# RESEARCH ACCOMPLISHMENTS

in

# BIODYNAMICS
# Deceleration & Impact

at the

## AIR FORCE MISSILE DEVELOPMENT CENTER

Holloman Air Force Base, New Mexico

# 1955-1958

Historical Division
Office of Information Services
Air Force Missile Development Center
Air Research and Development Command
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# FOREWORD

Scientists and technicians of the Aeromedical Field Laboratory at the Air Force Missile Development Center have made important contributions in many fields of biodynamics research. In addition to their achievements related to escape physiology, such as establishing the limits of human toleration to the windblast and deceleration forces experienced in emergency escape from high-performance aircraft, they have probed deeply into a variety of other biodynamics problems. Some of these concern aircraft and automotive crash forces, the stresses to be encountered in the atmospheric re-entry of manned space vehicles and satellites, and pure unapplied research in biodynamics designed to advance the sum of knowledge related to human reaction to various physical forces.

In the monograph here presented, Dr. David Bushnell, of the Air Force Missile Development Center's Historical Office, presents a carefully documented account of the successes and failures encountered in biodynamics research programs other than escape physiology. He has endeavored to place these accomplishments within the larger context of such work

undertaken elsewhere by the United States Air Force, the United States Navy, industrial corporations and academic institutions of the United States, plus some consideration of related efforts in Canada, Germany, and the Soviet Union.

This is the sixth of the series of monographs published this year devoted to aspects of the history of research in space biology and biodynamics in the Aeromedical Field Laboratory. Other titles of this series are The Beginnings of Research in Space Biology at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1946 - 1952; Major Achievements in Space Biology at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1953 - 1957; History of Research in Subgravity and Zero-g at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1948 - 1958; Major Achievements in Biodynamics: Escape Physiology, at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1953 - 1958; and Administrative History of the Aeromedical Field Laboratory at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1951 - 1958.

Without the cooperation of individuals from many agencies, this work would have been less complete and subject to greater probability of error in interpretation. Dr. Bushnell gratefully acknowledges the receipt of considerable material and other assistance from members of the Aero Medical Laboratory, Wright

Air Development Center; the Directorate of Life Sciences at Headquarters, Air Research and Development Command; and the Aviation Medical Acceleration Laboratory, Naval Air Development Center. The greatest of these contributions, of course, came from the staff of the Aeromedical Field Laboratory, Air Force Missile Development Center, which made available to Dr. Bushnell the entire files of the laboratory. Any error of fact or interpretation, unless otherwise cited, remains the responsibility of the Historical Office.

James Stephen Hanrahan
Chief, Historical Office
October 1958

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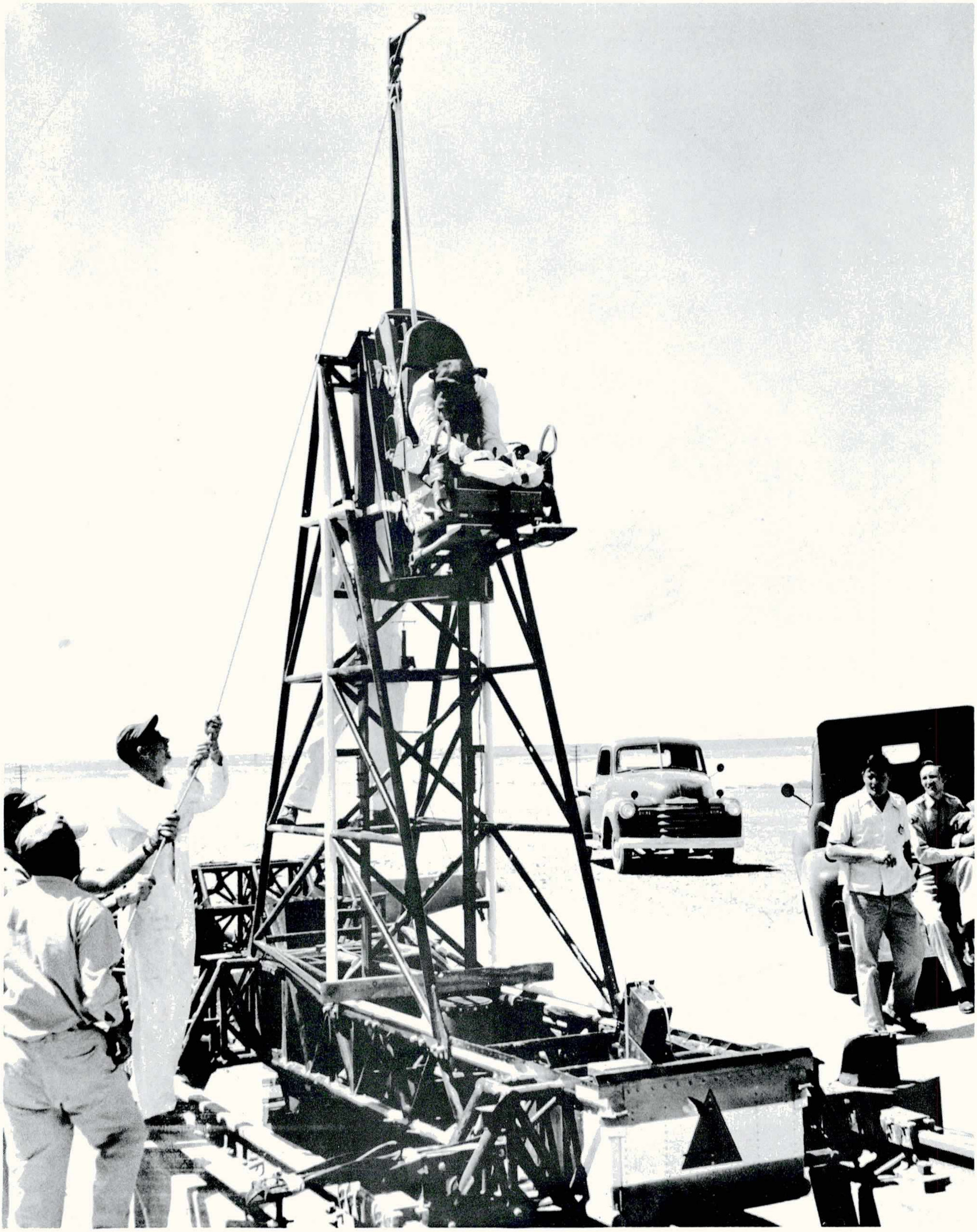


Drop-Seat Used in Aircraft Crash Experiments on the High-Speed Track

# BIODYNAMICS: DECELERATION AND IMPACT

## 1955 - 1958

In addition to major contributions in such space biology research fields as the hazards of cosmic radiation and the effects of subgravity and zero-g, the Aeromedical Field Laboratory of the Air Force Missile Development Center has made significant progress in biodynamics research. It was in 1953 that research in biodynamics began at the Holloman installation. As discussed in a previous monograph,[1] the initial primary concern in this area of endeavor was with the problem of escape from high-performance aircraft.

The memorable rocket-sled rides of Lieutenant Colonel (Doctor and later Colonel) John Paul Stapp were to provide data on human tolerance to windblast and deceleration encountered in escape situations. Research on the escape problem, however, has been only one aspect of the Laboratory's complex biodynamics program, and the famous high-speed track only one of the research and test facilities at Holloman Air Force Base that are used for this experimentation.

Tests conducted on the high-speed track, in addition to making available information related to escape, have provided pure research data on deceleration, and have also thrown light on such problems as aircraft crash forces and atmospheric re-entry.

Furthermore, the Aeromedical Field Laboratory staff has developed certain specialized test instruments, ranging from a mere swing seat to the highly-instrumented 120-foot Daisy Track, for the study of a wide array of impact forces.

The biodynamics research program of the Aeromedical Field Laboratory has been conducted primarily under the auspices of Project 7850, which was established in 1954-1955 with the title Biodynamics of Human Factors in Aviation. However, aviation was never stressed to the exclusion of other problems. Even automotive crash research was conducted as a separate task of Project 7850, while other project activities were oriented toward problems of manned space flight. Indeed, with the post-Sputnik revolution in Air Force research activity, scientists of the Aeromedical Field Laboratory at last became free to emphasize space work to their hearts' content. It has now become the primary--though still not exclusive--interest of Project 7850, which in March 1958 was revised and renamed Biodynamics of Space Flight.[2]

From the standpoint of administrative organization, Project 7850 was originally entrusted to the Aeromedical Field Laboratory's Biodynamics Branch. When the laboratory received an important new mission in biosatellite work in mid-1958, the Biodynamics Branch went into a state of suspended animation, losing its chief, Captain (Doctor) John D. Mosely, and all its personnel to a new

Satellite Operations Branch. The new branch also received responsibility for Project 7850, but with the understanding that it would receive low priority until people and resources were made available. Thus the biodynamics program, at least in the form known up to now, is also on semi-active status. But there is no intention of abandoning it outright. The program has already produced data that will be of value for a great many purposes, including biosatellite operations; and one other Air Force agency, the Aero Medical Laboratory at Wright Field, has promised to channel an ever growing amount of biodynamics work to the Holloman unit, especially in the testing of escape systems and personal equipment.[3]

