumbling on the straight stairs were noted.

The passageways provided the most efficient method of movement between compartments, with the passageway with walls on both sides (F) being the more efficient of the two types tested. Subjects used the walls for support and, in many cases, placed a hand on each wall, bouncing back and forth along the passageway. In the passageway with seats on the left side (E), when the simulator was rolled to the left, subjects fell into the space between the seat rows. The seat design may have contributed to this problem; subjects caught their feet on the seat legs along the aisle.

Movement forward through the passageway was slower than movement aft, possibly because of the support pole located 14 ft in front of the exit of the passageway when going forward. Subjects were warned about this padded pole prior to the tests, were cautious about it, and reduced their rate of movement to protect themselves.

All equipment was less efficient when the simulator was in unusual attitudes, with the passageway being the piece of equipment affected least by the simulator's attitude. It was noted that subjects did more to protect themselves in unusual attitudes; i.e., they moved slower, gripped the railings more often, and leaned on the walls to a greater extent. Also, the unusual attitudes required the subjects to use more strength, literally pulling themselves up when climbing the stairs.

Reduced vision by the use of goggles slowed passenger movement on all three types of equipment, both up and down the stairways and fore and aft through the passageway. In addition, subjects slipped and stumbled more while wearing the goggles.

It should be noted that, as the subjects became more familiar with the environment, the time needed to negotiate the various test paths was reduced. The conclusion might be drawn that those who are familiar with the environment, such as crewmembers, would be able to move much faster from compartment to compartment than those who are not familiar with the environment. This factor will be important in situations where visibility is reduced.

Design features play an important part in the safety of those using the equipment and in the flow rate. In addition to the already noted problems with seat legs, tread depth, and lack of a handrail, other design problems were noticed. Subjects reported scraping their hands and knuckles when the railing on the straight-segmented stairs was too close to the wall. Some subjects also reported they jammed their fingers when grasping the railing on the spiral stairway as they came to a vertical railing-support bar.

Observers noted that subjects used more caution when approaching either end of the equipment, especially during the reduced-vision trials.

Clothing style also contributed to safety. Loose clothing, especially sleeves and jacket hems, caught on the stair railings; flared pants legs caught on the steps; and shoe heels caught on the edge of the steps and, in three separate instances, broke. Women who wore high heels were much more careful, and therefore much slower, going up and down the stairs.

IX. Conclusion.

Straight-segmented stairways provide more efficient movement between different compartment levels than do spiral stairways and may also be safer. Passageways enclosed on both sides are more efficient and safer than passageways enclosed on only one side. Changes in attitude from horizontal reduced efficiency of all the equipment tested, Reduced visibility, such as might be encountered in smoke, also appreciably affected the efficiency and safety of passenger movement on the types of equipment tested.

REFERENCE

1. National Center for Health Statistics Data From the National Health Survey Weight, Height, and Selected Body Dimensions of Adults United States, 1960-1962. Washington, D.C., June 1965.

APPENDIX A

PHASE I TEST: FACTORS INFLUENCING PASSENGER MOVEMENT BETWEEN DECKS IN AIR TRANSPORT CATEGORY AIRCRAFT

I. Introduction.

The multideck passenger-carrying aircraft has the inherent problem of passenger movement from one deck to another. At the present time stairways are the only equipment offered to facilitate this movement. Specifically, the manufacturers offer a spiral staircase in the Boeing 747 and a straight-segmented staircase in the Lockheed L-1011. The aircraft companies have satisfactorily demonstrated the adequacy of stairs for emergency evacuation when the number of passengers is limited. However, their adequacy is questionable when the number of passengers is increased. This question becomes more relevant when the emergency evacuation takes place under less than ideal conditions.

Manufacturers and airline companies have requested an increase in the number of passengers that may be carried in either the upper (B-747) or lower (L-1011) deck. Because of these requests, the Federal Aviation Administration Flight Standards Service and the Office of Aviation Medicine cooperatively initiated a research task with the aim of establishing numerical performance ratings for the straight and spiral stairways as compared to the single-deck, unobstructed passageway required by FAR 25.813(a). This FAR states: "There must be a passageway between individual passenger areas, and leading from each aisle to each Type I and Type II emergency exit. These passageways must be unobstructed and at least 20 inches wide."

II. Method.

Because of the deadline imposed by the original research request from Flight Standards Service, the project was divided into two phases. Phase I will be discussed in this section.

III. Equipment.

Three pieces of equipment were used: A spiral stairway, a straight stairway, and a passageway.

The spiral stairs were an industrial-type steel assembly. Fourteen steps with a 7-in rise per step gave a total height of 98 in with a 280^{o} rotation. Stair treads were 9 in deep at the widest point, and antislip surfaces were cemented to the surface of the stair treads. A steel pipe bannister supported by a vertical rod from each step was placed at the outer circumference of the stairs. This bannister was on the left (descending) side of the stairs. Twenty inches away, on the inner circumference of the stairs, was a vertical pipe.

The straight wooden stairway was divided into two segments of seven steps each joined by a landing in a manner that necessitated a 180^{o} turn. The 14

steps had a 7-in rise for a total height of 98 in. Antislip surfaces were applied to the 9-in-deep stair treads. Bannisters on either side of the stairway were 20 in apart.

The wooden passageway was 20 in wide and 96 in long and contained no head obstructions.

IV. Environment.

The test was conducted inside CAMI's high-bay area.

V. Subjects.

A representative passenger load as defined by FAR 25,803* was provided by the University of Oklahoma (Office of Research Administration) contract subject pool. The 30 subjects were divided into groups of 10. Pertinent data on the groups are recorded in Table A-1.

TABLE A-1. Subject Description

Mean	Group A	Group B	Group C
Age	33.8	33.6	29.8
Height	68.8	67.2	68.1
Weight	156.5	147.2	156.6
Male/Female Ratio	6/4	6/4	5/5

VI. Experimental Design.

A "between" group, balanced for each group design, was used. The conditions were up and down the spiral stairs, up and down the straight stairs, and through the passageway. Each group was subjected to each condition two times (Trial 1, Trial 2). The experiment was designed so that a naive group was subjected to each condition. The sequencing of conditions was balanced so the variables of learning and transfer of learning were controlled. As a final test, all 30 subjects were subjected to each condition.

*FAR 25.803(5) states: "A representative passenger load of persons in normal health must be used as follows: (i) At least 30 percent must be female. (ii) Approximately 5 percent must be over 60 years of age, with a proportionate number of females. (iii) At least 5 percent but no more than 10 percent must be children under 12 years of age, prorated through that age group."

VII. Procedure.

The average of times taken by three independent stopwatches was regarded as the time for each trial. The first subject for each trial, positioned near the top of the stairs or entrance to the passageway, started when a bell sounded. Time ended when the last subject in the group placed his full weight on the first foot off the stairs. The first half of each group approached the stairway or passageway straight ahead and the second half approached at a 90^{o} angle.