## Aircraft Crash Forces

One of the less exotic aspects of the biodynamics program--one which has received only a modest amount of research effort but which has yielded certain interesting results--has been that related to crash forces experienced in aircraft accidents. The study of aircraft crash forces has obviously much in common with the study of escape from aircraft. Moreover, the first aero-medical sled runs on the Holloman high-speed track to deal expressly with a topic other than escape from aircraft were concerned with aircraft crash forces. These runs began on 21 April 1955 and lasted through 28 June, overlapping slightly with the earliest of the high-speed windblast runs by the sled Sonic Wind

Number 2.[4] Specifically, they aimed to reproduce the combined vertical and horizontal crash forces encountered in certain types of forced landings, basing the test configurations on actual crash data compiled by the National Advisory Committee for Aeronautics. As stated in one test report,[5]

> Pilots of high angle of attack jet aircraft, such as the Delta Wing F-102, have incurred back fractures caused by forced landings in which the tail was dragging the ground at near stalling speed with the pilot seated in the nose 55 feet beyond the end of the tail, and 18 to 25 feet above the ground. When tail structures catch on ground obstructions, the nose of the aircraft can be slammed to the ground viciously with forces estimated at better than 60 gs. For the protection of pilots, it is necessary to evaluate the combined effect of the two components by reproducing them on the deceleration sled.

In these tests an F-102 seat was rigged to drop vertically seventy inches and decelerate by impinging on a metal cylinder, while at the same time the entire apparatus, attached to a rocket sled, was being decelerated horizontally by water brakes on the high-speed track. In the first full-scale experiment of 21 April--which followed a series of static tests--an anthropomorphic dummy was used, sustaining peaks of roughly fifty g's vertical and twenty-five g's horizontal deceleration. Subsequently, anesthetized chimpanzees took part in the experiments. With varying types of protection and no irreversible injury they received forces ranging up to sixty g's vertical in combination with twenty g's horizontal deceleration. Taken

as a whole, the experiments supplied valuable data both on crash forces as such and on the value of different crash restraints and energy-absorbing seat cushions. For example, they demonstrated how the impact of vertical g-forces could be reduced by means of up-lifting chest and shoulder straps.[6]

Aircraft crash forces have also been studied on the crash-restraint demonstrator, informally referred to as Bopper, which is one of the specialized test facilities established at Holloman solely or primarily for the work of the Aeromedical Field Laboratory. The original version of the Bopper was acquired from Northrop Aircraft, Incorporated in March 1955 and was replaced by an improved model a year later. It is a seat propelled by elastic shock cord along a short, portable stretch of track; it can impart g-forces of short duration, with magnitude (on the new model) up to about thirty g's.

The Bopper was used in a special study of subject responses to low-impact aircraft crash forces. Participants in this test series experienced deceleration on the Bopper ranging up to 12 g's in both aft- and forward-facing positions, secured with seat belt only. Immediately after exposure, each subject released the seat belt manually and proceeded along an aisle to a simulated emergency exit. Subjects were carefully observed to see how quickly and efficiently they were able to release the belt and reach the exit--something that must be executed without delay

whenever there is danger of flash fires breaking out or in the event of a water landing. The results indicated that responses were slightly better after deceleration in the backward-seated position, thus supporting a point of view that Colonel Stapp and many other aeromedical officers had often urged upon the aviation industry, without much success.[7]

Although a technical note published on these Bopper tests related them expressly to an aircraft crash problem, any data on g-tolerances with seat-belt restraint was also of interest for automotive crash research. The officer who directed these tests (together with Colonel Stapp, who was chief of the entire laboratory from April 1953 to April 1958) was Lieutenant Sidney T. Lewis, whose primary assignment was task scientist for Automotive Crash Forces (Task 78507 of Project 7850). Naturally much of the work performed under the automotive crash program was applicable in turn to aircraft crash studies. Similarly, tests have been performed on the Daisy Track, whose main purpose is basic research on impact forces, in order to evaluate particular types of aircraft crash harness. Both the automotive crash program and the operation of the Daisy Track will be discussed below in greater detail.

However, at no time since the F-102 drop-seat experiments has aircraft crash research, as such, been one of the major activities of the Aeromedical Field Laboratory. When Project 7850, Biodynamics of Human Factors in Aviation, was established,

Captain John A. Recht Seated on "Bopper"

it contained a separate Task 78506, entitled Tolerance to Aircraft Crash Forces; and there was even talk of staging barrier crashes with jet aircraft on the Holloman high-speed track. But no such experiments were held, nor did the aircraft crash program ever have a full-time task scientist. In March 1958, finally, when Project 7850 was revised to become Biodynamics of Space Flight, Task 78506 was changed from Aircraft Crash Forces to Patterns of Deceleration in Space Flight. The new version of this task will also be discussed more fully below. Even now, aircraft crash study will not necessarily be excluded altogether from the work of Project 7850. Project documentation indicated that research would be conducted on "dynamic stress characteristics of the human body" as a factor in "design and specifications" for both aircraft and space vehicles; and the project is still interested in "impacts," which in turn include crash forces.[8]

## Later Deceleration Studies on the High-Speed Track

A separate monograph described how research at Holloman on escape from aircraft (as distinct from aircraft crash forces) led to high-speed track studies of windblast and deceleration that reached an early climax in Colonel Stapp's sled ride of 10 December 1954. That experiment was followed by further research studies with chimpanzee subjects on the high-speed track, but later experiments followed two increasingly divergent paths, one

concerned with windblast per se (as described in the previous study) and one with high-g, horizontal deceleration. The tests designed expressly for deceleration finally attained such high g-forces that windblast effects, if any, were wholly overshadowed. There also came a point, impossible to specify exactly, where g-forces produced were so much greater than even the momentary peaks likely to occur in an escape situation that such tests were no longer directly relevant to the aircraft escape problem. The fact that the tests went right ahead reflects a continuing interest in basic research data on deceleration, whether or not an immediate practical application was apparent.[9]

Colonel Stapp on 10 December 1954 experienced a g-plateau of twenty-five g's and peak force of forty g's. By November 1955, chimpanzees were being exposed to as much as eighty g's programmed deceleration at 4860 g's per second rate of onset. A final series of fifteen high-g experiments was held from October 1956 through March 1957, just after the track itself had been extended from 3550 to 5000 feet. Greater velocities and substantially higher g-forces now became possible even with the relatively heavy deceleration sled Sonic Wind Number 1. Programmed deceleration in this test series ranged up to 120 g's, but peak forces went considerably higher. A force of 247 g's was produced on one subject for a millisecond on 2 February 1957. Rate of onset for that same test was 16,800 g's per

second, which was also a record; and total duration of the decelerative phase was 0.34 second.

The effect on chimpanzee subjects naturally varied with the number of g's, duration, and also body position. The run of 2 February 1957 that attained a peak of 247 g's caused only "moderate" injuries to the test subject, but this happened to be the one run in the series in which the chimpanzee was seated facing backward. A run of 12 January 1957, with the subject facing forward, proved fatal even though the peak force was only 233 g's for one millisecond (total duration .35 second) and rate of onset slightly over 11,000 g's per second. One other fatality occurred at considerably lower deceleration, but in this case the subject's death was apparently due in large part to an ailment unrelated to g-forces. Speaking of the entire series of high-g runs on the 5000-foot track, Colonel Stapp later observed that "significant" injuries began in the neighborhood of 135 g's--with extremely short exposure, and with the subject enjoying the benefit of "maximum restraint." He also hypothesized that in the two standard seated positions, backward- and forward-facing, chimpanzee tolerance to transverse g was roughly comparable to that of human beings; but this is a subject of some controversy, and admittedly, when it came to probing the range of severe to lethal injury, no human test subject would attempt to verify the assumption.[10]

The later deceleration experiments were undertaken essentially as a form of basic physiological research, but the test results have been cited--by Colonel Stapp among others[11]--in connection with such problems of space flight as takeoff and re-entry of manned space vehicles. To be sure, rocket acceleration at takeoff will involve moderately high g-loads, which are generally regarded as tolerable on the basis of centrifuge tests and actual rocket experiments with animal subjects. Total durations would be longer than in the high-speed track deceleration tests, but it is predicted that peak g-forces will be on the order of eight to twelve g's.[12]

In the case of re-entry, a vehicle coming back from extreme altitude or outer space must encounter high decelerative forces as it comes in contact with denser layers of air. Such deceleration poses a complex problem for potential travelers, whether human space crews or animal test subjects, and two basic solutions have been suggested: to come straight down, experiencing high g-forces but holding them to short duration, or to follow a gradually descending path, with moderate g-forces but long duration. Other possible solutions lie in between. In any case, scientists concerned with the re-entry problem wanted a mass of data on tolerance to deceleration, including data on the forces that would be required to produce serious biological injury; and the tests on the Holloman high-speed track helped supply the

information needed.