VIII. Results.

The results for the individual group tests are summarized in Table A-2. The results for the final test when all 30 subjects were subjected to each condition are summarized in Table A-3.

TABLE A-2. Means for Groups of 10 (s)

Trial	Spiral Up	Spiral Down	Straight Up	Straight Down	Passage-way
1	21.83	19.93	14.67	14.80	7.83
2	18.83	17.50	13.77	14.03	7.30
Average	20.33	18.72	14.22	14.42	7.57

TABLE A-3. Time for 30 Subjects (s)

Spiral Up	Spiral Down	Straight Up	Straight Down	Passageway
48.3	46.7	34.6	33.3	18.5

IX. Discussion.

Sufficient data are not available to formulate any definite conclusions. Further research is necessary to substantiate the data and introduce other variables.

APPENDIX B

Subject Information

SUBJECT CONSENT FORM

THIS FORM MUST BE SIGNED AND WITNESSED

ATTACHMENT "B"

GENERAL ASSUMPTION OF RISK

In consideration of my selection by the University of Oklahoma Office of Research Administration and my acceptance by the Federal Aviation Administration as a human subject in Aeromedical Research I hereby assume the full risk and responsibility for any accident, injury, or bodily harm occurring as a result of any research activity in which I may hereafter participate, if such accident, injury, or bodily harm is not proximately caused by negligence or fault of the Federal Aviation Administration or of its employees. I certify that I am 21 years of age or older.

Signature:_____

Date:_____

WITNESS:

_____

PARENTAL PERMISSION AND ASSUMPTION

The following parental permission and assumption shall be completed by parents of subject under 21 years of age:

We are the parents of_____, age_____. We hereby give permission for our son/daughter voluntarily to participate in research experiments conducted by the Federal Aviation Administration. For ourselves as parents, we assume the risk and responsibility of any accident, injury, or bodily harm occurring in relation to such experiments, if not proximately caused by the neglect or fault of the Federal Aviation Administration or its employees.

_____ _____
Signature of Father Date

_____ _____
Signature of Mother Date

WITNESS:

_____

INSTRUCTIONS GIVEN TO SUBJECTS

We would like to welcome you to the Federal Aviation Administration Civil Aeromedical Institute. Our Institute conducts many tests to develop new techniques to further aviation safety,

Now that we have your attention, you are probably wondering why this is taped. It is taped so all our test subjects will be given the same instructions. This will enable us to collect the most useful information. There is important information contained in these instructions. We hope you will give us your attention.

This experiment today is to find the best way of going between decks on big, wide-bodied jets like the Boeing 747, which has two stories. We want to see what will happen if people in a group do this in a hurry if the airplane is tilted or the lights are dim. We are particularly interested in seeing how long it takes to go from one floor to another.

You will be going up and down stairs and through passageways. These stairs will be both straight and spiral. Going up or down stairs may seem normal and natural, but when the stairs are tilted or in dim light, it is different. However, these are conditions which might occur in an aircraft accident.

There are risks anytime you go up and down stairs. There is an additional risk here because you will be in a group, in a hurry, the stairs will be tilted, and you will be in dim light. If anything happens you will hear this sound . . . . If you hear the sound, STOP where you are. If you should see someone fall, don't wait for the sound, STOP. Again, if you hear this sound . . . . , STOP. We want you to move as fast as you can, but don't be pushy. We have done all we could do to prevent injuries, and with your help this experiment should be safe.

Thirty tests are planned for today. Rest periods will be provided so that you may relax and tend to any personal needs. It is important that you stay for all the tests, but if you need to stop, you may leave at any time. If anything happens or you need to leave, tell Mr. Garner, who is in charge of this experiment. Your help will provide information which may save lives in airplane crashes.

Do you have any questions?

We ask that you do not smoke while in the test area. Please check again to make sure that you have removed all sharp objects from your pockets.

Next, you will form a single file line to get a number assigned. Please stay in this order for each test. Always follow the same person who will be in front of you in line. After you get your number, we will take you to the test area and explain your duties.

TABLE B-1. Subject Data
Day 1

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex
200	18	72.0	190	M
201	20	69.0	150	M
202	20	71.0	170	M
203	8	54.0	60	F
204	34	66.5	123	F
205	44	68.0	150	M
206	21	69.0	135	F
207	19	69.5	135	M
208	14	64.0	118	F
209	13	63.0	115	F
210	35	66.0	116	F
211	15	63.0	100	F
212	47	65.0	135	F
213	30	70.0	155	M
214	53	68.0	154	F
215	51	73.0	220	M
216	49	71.0	184	M
217	46	68.0	125	F
218	27	68.0	152	F
219	24	68.0	190	M
222	39	71.0	200	M
223	37	70.0	155	M
226	14	61.0	100	F
227	35	61.0	130	F
228	13	62.0	104	F
229	45	74.0	150	M

TABLE B-2. Subject Data
Day 2

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex
200	25	71.0	171	M
201	24	65.0	102	F
202	22	60.0	93	F
203	21	71.0	135	M
204	10	50.0	80	M
205	42	63.0	118	F
206	44	68.0	165	M
207	41	63.0	145	F
208	15	72.0	200	M
209	31	70.0	130	M
210	19	69.0	160	M
211	27	70.0	185	M
212	18	65.0	112	F
213	20	71.0	155	M
214	15	68.0	135	M
215	56	63.0	145	F
216	36	62.0	140	F
217	16	67.0	130	M
218	39	61.0	140	F
219	15	65.0	125	F
222	22	73.0	160	F
223	11	58.0	86	F
226	14	62.0	118	F
227	12	50.0	64	F

TABLE B-3. Subject Data
Day 3

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex
200	24	72.0	150	M
201	25	72.0	220	M
202	36	69,0	140	M
203	53	61,0	105	F
204	50	72.0	190	M
205	24	72,0	160	M
206	36	69.0	120	M
207	10	60.0	69	M
208	27	67.0	146	F
209	27	60.0	110	F
210	34	69,0	190	M
211	16	71.0	145	F
212	17	70.0	140	F
213	26	64.0	135	F
214	34	70,0	190	M
215	16	66.0	123	M
216	15	62.0	117	F
217	34	69.0	260	M
218	36	62.0	140	F
219	12	57.0	95	M
222	35	64.0	190	F
223	19	74.0	160	M
226	21	69.0	155	M
227	43	64.0	135	F
228	67	69.0	155	M
229	23	71.0	170	M

TABLE B-4. Subject Data
Day 4

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex	
200	24	73.0	170	M	
201	24	73.0	225	M	
202	24	74.0	175	M	
203	58	71.0	170	M	
204	21	66.0	130	F	
205	21	75.0	167	M	
206	22	76.0	180	M	
207	22	70.0	160	M	
208	32	65.0	130	F	
209	43	66.0	158	F	
210	18	69.0	150	M	
211	17	64.0	117	F	
212	17	68.0	150	F	
213	20	74.0	150	M	
214	17	60.0	105	F	
215	17	65.0	137	F	
216	25	68.0	150	M	
217	25	72.0	170	M	
218	24	69.0	150	M	
219	39	65.5	125	F	
222	39	62.5	125	F	
223	41	75.0	235	M	
226	21	64.0	127	F	
227	12	60.0	87	M	
228	13	63.0	105	M	
229	34	63.0	135	F	STANDBY

TABLE B-5. Subject Data
Day 5

Jacket Number	Age (yr)	Height (in)	Weight (in)	Sex
200	21	60.0	118	F
201	18	62.0	105	F
202	21	64.0	119	F
203	36	69.0	120	M
204	27	65.0	165	F
205	24	74.0	175	M
206	24	73.0	225	M
207	13	67.0	120	M
208	43	63.0	125	F
209	34	70.0	180	M
210	19	71.0	185	M
211	21	71.0	165	M
212	25	68.0	135	F
213	24	72.0	165	M
214	37	65.0	130	F
215	38	67.0	140	F
216	32	68.0	135	F
217	35	66.5	130	F
219	24	68.0	123	F
222	24	68.0	123	F
223	23	68.0	135	M
226	53	66.0	200	M
218	22	74.0	150	M

TABLE B-6. Subject Data
Day 6

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex
200	34	70.5	180	M
201	17	69.0	163	M
202	14	65.0	139	F
203	25	69.5	164	M
204	21	68.0	155	M
205	25	69.0	145	M
206	14	68.0	130	M
207	16	63.0	118	F
208	18	62.0	105	F
209	18	68.0	117	F
210	22	77.0	200	M
211	22	67.0	140	M
212	21	72.0	160	M
213	22	72.0	160	M
214	49	66.0	170	F
215	25	66.0	180	M
216	17	71.0	140	F
217	16	71.0	145	F
218	49	69.0	185	M
219	9	52.0	72	M
222	21	69.0	154	M
223	33	64.0	140	F
226	26	70.0	170	M
227	26	64.0	135	F
228	34	63.0	135	F

TABLE B-7. Subject Data
Day 7

Jacket Number	Age (yr)	Height (in)	Weight (lb)	Sex
200	50	70.5	190	M
201	12	58.0	87	M
202	17	71.5	150	F
203	40	67.5	152	F
204	21	70.0	170	M
205	17	70.0	190	M
206	17	68.0	175	M
207	32	65.0	130	F
208	43	68.0	155	M
209	14	65.0	115	F
210	13	63.0	107	M
211	14	65.0	100	F
212	17	71.0	155	M
213	16	66.0	122	F
214	15	65.0	115	F
215	49	69.0	185	M
216	16	69.0	129	F
217	15	63.0	100	F
218	10	48.0	65	F
219	32	62.0	114	F
222	17	72.0	165	M
223	50	65.5	185	F
226	45	72.0	190	M
227	41	75.0	225	M
228	55	73.0	190	M

APPENDIX C

Statistical Ratios

TABLE C-1. Data Comparison
Seconds/Passenger Rate
Trial/Baseline

Test Days 1-4

Attitude	Pitch 0° Roll 0°	Pitch 0° Roll 12°R	Pitch 0° Roll 12°L	Pitch 0° Roll 12°M	Pitch 7° Roll 12°R	Pitch 7° Roll 12°L	Pitch 7° Roll 12°L	Pitch 7° Roll 12°M
Spiral	1.04	1.09	1.38	1.28	1.08	1.10	1.42	1.26
Spiral	1.01	1.06	1.24	1.15	1.06	1.15	1.26	1.20
Straight	1.01	1.10	1.16	1.13	1.15	1.32	1.33	1.33
Straight	1.10	1.18	1.21	1.19	1.16	1.25	1.27	1.26
Passage	1.03	1.20	1.20	1.20	0.97	1.06	1.10	1.08
Passage	1.06	1.20	1.28	1.23	1.11	1.33	1.35	1.34
Spiral	1.03	1.07	1.31	1.19	1.07	1.12	1.34	1.23
Straight	1.05	1.14	1.18	1.16	1.15	1.29	1.30	1.29
Passage	1.05	1.20	1.23	1.22	1.04	1.19	1.22	1.21

L = left
R = right
M = mean (left + right ÷ 2)

TABLE C-2. Data Comparison
Seconds/Passenger Rate
Trial/Baseline

Test Days 1-4

Attitude	Pitch 0° Roll 0°	Pitch 0° Roll 0°	Pitch 0° Roll 12°R	Pitch 0° Roll 12°L	Pitch 0° Roll 12°M	Pitch 0° Roll 0°	Pitch 0° Roll 12°R	Pitch 0° Roll 12°L	Pitch 0° Roll 12°M
Spiral/Straight	1.17	1.21	1.15	1.40	1.27	1.10	0.99	1.24	1.12
Spiral/Passage	1.97	1.97	1.75	2.24	1.99	2.06	1.86	2.24	2.06
Straight/Passage	1.68	1.63	1.53	1.60	1.56	1.87	1.89	1.81	1.85
Spiral/Straight	1.18	1.08	1.08	1.20	1.14	1.08	1.07	1.19	1.13
Spiral/Passage	1.87	1.80	1.63	1.91	1.77	1.91	1.82	1.91	1.87
Straight/Passage	1.58	1.66	1.52	1.59	1.55	1.77	1.71	1.61	1.66
Spiral/Straight	1.18	1.14	1.11	1.30	1.21	1.09	1.02	1.21	1.12
Spiral/Passage	1.92	1.88	1.69	2.07	1.88	1.98	1.84	2.07	1.96
Straight/Passage	1.63	1.65	1.52	1.60	1.56	1.82	1.80	1.71	1.75

L = left
R = right
M = mean (left + right ÷ 2)

TABLE C-3. Data Comparison
Seconds/Passenger Rate
Ratio/Over Baseline

Test 5 (goggles)

Attitude	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0°	1st Pitch 7° Roll 12°L	2nd Pitch 7° Roll 12°R	Total Pitch 7° Roll 12°L
Spiral	1.72	1,39	1.56	2.34	2,08	2.21
Spiral	1.66	1.48	1,57	2,49	1,85	2.17
Straight	1,53	1.41	1.47	2.20	1.88	2.04
Straight	1.49	1,40	1.45	2.29	1,77	2.03
Passage	1.54	1.42	1,48	1,87	1.67	1.77
Passage	1.51	1,37	1.44	2.11	1.81	1.96
Spiral	1.69	1,43	1,56	2,41	1,96	2,19
Straight	1.51	1,40	1,46	2.24	1,83	2,04
Passage	1.52	1,40	1.46	1.98	1.74	1.86

Baseline

Test 5 (without goggles)