No one expects that re-entry configurations will call for exposure to forces even approaching the extreme decelerations applied in some of the Holloman tests. On the other hand, re-entry patterns are more problematical than the accelerations anticipated in manned space travel. A year and a half ago, before the various Soviet and United States satellites contributed new knowledge on the density of the upper atmosphere, re-entry patterns were even more problematical than they are now. In reaching conclusions about human tolerance from chimpanzee test results, moreover, it is desirable to have a wide margin for possible error. At the very least, whether for re-entry or for other operational problems, it is comforting to know that fellow primates have experienced forces above one hundred g's with only minor injury, and in one case actually lived through a deceleration of almost 250 g's.

## Other Research Related to G-Forces Anticipated in Space Flight

Track-testing could not, of course, provide all the data needed to study the g-patterns of future space flight. It could produce extremely high g-forces but was limited to short durations. For more prolonged exposures it is necessary to turn to centrifuge testing, and especially to the human centrifuges located at the

Aero Medical Laboratory of Wright Air Development Center and at the Aviation Medical Acceleration Laboratory of the Naval Air Development Center, Johnsville, Pennsylvania. The Johnsville centrifuge, in particular, was used for one series of tests oriented toward the re-entry problem in which Holloman's Aeromedical Field Laboratory also participated.

During the winter and spring of 1956-1957 the Human Factors Division (later Directorate of Life Sciences) of Headquarters, Air Research and Development Command arranged this test series as an interservice research effort in which the Aeromedical Field Laboratory supplied chimpanzees, the Navy's Johnsville centrifuge spun them at high g, and the Armed Forces Institute of Pathology performed autopsy services. Colonel Stapp helped coordinate all these efforts, and Captain John D. Mosely, who headed the Aeromedical Field Laboratory's Biodynamics Branch, assisted the Navy at Johnsville in the actual centrifuge runs.

Several different tests were made, subjecting chimpanzees to as much as forty g's applied transversely for sixty seconds. The test configurations were dictated primarily by re-entry planners who allowed a wide margin for possible differences between chimpanzee and human tolerances. All five chimpanzees used survived the centrifugation, but electrocardiograph abnormalities were recorded during the tests, and internal injuries were found when the animals were sacrificed afterward. The one animal that took

forty g's for sixty seconds in a completely supine position was apparently little harmed by the experiment; the same could not be said of the other four, which were tested in partially prone or partially supine position and suffered more severe damage. Just what this proved for re-entry was not wholly clear, in view of the uncertain correlation between chimpanzee and human tolerances. However, the test results did confirm the dangers involved in exposure to prolonged high g.[13]

The Aeromedical Field Laboratory proposes to conduct further experiments of its own on the g-forces anticipated in manned space travel as a part of Task 78506 (of Project 7850), Patterns of Deceleration in Space Flight. As already mentioned, this task was established in place of the former Task 78506, Tolerance to Aircraft Crash Forces, at the same time that Project 7850 was re-written as Biodynamics of Space Flight. Task scientist since the beginning has been Lieutenant Albert Zaborowski, although he has never been able to devote all his time to this one activity.

Despite the formal title Patterns of Deceleration in Space Flight, the task program is concerned with acceleration as well as deceleration problems. Principally, it aims to simulate the following conditions of space flight with both animal and human subjects:[14]

1. The "notched" decelerations encountered during multistage rocket takeoff, with varying periods of coasting between the three thrust stages.

2. The forces encountered during maneuvering of the space vehicle at extremely high velocities using reverse or unbalanced rocket thrust.

3. The forces encountered on impact during landings on other planets.

4. The forces encountered during re-entry into the atmosphere.

The Holloman complex of test facilities offers many possibilities for experimentation along these lines. The recent extension of the high-speed track to 35,000 feet naturally increases the range of possible test performance with that instrument. Task 78506 may also use the short Daisy Track for some purposes, and has already used the Bopper or crash-restraint demonstrator for deceleration experiments in which the "test subjects" were blocks of wood immersed in sugar solution.[15]

As indicated by this last type of experimentation, the Aeromedical Field Laboratory is one of the various research agencies currently interested in the use of fluids for g-protection. Journalists and information officers have taken delight in tracing the theoretical principles involved in this all the way back to ancient Greece, and in giving credit to Archimedes as the spiritual father of underwater g-protection.[16] The starting point for modern research in this field appears to be a German effort in the 1930's to develop water-lined anti-g suits. Even better known are Canadian tests during World War II in which the subject was spun on a centrifuge with most of his

body under water. The Canadians were looking for ways to improve their aircraft anti-g suits, and they decided at the time (as the Germans had earlier) that water protection was not wholly practical for this purpose.[17]

Since 1957, the United States Navy's Aviation Medical Acceleration Laboratory and the Aero Medical Laboratory at Wright Field have again been conducting centrifuge tests on the water-immersion principle. So far the Navy holds the record as to maximum g-forces sustained with the aid of water immersion: four seconds above fifteen g's, with a peak of sixteen. This is part of one simulated re-entry pattern, and indications are that "considerably" higher tolerance levels can be attained in future experiments. But only the Wright Field scientists, whose present equipment sets a limit of about twelve g's for this type of testing, have immersed the subject's head as well as the rest of his body in water. Tolerance has been established at twelve g's for almost four minutes.[18]

From human experiments it is a far cry to Lieutenant Zaborowski's wooden blocks. Obviously, his Bopper tests were only to explore test procedures, including the effects of using different solutions. Later tests will be made with fish, frogs, and small mammals; in fact another activity in which Lieutenant Zaborowski has been engaged is the design and fabrication of a special mouse diving suit. The culmination of this one type of research will be tests on the

35,000-foot track with chimpanzee or human subjects submerged in a special water tank that is already on order. It should not be thought, however, that Task 78506 is exclusively concerned with the possible uses of fluids in manned space flight. It merely happens that the first actual experimentation was directly related to this procedure. In the end, a wide range of g-patterns will be tested both with and without this and other protective devices.[19]

Although research on acceleration and deceleration patterns of space flight was primarily a responsibility of the Biodynamics Branch, at least until the recent reorganization of the Aeromedical Field Laboratory, staff members of the Space Biology Branch--which has been abolished outright--made some contribution to these studies. The Space Biology Branch, headed by Lieutenant Colonel (Doctor) David G. Simons, had charge of Project 7851, Human Factors of Space Flight, which took in both subgravity research and the various cosmic radiation and cabin environment studies that gave rise to the Man-High balloon flights. However, Project 7851 also contained a separate Task 78502, entitled Descent and Recovery (Re-entry).

When first established in 1954, this task was regarded as a natural outgrowth and continuation of work done earlier in devising techniques for the recovery of animal capsules carried to the upper limits of the atmosphere in research rockets. Simons personally had been concerned with "descent and recovery" of the

first two biological V-2 experiments in 1948-1949, when, as an officer of the Aero Medical Laboratory at Wright Field, he helped launch these flights from White Sands Proving Ground, New Mexico. Some of his experience in recovery of balloon-borne animal experiments for cosmic ray research was likewise valuable for the task program. As it developed, however, the task also looked ahead from recovery of animal experiments toward an examination of deceleration, thermal effects, and related problems posed by re-entry of manned vehicles into the earth's atmosphere.[20]

For lack of sufficient people and resources, Descent and Recovery (Re-entry) as a separate task was never fully activated. One of several part-time task scientists who worked on the program at different periods was Mr. Reinhard Krause, an aeronautical engineer whose primary assignment was to another unit of the Air Force Missile Development Center's Directorate of Research and Development (now Directorate of Advanced Technology). Krause did not attempt to conduct a test program but contributed some theoretical calculations concerning velocities and decelerative force in possible re-entry trajectories. (Subsequently he published a technical report, co-authored with W. F. Haldeman, entitled Vertical Descent Trajectories Including Re-Entry into the Atmosphere.) The most recent task scientist was Captain Druey P. Parks, who also served as administrative officer of the Space Biology Branch, but he inherited this role at a time when he was

chiefly engrossed in preparations for the Man-High program of high-altitude balloon flights and thus unable to devote much attention to Task 78502.[21]

Part of the effort spent on Man-High was at least related to Task 78502. Various scientific experiments were planned in connection with the Man-High flights in order to accumulate data on physical conditions of the upper atmosphere. These naturally had some bearing, directly or indirectly, on such problems as re-entry, one example being the attempt (which proved unsuccessful) to measure gravity at high altitude with a balloon-borne gravity meter.[22] Then, in the lull that followed Simons' record ascent of 19-20 August 1957, Captain Parks was able to devote his main efforts at least briefly to the work of Task 78502. He began modestly, proposing to drop anthropomorphic dummies from high-altitude balloons in an open escape device, either the experimental Convair "B" ejection seat with rounded bottom and stabilizing booms or the intermediate Weber F-106 seat. After a number of balloon bursts and weather difficulties, the first wholly successful test took place on 29 January 1958, when the Convair seat was dropped from 85,000 feet and accelerated by free fall in 37.12 seconds to a maximum speed of .98 mach, at which point it began to slow down from air resistance. G-forces, oscillations, and other free-fall characteristics were studied in this carefully-instrumented introductory experiment.