Attitude	Baseline Pitch 0° Roll 0°	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0°	1st Pitch 7° Roll 12°L	2nd Pitch 7° Roll 12°L	Total Pitch 7° Roll 12°L
Spiral/Straight	1.18	1,32	1.16	1.25	1.30	1,30	1.27
Spiral/Passage	2.02	2,27	2.01	2.15	2.38	2.40	2.39
Straight/Passage	1.71	1.72	1,72	1,72	1.90	1.85	1.88
Spiral/Straight	1,15	1,27	1.21	1.24	1.25	1.20	1.23
Spiral/Passage	2.01	2.18	2,12	2.15	2.52	2.14	2.34
Straight/Passage	1.75	1,71	1,76	1.73	2,02	1.78	1.91
Spiral/Straight	1,16	1,30	1,19	1.24	1.25	1.25	1.25
Spiral/Passage	2.01	2.23	2.06	2.15	2.45	2.27	2.37
Straight/Passage	1,73	1.71	1.74	1,73	1.96	1.82	1.89

L = left
R = right

TABLE C-4. Data Comparison
Seconds/Passenger Rate
Ratio/Over Baseline

Test 6 (Emergency lighting)

Attitude	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0°	1st Pitch 7° Roll 12°R	2nd Pitch 7° Roll 12°R	Total Pitch 7° Roll 12°R
Spiral	1.08	1.05	1.07	1.55	1.43	1.49
Spiral	0.98	1.02	1.00	1.39	1.37	1.38
Straight	1.11	1.04	1.07	1.36	1.35	1.35
Straight	1.15	1.09	1.12	1.30	1.24	1.27
Passage	1.07	1.11	1.09	1.19	1.18	1.18
Passage	1.14	1.10	1.12	1.41	1.25	1.33
Spiral	1.03	1.04	1.03	1.47	1.40	1.43
Straight	1.13	1.06	1.10	1.33	1.29	1.31
Passage	1.10	1.10	1.10	1.30	1.21	1.25

Baseline

Test 6 (Emergency lighting)
(Industrial Stairs)

Attitude	Normal Light Pitch 0° Roll 0°	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0°	1st Pitch 7° Roll 12°R	2nd Pitch 7° Roll 12°R	Total Pitch 7° Roll 12°R
Spiral/Straight	1.40	1.37	1.42	1.40	1.60	1.48	1.54
Spiral/Passage	2.52	2.47	2.41	2.44	3.01	2.96	2.99
Straight/Passage	1.80	1.80	1.69	1.75	1.88	2.00	1.94
Spiral/Straight	1.40	1.18	1.30	1.24	1.50	1.54	1.52
Spiral/Passage	2.50	2.22	2.31	2.26	2.69	2.82	2.75
Straight/Passage	1.79	1.88	1.77	1.83	1.80	1.83	1.82
Spiral/Straight	1.40	1.27	1.36	1.32	1.55	1.51	1.53
Spiral/Passage	2.51	2.34	2.36	2.35	2.85	2.89	2.87
Straight/Passage	1.80	1.84	1.73	1.79	1.84	1.92	1.88

L = left
R = right

TABLE C-5. Data Comparison
Seconds/Passenger Rate
Ratio/Over Baseline

Test Day 7

Attitude	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0	1st Pitch 7° Roll 12°R	2nd Pitch 7° Roll 12°R	Total Pitch 7° Roll 12°R
Spiral	1.80	1.69	1,74	2,57	2.11	2,34
Spiral	1.68	1.53	1,61	2.97	2.06	2.52
Straight	1,63	1.62	1.62	2.32	2.01	2.16
Straight	1.75	1,75	1.75	2.62	2.00	2.31
Passage	1.60	1.50	1.55	2.10	1.69	1.90
Passage	1.55	1.46	1,51	2.11	2.06	2.08
Spiral	1.74	1,61	1.67	2.77	2.09	2.43
Straight	1,69	1.68	1.69	2.47	2.00	2,24
Passage	1.58	1.48	1.53	2.10	1.86	1.98

Baseline

Test Day 7

Attitude	Normal Light Pitch 0° Roll 0°	1st Pitch 0° Roll 0°	2nd Pitch 0° Roll 0°	Total Pitch 0° Roll 0°	1st Pitch 7° Roll 12°R	2nd Pitch 7° Roll 12°R	Total Pitch 7° Roll 12°R
Spiral/Straight	1.49	1.65	1.56	1.60	1.66	1.58	1.62
Spiral/Passage	2.72	3.09	3.09	3.09	3.33	3.08	3.21
Straight/Passage	1.82	1,87	1.98	1.93	2,00	1.96	1.98
Spiral/Straight	1.47	1.41	1,29	1.35	1.67	1.51	1.60
Spiral/Passage	2.76	2.93	2.85	2.89	3.90	3.05	3.50
Straight/Passage	1,88	2.08	2,21	2.14	2.34	2.02	2.19
Spiral/Straight	1,48	1.52	1.42	1.47	1.66	1.54	1.61
Spiral/Passage	2.74	3.01	2,97	2.99	3.61	3.07	3.36
Straight/Passage	1.85	1,98	2.10	2.04	2.17	1.99	2.08

L = left
R = right

APPENDIX D

Test Day Protocols

TABLE D-1. Day 1: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Pitch Down	Roll
1	Up			0	0
2	Down			0	0
3		Up		0	0
4		Down		0	0
5			Fore	0	0
6			Aft	0	0
7	Up			0	0
8	Down			0	0
9		Up		0	0
10		Down		0	0
11			Fore	0	0
12			Aft	0	0
13	Up			7	0
14	Down			7	0
15		Up		7	0
16		Down		7	0
17			Fore	7	0
18			Aft	7	0
19	Up			0	12R
20	Down			0	12R
21		Up		0	12R
22		Down		0	12R
23			Fore	0	12R
24			Aft	0	12R
25	Up			7	12L
26	Down			7	12L
27		Up		7	12L
28		Down		7	12L
29			Fore	7	12L
30			Aft	7	12L

TABLE D-2. Day 2: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Pitch Down	Roll
1	Up			0	0
2	Down			0	0
3		Up		0	0
4		Down		0	0
5			Fore	0	0
6			Aft	0	0
7	Up			7	12R
8	Down			7	12R
9		Up		7	12R
10		Down		7	12R
11			Fore	7	12R
12			Aft	7	12R
13	Up			0	12L
14	Down			0	12L
15		Up		0	12L
16		Down		0	12L
17			Fore	0	12L
18			Aft	0	12L
19	Up			7	0
20	Down			7	0
21		Up		7	0
22		Down		7	0
23			Fore	7	0
24			Aft	7	0
25	Up			0	0
26	Down			0	0
27		Up		0	0
28		Down		0	0
29			Fore	0	0
30			Aft	0	0