According to project plans, tests were to be staged later on with high-velocity rocket test vehicles, in order to simulate and study different re-entry curves.[23]

These later tests have not and will not be conducted, since shortly after the 29 January experiment the task itself was formally eliminated from the Aeromedical Field Laboratory program. This move was taken chiefly on grounds of duplication of research at Wright Air Development Center, which had primary responsibility for re-entry work in the United States Air Force.[24] The Holloman laboratory will nevertheless continue to contribute pertinent data on re-entry decelerations through its over-all program in biodynamics.

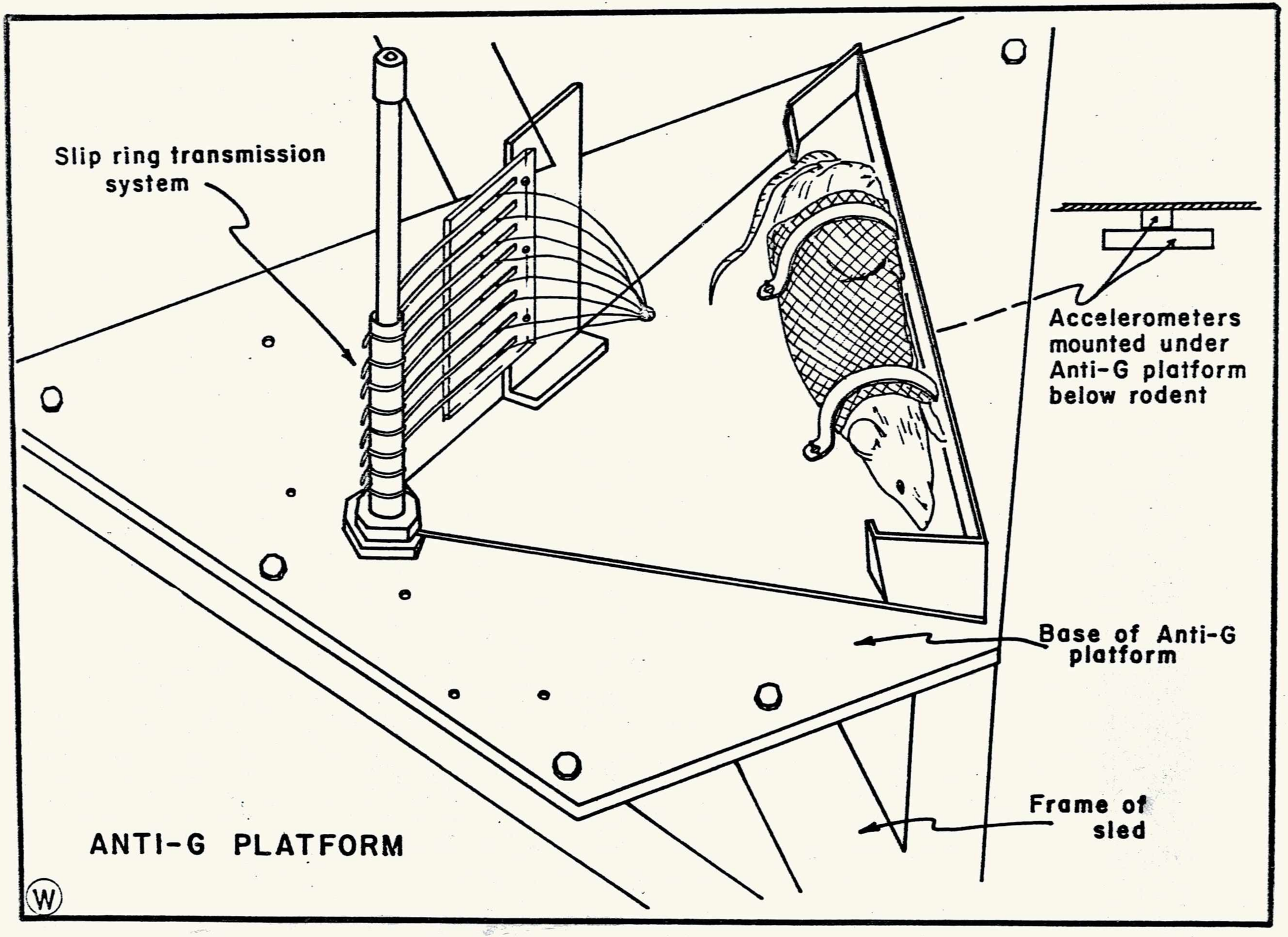
Another scientist who was assigned until recently to the Space Biology Branch, Dr. Harald J. von Beckh, has been working intermittently on a device of his own for protection against g-forces. Von Beckh came to Holloman as task scientist for subgravity studies, and within the general field of subgravity research he was especially interested in the effect of weightlessness immediately preceded or followed by relatively high g-forces, as in rocket takeoff and re-entry. His experimentation along these lines has been discussed in another monograph of this series.[25] At the same time, however, he has conceived an "anti-g capsule" which would give protection not by water immersion but by automatically positioning the body at all times

to receive g-forces transversely, in which case human tolerance levels are invariably highest. Dr. von Beckh has proposed that this system be used in developing a capsule for escape from aircraft, but it is also applicable for use in space vehicles.[26]

Von Beckh has already tested the basic features of his idea in animal experiments at Holloman. In the early part of 1958 he exposed mice to high g-forces on two small materiel centrifuges and established that their tolerance was substantially increased by attaching them to a swinging anti-g platform of his own making. Accelerative stress in a direction longitudinal to the body was negligible, since the platform automatically positioned the mice to receive their g's transversely. Though dizzy from spinning at the end of the run, the mice survived exposure to 400 g's for almost fifteen seconds. This surpassed the previous centrifuge record for mice of 320 g's, sustained for an even shorter period.[27]

A slightly different form of Dr. von Beckh's device has produced similar results (though at much lower g-levels) with rats on the short Daisy Track,[28] which is discussed in the following section of this monograph. Still another variation has even been used operationally, in rocket experiments with animal subjects. This was a purpose for which Von Beckh predicted that his device would prove extremely helpful, since[29]

> ...during the re-entry phase, during ejection from the nose cone and especially during uncontrolled parts of the trajectory, which might be caused by imperfections


Slip ring transmission system
Accelerometers mounted under Anti-G platform below rodent
Base of Anti-G platform
Frame of sled
ANTI-G PLATFORM
W

> of the automatic guidance system, the subject would be exposed to severe accelerations with continuously varying direction, intensity, and rate of onset.

Accordingly, Dr. von Beckh's principle was frankly copied in the experiment that sent three ill-fated mice aloft in three Thor-Able missiles from the Air Force Missile Test Center, Florida, in the course of 1958. Two of Von Beckh's Holloman colleagues, Captain (Doctor) Grover J. D. Schock and Technical Sergeant Edward C. Dittmer, were even present at the Ramo-Wooldridge Corporation in Los Angeles, helping project scientists to incorporate the anti-g device as well as giving advice on environmental control problems for the Thor-Able mouse compartment.[30] Alas, all the mice were lost at sea, so that there is no way of knowing how well the anti-g device functioned in this case.

## Tolerance to Impact Forces (Task 78503): Research on the Daisy Track and Related Test Facilities

Probably the most active of all the formal subdivisions of Project 7850 has been Task 78503, Tolerance to Impact Forces. Other tasks of the same project are concerned with impact forces, but usually with application to a particular set of operational problems. Task 78503, by contrast, seeks to compile basic research data on as broad as possible a range of short-duration g-forces.[31]

The task objective has been stated as follows:

> Human, animal, and anthropomorphic dummy reactions to dynamic linear forces of 50 to 5000 g per second rate of onset, 10 to 200 g magnitude and durations of 10 to 100 milliseconds will be determined for all phases of body orientation.

Not all official statements have used these same figures, which are intended only to provide a rough frame of reference, and most of the high-speed track deceleration experiments fell within the limits set. However, those experiments were conducted as a "project-level" activity and were not looked upon as coming under any one task subdivision. The primary though not the only instrument for the research of Task 78503 has been the Holloman short track, or Daisy Track as it is usually called.

The Daisy Track was designed expressly for use by the Aeromedical Field Laboratory, was formally inaugurated in 1955, and is located immediately adjacent to the buildings of the laboratory complex. It consists of two rails five feet apart and 120 feet long. According to the original proposal made in 1953 by Colonel Stapp, who was then head of the laboratory, propulsion was to have been by compressed air catapult--hence the analogy with the popular Daisy air rifle which gave the track its name. As a result of administrative and funding complications, this propulsion device still is not in service, although it is currently on order and parts of the equipment have been delivered. In the meantime, propulsion is by powder-cartridge catapult. This system has been reasonably satisfactory

even though it cannot offer quite the same precision or performance range.