TABLE D-3. Day 3: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Pitch Down	Roll
1	Up			0	0
2	Down			0	0
3		Up		0	0
4		Down		0	0
5			Fore	0	0
6			Aft	0	0
7	Up			0	12L
8	Down			0	12L
9		Up		0	12L
10		Down		0	12L
11			Fore	0	12L
12			Aft	0	12L
13	Up			0	0
14	Down			0	0
15		Up		0	0
16		Down		0	0
17			Fore	0	0
18			Aft	0	0
19	Up			7	12R
20	Down			7	12R
21		Up		7	12R
22		Down		7	12R
23			Fore	7	12R
24			Aft	7	12R
25	Up			7	0
26	Down			7	0
27		Up		7	0
28		Down		7	0
29			Fore	7	0
30			Aft	7	0

TABLE D-4. Day 4: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Pitch Down	Roll
1	Up			0	0
2	Down			0	0
3		Up		0	0
4		Down		0	0
5			Fore	0	0
6			Aft	0	0
7	Up			7	0
8	Down			7	0
9		Up		7	0
10		Down		7	0
11			Fore	7	0
12			Aft	7	0
13	Up			7	12L
14	Down			7	12L
15		Up		7	12L
16		Down		7	12L
17			Fore	7	12L
18			Aft	7	12L
19	Up			0	0
20	Down			0	0
21		Up		0	0
22		Down		0	0
23			Fore	0	0
24			Aft	0	0
25	Up			0	12R
26	Down			0	12R
27		Up		0	12R
28		Down		0	12R
29			Fore	0	12R
30			Aft	0	12R

TABLE D-5. Day 5: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Boeing Stairs

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Attitude Pitch	Attitude Roll	Lighting
1	Up			0	0	NOR*
2	Down			"	"	"
3		Up		"	"	"
4		Down		"	"	"
5			Fore	"	"	"
6			Aft	"	"	"
7	Up			7	12R	EL** GOG***
8	Down			"	"	"
9		Up		"	"	"
10		Down		"	"	"
11			Fore	"	"	"
12			Aft	"	"	"
13	Up			0	0	"
14	Down			"	"	"
15		Up		"	"	"
16		Down		"	"	"
17			Fore	"	"	"
18			Aft	"	"	"
19	Up			"	"	"
20	Down			"	"	"
21		Up		"	"	"
22		Down		"	"	"
23			Fore	"	"	"
24			Aft	"	"	"
25	Up			7	12R	"
26	Down			"	"	"
27		Up		"	"	"
28		Down		"	"	"
29			Fore	"	"	"
30			Aft	"	"	"

*NOR - normal cabin light
**EL - emergency lighting
***GOG - goggles

TABLE D-6. Day 6: Thirty Naive Subjects
(Standard Airline Passenger Mix)
Industrial Stairs

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Attitude Pitch	Attitude Roll	Lighting
1	Up			0	0	NOR*
2	Down			"	"	"
3		Up		"	"	"
4		Down		"	"	"
5			Fore	"	"	"
6			Aft	"	"	"
7	Up			7	12R	EL** GOG***
8	Down			"	"	"
9		Up		"	"	"
10		Down		"	"	"
11			Fore	"	"	"
12			Aft	"	"	"
13	Up			0	0	"
14	Down			"	"	"
15		Up		"	"	"
16		Down		"	"	"
17			Fore	"	"	"
18			Aft	"	"	"
19	Up			"	"	"
20	Down			"	"	"
21		Up		"	"	"
22		Down		"	"	"
23			Fore	"	"	"
24			Aft	"	"	"
25	Up			7	12R	"
26	Down			"	"	"
27		Up		"	"	"
28		Down		"	"	"
29			Fore	"	"	"
30			Aft	"	"	"

*NOR - normal cabin light
**EL - emergency lighting
***GOG - goggles

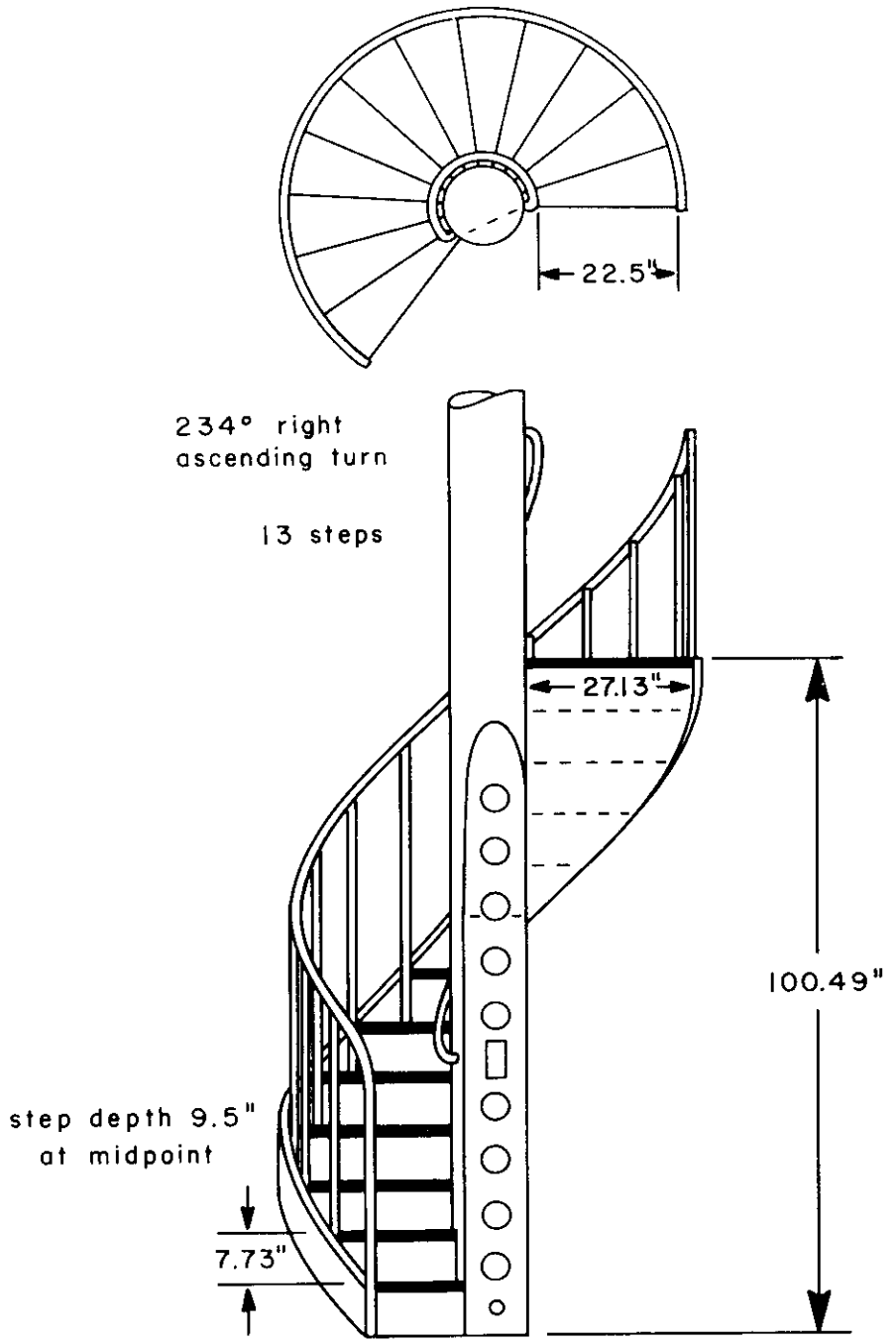
TABLE D-7. Day 7: Thirty Naive Subjects
(Standard Airline Passenger Mix)