Braking for deceleration was provided at first by a lead cone device, but this proved unsatisfactory in preliminary tests. A water braking system was then adopted instead and is still in use. The original sled used on the Daisy Track required the subject to lie on his side in a "seat" that could be rotated in all directions by fifteen-degree increments; in high-speed track sled experiments, by contrast, the subject had to assume one of two positions, forward- or backward-facing in an upright seat. Moreover, in the autumn of 1957 the Aeromedical Field Laboratory acquired another sled with upright seat suitable for use on the Daisy Track. Orientation of this seat can be changed by ten-degree increments through a full 360 degrees.[32]

The one area of performance in which the Daisy Track simply cannot compete with the long track is sled velocity and thereby exposure to windblast. In deceleration it is capable of producing g-forces as high as those that have been obtained in aeromedical tests on the long track, although it does not provide as long an exposure to decelerative force. The number of possible body orientations was a distinct advantage, and since the operation of the Daisy Track required less elaborate preparations a greater number of experiments could be run in the same period of time. The Daisy Track provided more

accurate and abundant measurements by means of "direct recording pickups with trailing cable leads" from the sled to a fifty-channel oscillograph. Last but not least, the Daisy Track was remarkably inexpensive to operate. Runs cost about one hundred or one hundred fifty dollars each, as against the usual several thousand dollars for a test on the high-speed rocket track.[33]

The Daisy Track was completed in the summer of 1955, and the first actual sled run took place on 22 September 1955. This was only a preliminary test, and it was several weeks before a run was made with a live subject. There were various adjustments to be made first on the basis of preliminary testing, including replacement of the unsatisfactory lead cone braking device. The first chimpanzee subject tried out the new facility in mid-November; still more animal runs and engineering testing experiments, not to mention two dummy runs, were then held before the first human experiment on 17 February 1956. The original volunteer subject was Lieutenant Wilbur C. Blount, who at that time was task scientist for Task 78503.[34]

The Daisy Track has remained one of the busiest of Holloman's specialized research facilities, despite some temporary interruptions. One such interruption occurred early in 1957 when the Center's Missile Test Track Division (now called Track Test Division), which has ultimate supervision over both long and short tracks, expressed fear that the one sled then available was unsafe

as a result of the heavy loads it had sustained. The sled was taken out of commission for about a month while undergoing x-ray studies, and when these revealed no sign of cracks or metal fatigue the facility went back in operation. In September of the same year the number of Daisy runs accomplished passed the two hundred mark, and by mid-October 1958 it stood at 390--as compared with less than a hundred aeromedical experiments on the long track from November 1953 to the present.[35]

Animal experiments have figured less prominently in Daisy tests than on the long track. Most test configurations to date have not been of an order to cause serious injury, and therefore it has normally been possible to use human subjects. Nevertheless, chimpanzees did take part in some of the early tests and helped check out the facility for human use. On two later occasions hogs, which have never been privileged to ride the long track, took part in preliminary experiments with a new test configuration and received spinal fractures from an impact force measured at less than thirty g's. This unfortunate result was due to the particular combination selected of g-forces and body orientation (forces parallel to spine), and to the nature of the hogs themselves, including the "virtual impossibility of properly restraining these animals" on the sled.[36]

Bears, which joined the Aeromedical Field Laboratory staff only in the fall of 1957, have also ridden the Daisy Track. The

first instance occurred in connection with an automotive crash conference described below, but soon afterward runs were started in a test series"seeking correlation between spinal injury in bears and humans." Finally, rats served as subjects in tests of Doctor von Beckh's anti-g swinging platform on the Daisy Track. Runs have not been made expressly for the rats, but the anti-g platform is small enough to be mounted on the sled in tests scheduled primarily for some other research objective. It has been notably successful so far, increasing subject tolerance by holding longitudinal g-forces (as distinct from transverse) to insignificant values even on some relatively high-g runs.[37]

Human tests, which have formed much the greatest part of research activity on the Daisy Track, started out with a series of low-g experiments mainly intended for subject indoctrination. Since then, most officers and enlisted men assigned to the Biodynamics Branch have taken part as subjects, naturally including Captain Eli L. Beeding, Jr., who succeeded Lieutenant Blount as task scientist in the latter part of 1956. Colonel Stapp likewise took part, although his three Daisy rides failed to attract the same attention as his earlier rides on the long track. His so-called "grounding" from high-speed track experiments in June 1956 did not, of course, apply to Daisy tests.

Test subjects on the Daisy Track have tolerated forces above thirty g's in the relatively unfavorable position that is

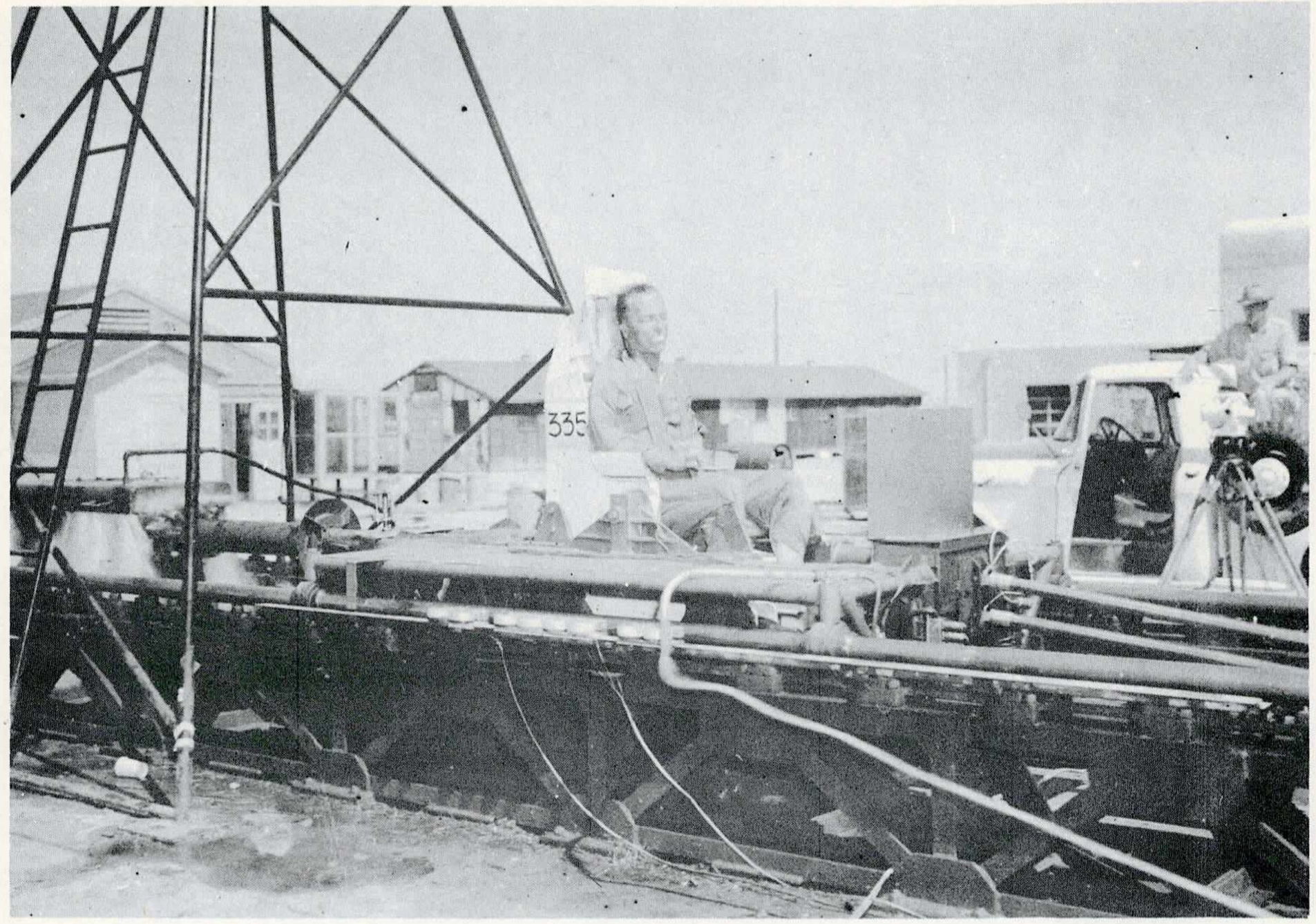
standard for upward ejection from aircraft (g-forces parallel to spine). Still higher forces have been sustained without injury in other body positions. Total durations have been as low as .035 second and have seldom much exceeded one-tenth second--as compared with a plateau of more than twenty-five g's for 1.1 seconds recorded on Colonel Stapp's rocket sled ride of 10 December 1954. Physiological effects have varied with maximum force, duration, body position and restraints, and also individual tolerance, which is much higher for some persons than for others. But no test has ever produced more than temporary ill effects.[38]

The all-time record among Daisy tests was a run of 16 May 1958, with Captain Beeding himself as test subject. Deceleration measured on Captain Beeding's chest was eighty-three g's, substantially more than the highest g-force previously experienced in any human experiment either at Holloman or at other research installations. Duration was one-tenth second and rate of onset calculated at 5000 g's per second; position was seated upright and backward-facing. After the run Captain Beeding gradually went into a state of shock, but he recovered in less than ten minutes. He entered the base hospital for treatment of sore vertebrae and detailed observation, but apparently suffered no permanent ill effects. On the other hand, Captain Beeding admitted that he considered eighty-three g's about the limit of voluntary human tolerance for the test configuration that was used. He pointed

out further that his experience underscored the desirability of backward-facing seats in passenger aircraft; there is even some question whether he would have lived through the ordeal if his seat had been facing the other direction. It is interesting to note, finally, that Captain Beeding did not ride alone on 16 May 1958. His sled also carried Doctor von Beckh's anti-g platform, whose rat passenger did not go into a state of shock.[39]

Since the aim of Task 78503 is to accumulate general research data on the physiological effects of impact force, test configurations on the Daisy Track are not necessarily determined by any one specific Air Force problem. However, the track has also been used to test particular items of equipment, such as integrated harness designs for B-52 and F-104 aircraft, and force-attenuating seat cushions. It has even been used to check out recording equipment for the Holloman high-speed test track. In the case of B-52 harness testing, runs had to be suspended before completion of the planned series because one test at thirty-five-g level caused hospitalization of the subject for two days. Arrangements were than made to have the harness equipment redesigned.[40]

For that matter, data acquired on impact forces per se will be useful for study of a great many different problems. These include not only aircraft seating arrangements, but also stresses in catapult and rocket takeoff, and re-entry deceleration. Something has been said in a previous monograph concerning the




16 May 1958: Captain Beeding Absorbs 83 G's on the Daisy Track

(Below: Close-up of the Same)

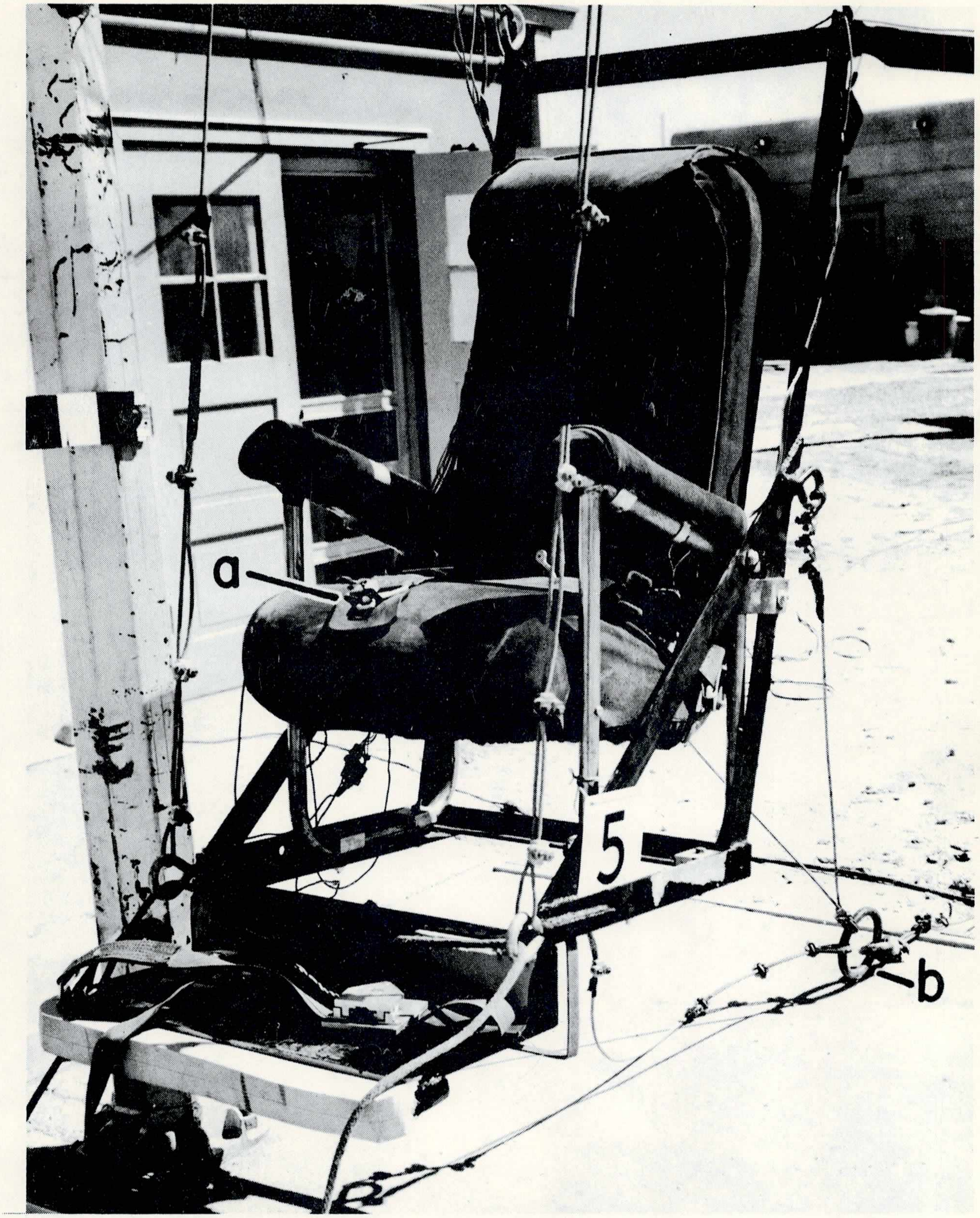
importance of research on the Daisy Track for study of escape from aircraft. Even so, it is worth noting again here as one example that the tests in which men sustained over thirty g's in position for upward ejection and emerged unharmed appear to give more leeway--or at least a greater safety margin--to the designers of escape systems than was formerly thought possible.[41]

As stated before, the Daisy Track is the primary but not the only research tool for Task 78503. The Bopper described in connection with aircraft crash experiments is a fairly handy instrument for general study of impact forces as well, although naturally it is an instrument of much more limited performance than the Daisy Track. Still another device for study of impact forces is a swing seat prepared in mid-1955 especially for aeromedical research and located, like the Daisy Track, in the back yard of the Aeromedical Field Laboratory. The swing has a platform on which an aircraft or other type seat is installed, raised to desired dropping height by means of a crane, and then decelerated by aircraft cables attached to the back of the platform at the moment its fall places it perpendicular to the ground. Forces are applied for extremely brief duration--for example, twenty-three g's with the peak lasting just one millisecond. The swing seat is capable of greater g-forces than this, depending principally on the height from which the seat is dropped; but it has various limitations, and to some extent it has served simply to obtain

rough parameters for the planning of other experiments. It has also been used in its own right for certain test series relating principally to Task 78507, Automotive Crash Forces, and it will be discussed further under that heading.[42]

In June 1955, even before the inauguration of the swing-seat, a more primitive variety of impact test was conducted in which a shot bag was simply dropped against an anesthetized hog "to determine the threshold of tissue damage by force transmissible through the abdomen wall...." This was an area of the body especially vulnerable to crash forces, so that the test procedure was of obvious interest for both aircraft and automotive crash research. The officer directly in charge of the shot-bag experimentation--Major Joseph V. Michalski, who technically preceded both Lieutenant Blount and Captain Beeding as task scientist of Task 78503--managed to conduct just one actual test before leaving Holloman in mid-1955 on permanent change of station. However, this was a forerunner of other impact tests with hog subjects on the swing-seat that were held specifically under the auspices of the automotive crash program.[43]

One final example of the concern of the laboratory's biodynamics program with all manner of impact forces is the effort spent on developing a non-penetrating projectile which can be fired at close range "to produce concussion in animal subjects."[44] This effort was technically considered a part of Task 78503, but




Swing Seat with
a. Three-Inch-Wide Lap Belt
b. Snub Cable Decelerator

was assigned as a part-time additional duty to Captain (Doctor) John A. Recht, a trained veterinarian whose primary responsibility is to care for the Holloman laboratory's animal colony. Recht tested various types of rounds before finding one that seemed workable for research purposes. Because of limited time and resources, no serious testing has been conducted with this device, but potentially it could make a contribution not only to basic research on concussion but also to the study of specific crash problems such as the effect of collision with loose objects in an aircraft cockpit.[45]

## Tolerance to Total Pressure Change: Task 78504

Another task of Project 7850 is Tolerance to Total Pressure Change (Task 78504), which seeks to determine human and animal responses to negative or positive total pressure change in the range of one to ten atmospheres occurring in .005 to five seconds and in single or multiple cycles.[46] Task scientist from 1956 until he left the service in mid-1958 was Captain (Doctor) Donald F. Patterson, an Air Force veterinarian who like Captain Recht, was assigned to the Veterinary Services Section of the Aeromedical Field Laboratory's Laboratory Services Branch (now Laboratory Branch). At present the task scientist is Lieutenant William Ward.

In explaining the objectives of this task, Captain Patterson

pointed out that the physiological effects of[47]

> ...increased pressures on the human body surface have been studied in relation to undersea diving, but investigations in this area have been largely concerned with slowly increasing pressures such as are encountered in descent beneath water. The effects of abruptly increasing, or rapidly cycling pressures as are exerted on the body due to windblast and deceleration during high speed bailout have not been adequately studied.... Abrupt external pressures, transmitted hydraulically through the blood vessels, may exceed the rupture points of small vessels in various organs including the eye.