Test No.	Spiral Stairs	Straight Stairs	Passage-way	Attitude Pitch	Attitude Roll	Lighting
1	Up			0	0	NOR*
2	Down			"	"	"
3		Up		"	"	"
4		Down		"	"	"
5			Fore	"	"	"
6			Aft	"	"	"
7	Up			7	12R	EL**
8	Down			"	"	"
9		Up		"	"	"
10		Down		"	"	"
11			Fore	"	"	"
12			Aft	"	"	"
13	Up			0	0	"
14	Down			"	"	"
15		Up		"	"	"
16		Down		"	"	"
17			Fore	"	"	"
18			Aft	"	"	"
19	Up			"	"	"
20	Down			"	"	"
21		Up		"	"	"
22		Down		"	"	"
23			Fore	"	"	"
24			Aft	"	"	"
25	Up			7	12R	"
26	Down			"	"	"
27		Up		"	"	"
28		Down		"	"	"
29			Fore	"	"	"
30			Aft	"	"	"

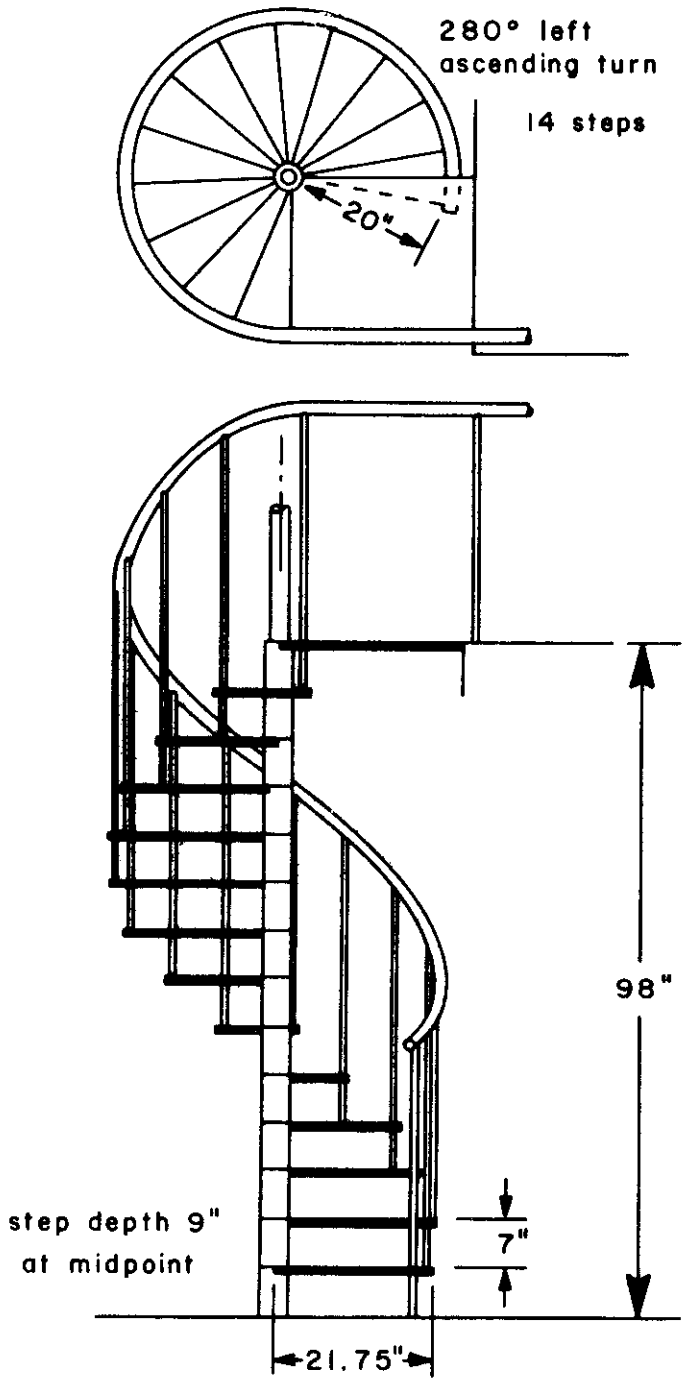
*NOR - normal cabin light
**EL - emergency lighting