As the above quotation indicates, this task is another of the research activities of the Aeromedical Field Laboratory with a bearing on high-speed escape from aircraft. But the range of possible applications extends far beyond the escape problem. The physiological effects to be studied by this research task are also present in explosions, for instance atomic blasts, and are relevant to various problems of manned space travel. Recent interest in the use of a fluid medium for attenuating the acceleration and deceleration forces encountered in rocket flight makes experimentation on the effects of various pressure patterns extremely pertinent; conceivably, the attenuation of g-forces would be offset (at least in part) by a sharp buildup of pressure, caused by the g-loading and increased weight of the fluid itself. Finally, there is a need for basic research to distinguish the effects of pressure change per se from the effect of other forces that in practice may be applied at the same time. However,

the Aeromedical Field Laboratory is primarily interested in positive not negative pressure changes--in compression not decompression--since the latter is already a subject of extensive research at the Aero Medical Laboratory of Wright Air Development Center. Some work is also being done at different locations on abrupt positive pressure change--using shock tubes and other specialized test facilities--but there is need for much more research on the subject.[48]

Although the Aeromedical Field Laboratory has been devoting intermittent efforts to this task since 1955, no actual tests have yet been performed. As a result of manpower and fund limitations, the task has not progressed beyond the stage of planning and preparations. Certain items of test equipment have been assembled, and members of the laboratory staff are familiarizing themselves with their operation. Other items have been designed (with help from other units of the Air Force Missile Development Center's Directorate of Research and Development), including principally a chamber capable of exerting "pressure in the range of 1 to 5 atmospheres to the body surface of rabbits."[49] But the Center is still in the process of obtaining the apparatus, which probably will not be available until the latter part of 1958. It will then be used in exploring the effect of varying combinations of magnitude, onset, and duration of compression on animal test subjects. Ultimately it may be

desirable to obtain larger and more exacting equipment for testing similar pressure changes with primates and human subjects, but small animals must first lead the way.[50]

## Automotive Crash Forces

The one remaining research task of Project 7850 is Task 78507, Automotive Crash Forces. This was one of the first subdivisions of Project 7850 to become active as a separate task, but it also deserves to stand slightly apart, as a concluding installment to the present study. Historically speaking, it has preserved a more sharply defined identity from first to last than most other tasks; at the same time, it is one of the better known, and less understood, of all the many activities of the Aeromedical Field Laboratory.

The stated objective of this task is:[51]

> To measure the actual forces incurred in automotive crashes. To establish criteria for modifications and specifications for vehicles, personnel restraints and...regulations for automotive safety.

The presence of such a task at an aeromedical research institution, as part of a project whose full title was formerly Biodynamics of Human Factors in Aviation and is now Biodynamics of Space Flight, has caused much raising of eyebrows in some quarters. Yet few have questioned the importance of the research objective, since automobile accidents rank second as a cause of

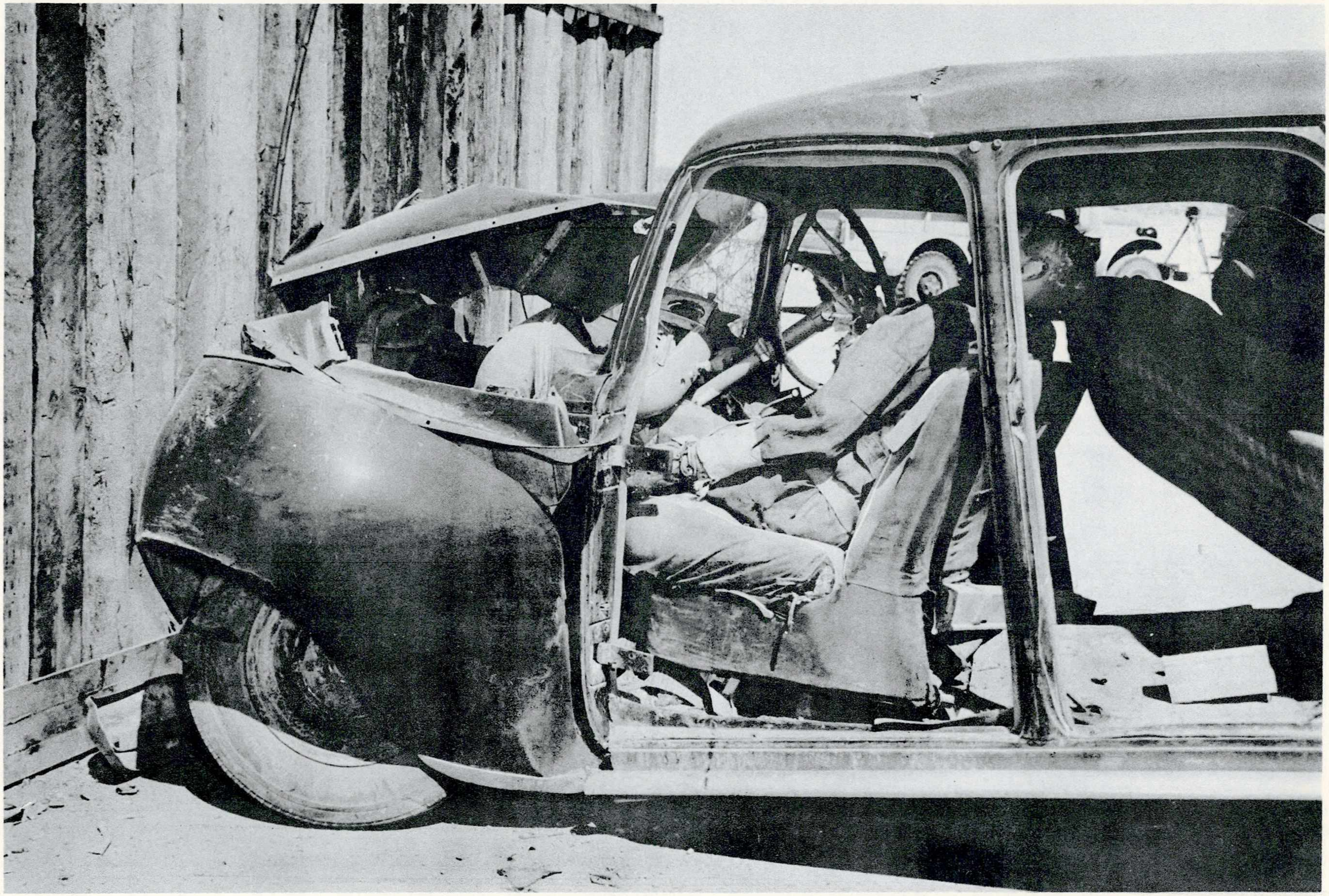
death and first as a cause of hospitalization among Air Force personnel (and unquestionably first as a cause of death among Army personnel).[52] There was good reason to undertake such a program at Holloman's Aeromedical Field Laboratory in particular, in view of the extensive background of Colonel Stapp and his co-workers in the study of impact forces. Both aircraft and automotive crash forces, moreover, had much in common.

The automotive crash program was initiated as an outgrowth of discussions in the latter half of 1953 between Colonel Stapp and officials of the School of Aviation Medicine, Randolph Field, Texas. The original thought was to create a joint "Project Marionette" between Holloman and the School of Aviation Medicine, doing auto crash research as part of the School's official mission in the field of preventive surgery but "subcontracting...the experimental portion" (such as artificially-staged crashes) to the Aeromedical Field Laboratory.[53] However, since the actual work was to be done at Holloman, the Human Factors Office at Headquarters, Air Research and Development Command preferred to make the program a task of Holloman's Project 7850 rather than a separate joint project. It was therefore included in the original development plan for Project 7850, prepared in the spring of 1954. The Commission on Accidental Trauma of the Armed Forces Epidemiological Board duly proclaimed Holloman's Aeromedical Field Laboratory to be

the sole Defense Department agency for automotive crash research, although the task was never funded or manned on lavish scale. It was in fact a relatively inexpensive research effort, especially as compared with the cost of burying a single airman and training his replacement.[54]

The most spectacular task activity has been the staging of actual crashes. The first such crash occurred on 10 March 1955, using two dummies, secured by lap belts, in a 1945 Dodge weapons carrier. This was essentially a trial run, uninstrumented, for what was billed as the first "full scale auto crash test" on 17 May 1955. The latter was conducted as part of an automotive safety conference held at Holloman for representatives of industry, government, and academic institutions.