APPENDIX E

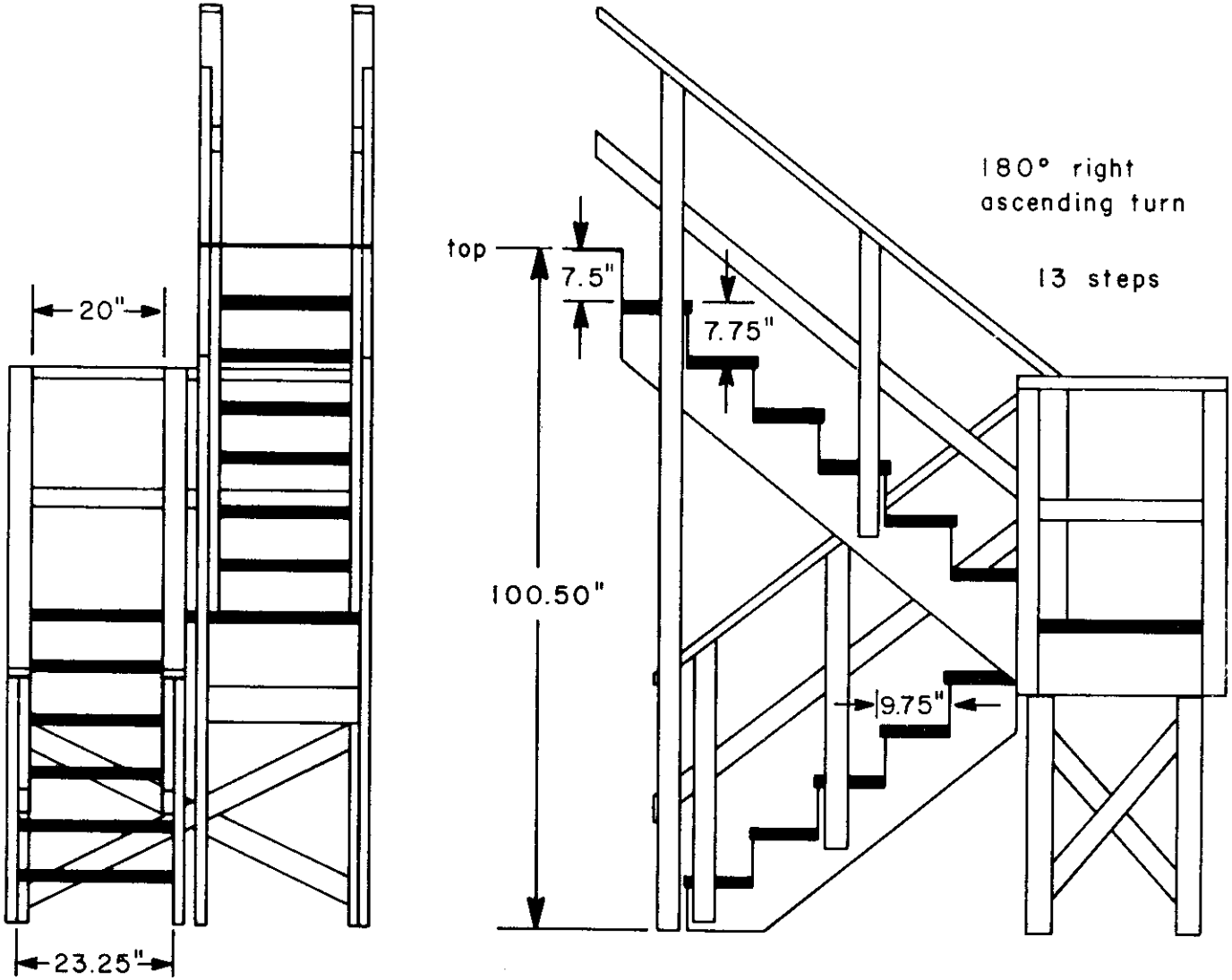
Drawings of Equipment



(A) SPIRAL STAIRWAY
similar to aircraft stairs, carpeted,
234° right ascending turn.

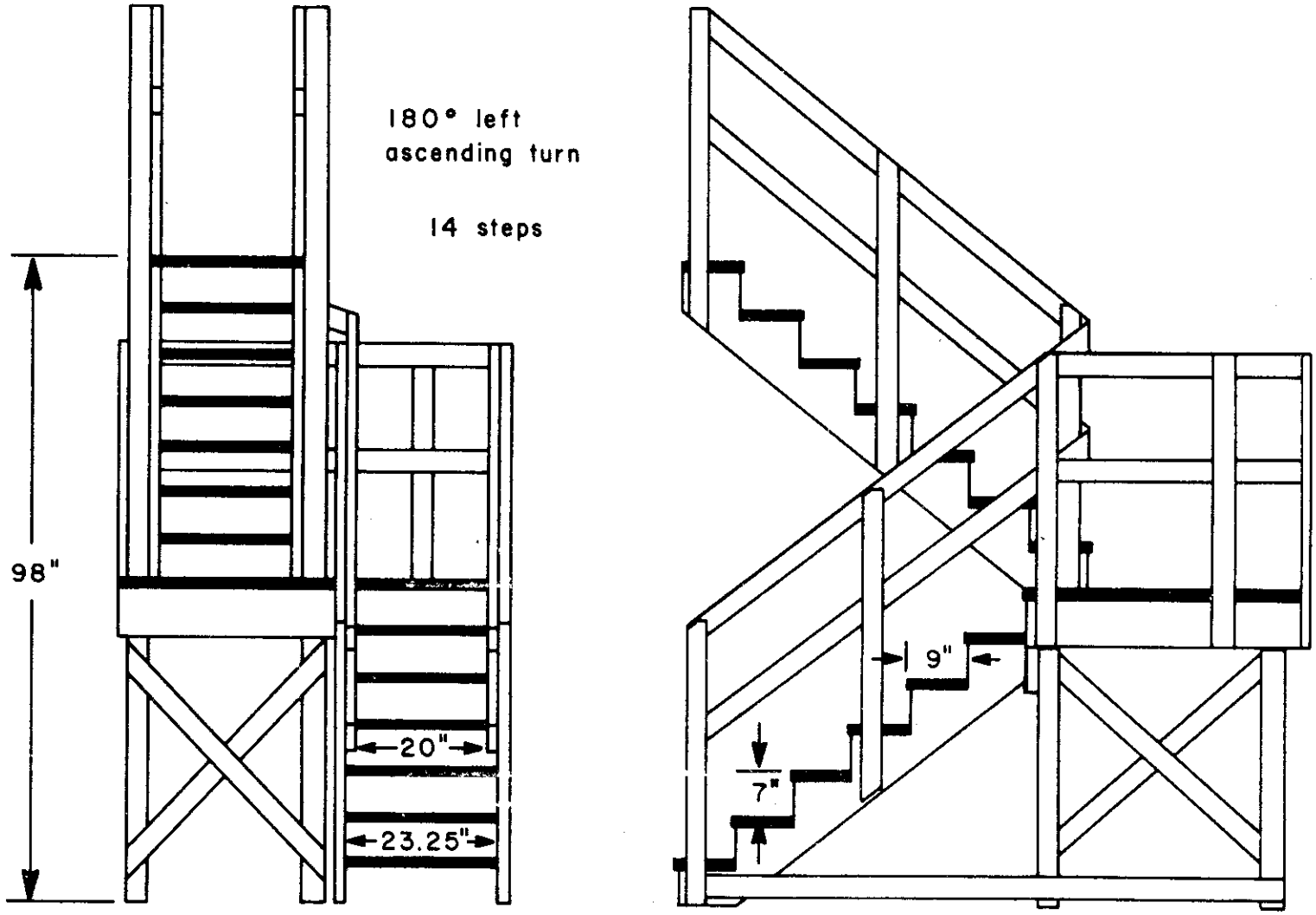


(B) SPIRAL STAIRWAY
similar to industrial stairs, carpeted, 280° left ascending turn.



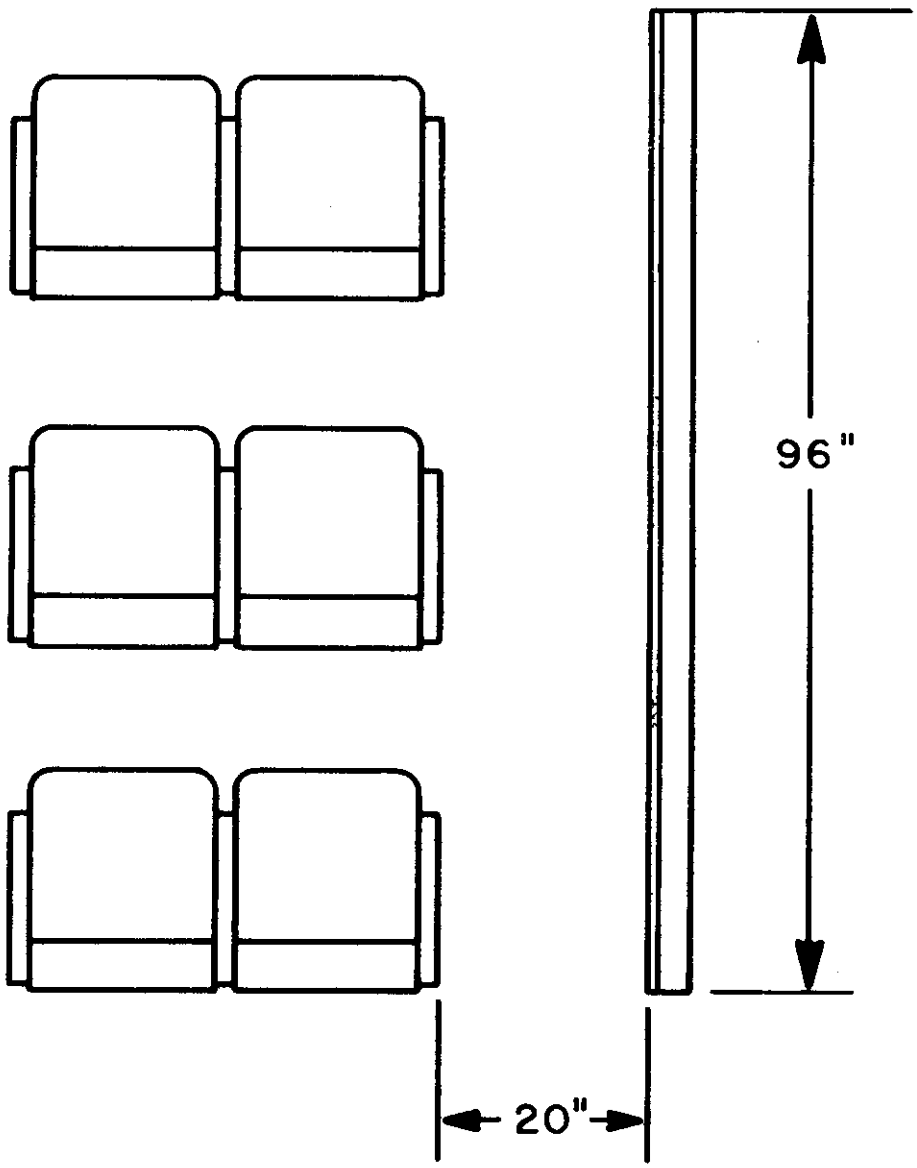
© STRAIGHT STAIRWAY

2 segments of 6 steps each (plus 1 step, 7.5 inches to top), carpeted, 180° right ascending turn.



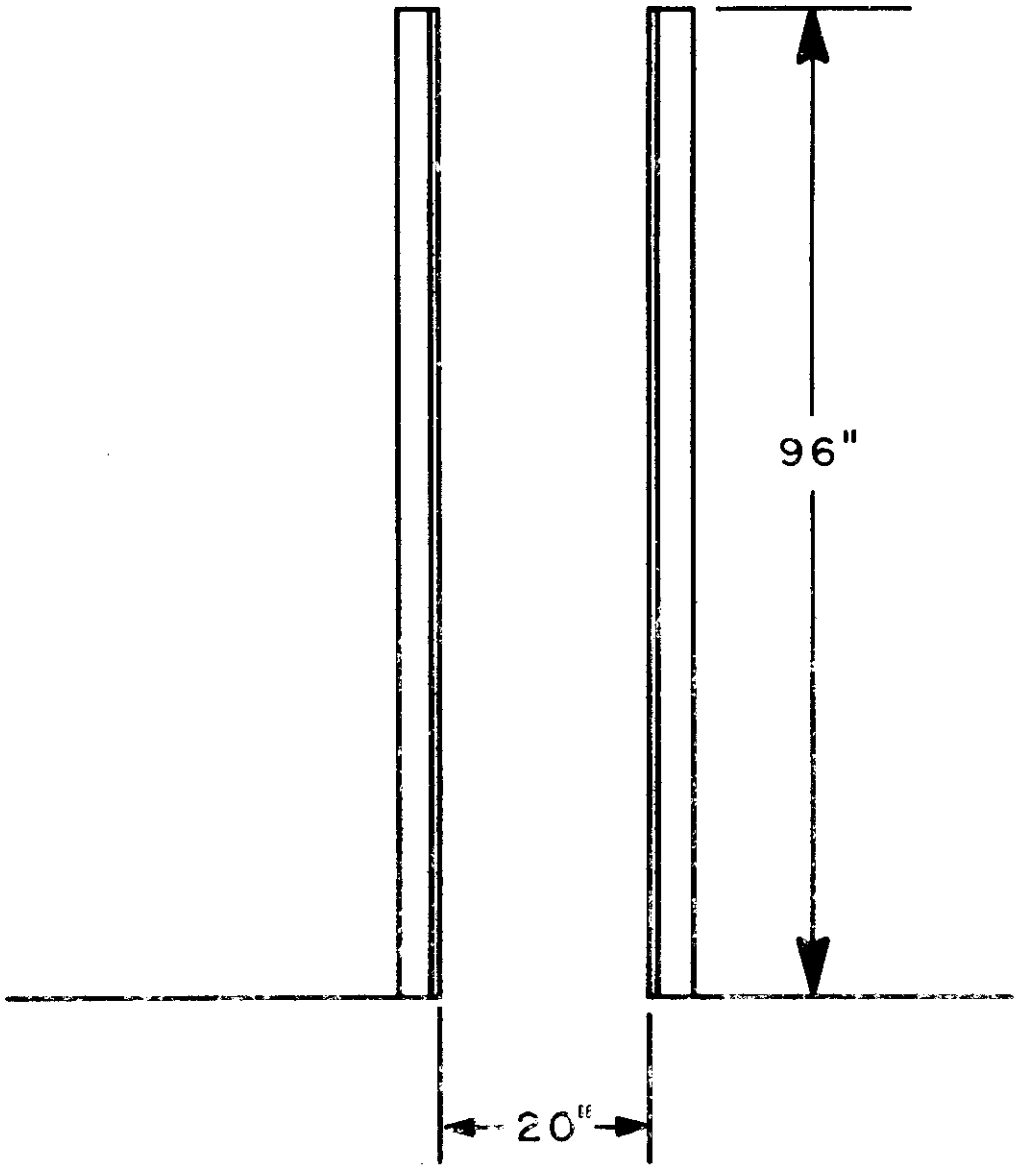
Ⓓ STRAIGHT STAIRWAY

2 segments of 7 steps each, carpeted, 180° left ascending turn.



(E) PASSAGEWAY

96 inches long, 20 inches wide, aircraft seats on the left, paneled on one side.



(F) PASSAGEWAY

96 inches long, 20 inches wide, paneled on both sides.

*U.S.GPO:1992-661-063/40073