Since that time there have been many more staged crashes, using Air Force salvage vehicles that are no longer worth repairing, with both dummy and animal subjects. Some have been crashes against a fixed barrier or another vehicle, while in other cases a roll-over accident was reproduced. Most early attempts to stage an artificial roll-over were unsuccessful, but in due course the technical difficulties were overcome. One ingenious improvement, introduced in October 1957, was to do the rolling over onto a bed of worn-out rubber tires; by this means the test vehicle could be used in an experiment at twenty to twenty-five miles an hour and emerge in good enough



Car Crash With Dummy Subject

shape to be rolled over again in later tests. Still another category of crash experiment was one in which the vehicle was suddenly stopped by means of a metal cable attached to its frame, thus allowing the study of impact forces to which interior occupants would be subjected in a crash without seriously harming the structure of the vehicle. The other end of the cable passes through a mechanical snubber that could be adjusted to produce the desired crash configuration. This equipment was supplied to the laboratory about 1 October 1957 by General Motors Corporation, for the token price of $25. Like the bed of tires, it allowed re-use of the test vehicle; and it allowed sufficiently good control for the current task scientist, Lieutenant Daniel L. Enfield, to use himself as a test subject--something he had not yet done in other types of crashes.[55]

In all these experiments the procedure has been to measure g-forces, observe the effects either on test vehicles or on their occupants, and test the effectiveness of various safety devices. However, the work of Task 78507 has involved considerably more than staging crashes with actual vehicles. For instance, tests were conducted in August 1955 and again in June 1956 on certain energy-absorbing steering wheels developed by the Ford Motor Company. For this purpose anesthetized hogs were placed in the Aeromedical Field Laboratory's newly-devised swing-seat and then released to impact at twenty miles an hour

against both conventional and energy-absorbing wheels. The results clearly showed that injuries were reduced by use of the improved steering wheel. This was a type of experimentation that the Ford engineers had been unable to perform on their own, since company legal and public relations officers flatly refused to countenance the use of test animals.[56]

The swing seat was also used in the auto crash program with dummies and human subjects, the first human test subject being Lieutenant Sidney T. Lewis, Lieutenant Enfield's immediate predecessor as task scientist.[57] Swing-seat decelerations were almost unrealistically brief as compared with forces sustained in actual crashes, but at least the contraption was easy to operate. To be sure, humans were not impacted against a steering wheel or anything else. Instead, the seat was one of various devices used to compile data on tolerance to deceleration when restrained by lap or seat belt only and to test performance of different belts, including some expressly designed for automotive use and others prepared for commercial or military aircraft.

This experimentation somewhat resembled earlier German tests of lap-belt deceleration with a swing device, but participants at Holloman endured higher g-forces. About twenty-three g's were sustained without injury on the Holloman swing-seat, although for some volunteer subjects a very definite pain threshold had been reached. Using hog subjects again, swing-seat tests were

held to explore the range from serious to lethal injuries caused by deceleration sustained with lap belt only. In these tests it was found that about forty g's were needed to produce "definite injuries to lungs, heart, abdominal organs" and "something in the order of 50 G's" for lethal effects.[58]

The auto crash task has used the Daisy Track, for more lap-belt-only tests with human subjects, and to a somewhat greater extent the short Bopper or crash-restraint demonstrator. The improved model of the Bopper received in March 1956 has been used with dummy, animal, and human subjects to study deceleration with a variety of safety restraints, at forces ranging up to and slightly above twenty-five g's. In mid-1957, for instance, the Bopper was being used to evaluate a combination of conventional lap belt plus a single diagonal strap across the chest and one shoulder. Earlier Lieutenant Lewis rode the Bopper with lap belt only to a roughly twenty-seven-g stop, sustaining considerable discomfort but no irreversible injury.[59]

The most recent test facility to be enlisted for auto crash research is the tilting seat developed by the Aeromedical Field Laboratory's Space Biology Branch for use in subgravity studies. The seat is normally placed under water, to study subject reactions under a condition of sensory deprivation simulating subgravity, but Lieutenant Enfield used it out of water in the spring of 1958, tilting the seat completely upside down. Test

subjects tried to release a seat belt in the upside-down position, and information was gathered both on the speed and efficiency of different subjects and on the amount of force required for the operation.[60]

Still other work for the automotive crash program has been performed away from Holloman on a contract basis. A contract of December 1955 was signed with the University of Minnesota for designing a hydraulic bumper to absorb and reduce crash forces and also a superstructure to protect the occupants of open-top military vehicles (such as weapons carriers) in roll-over accidents. The work was entrusted principally to Professor James J. Ryan, whose final report of 31 July 1958 announced that both contract efforts had been successful. Ryan predicts that his experimental roll-over structure--a framework of metal tubing extending above the vehicle occupants--will give protection from any but "superficial injuries," in roll-overs at speeds up to forty miles an hour. It is assumed, of course, that the occupants must also have "adequate seat-belt support." The hydraulic bumper has brought impact forces in a thirty-mile-an-hour, solid-barrier collision to within human tolerance limits, again assuming the use of safety-belt restraint; in fact it has absorbed as much as eighty-five per cent of total initial impact energy in tests with a weapons carrier.[61]

A second contract was signed in 1956 with the Institute

of Transportation and Traffic Engineering of the University of California at Los Angeles, whose crash injury research program dates back to 1948. In this case the purpose was to conduct a series of instrumented collision experiments that would supplement the data gathered in crash experiments at Holloman. Since the Institute could devote more personnel and resources to this type of work than could the Aeromedical Field Laboratory itself, results have been quite satisfactory. The contract should be completed by the end of 1958.[62]

The Holloman auto crash program has been closely coordinated with still other outside institutions, beside the two universities holding crash research contracts. For instance, the crash injury research program at Cornell University Medical College supplied statistical data from actual highway crashes to be used in planning tests at Holloman.[63] Still wider coordination was obtained by holding regular meetings at Holloman Air Force Base with industrial, civic, and academic representatives interested in automotive safety problems. The public demonstration held in May 1955, which really marked the formal inauguration of the Holloman program, was followed by similar gatherings in October 1956 and November 1957.[64] Nor did Colonel Stapp, in particular, wait for these annual meetings in order to speak out on automotive safety problems, and above all on the case for safety belts, which has been further strengthened by

results of the Holloman crash program. Colonel Stapp seldom missed an opportunity to tell the public that failure to install seat belts is "negligent suicide." He has naturally installed them in his own car, and has publicly praised automobile manufacturers for their growing interest in safety devices.[65]

Thanks to the pleas of Colonel Stapp and others of like mind--including the American College of Surgeons and the Armed Forces Epidemiological Board--the armed forces have committed themselves in principle to the installation of seat belts in all military vehicles. The principle has not yet been generally applied in practice, since the services have taken ample time to work out details and weigh the pros and cons of different types of belts. Nevertheless, a start has been made toward equipping vehicles assigned to Holloman Air Force Base, and meanwhile the Aeromedical Field Laboratory has been reviewing possible seat-belt standards both for military use and for the automotive fleets of the General Services Administration.[66]

Colonel Stapp was so firmly convinced of the continuing importance of the car crash program that he sought to raise it to the status of a separate project rather than merely a task of Project 7850. In 1956 this move was approved both at Center level and at command headquarters, but ultimately it failed for lack of support at Headquarters, United States Air Force, where some persons claimed that enough information on automotive crash

forces was already available.[67] No doubt the rejection of the new project also reflected enduring skepticism in some quarters as to the advisability of doing automotive research at an aeromedical laboratory.

Criticism of the Holloman car crash program briefly came to a head in the summer of 1957, following the publication of illustrated news stories concerning crashes staged by Mr. Derwyn Severy of the Institute of Transportation and Traffic Engineering, University of California at Los Angeles. Severy was directly in charge of the crash research contract entrusted to the Institute by the Aeromedical Field Laboratory, so that the Air Force was duly mentioned in connection with this publicity; and when the stories showed late-model sedans being crashed for research purposes there were some persons, including at least one Congressman, who concluded that the Air Force was purchasing new cars just to have them wrecked. Actually, of course, Severy does research for other sponsors as well, including automobile manufacturers, and no late models were ever crashed on behalf of the Holloman program. At the same time, Severy himself was quoted as saying that a seat belt to save lives in a head-on high-speed collision had not yet been devised--a technically true statement but one that, in its context, could easily suggest that the merits of seat belts were being exaggerated by such proponents as Colonel Stapp. Certainly the opponents of the seat belt campaign did not fail to make this

point.[68]

The entire affair was summed up by Colonel Stapp as a "ridiculous series of publicity blunders and Congressional trumpeting resulting therefrom,"[69] but it was enough to hearten critics of the Holloman crash program, while the fear of "Congressional trumpeting" made officials at higher headquarters understandably hesitant to rush to the program's defense. Nevertheless, this minor tempest was followed by an important triumph. It was one more reason for Colonel Stapp's co-workers and allies in the industrial and academic fields, such as Mr. John O. Moore, head of the Cornell crash research program, to arrange a personal appearance for him before the House of Representatives Special Subcommittee on Traffic Safety. This subcommittee, headed by Congressman Kenneth A. Roberts of Alabama, was just then investigating the very subject of automotive safety devices. When Colonel Stapp gave his testimony, on 5 August 1957, he was able to clear up misconceptions that had arisen and thoroughly convinced Roberts and other Congressmen of the value of the Holloman crash research program. Congressman Roberts even went so far as to assure Colonel Stapp that he should have no worry about funds for his automotive crash research in the next year's budget.[70]

Unfortunately for the auto crash task, the Air Force itself decided that this program should be phased out by October 1958,[71]

and Congress did not try to overrule the decision. Even if the task had not been formally cancelled, it would have enjoyed extremely low priority amid all the biosatellite efforts and related workload assigned to the Aeromedical Field Laboratory in the course of 1958.

Nevertheless, it is worth noting that in November 1957 the laboratory held the last, the most elaborate, and certainly the most interesting of all its yearly meetings with outside representatives on automotive crash problems. Entitled Third Annual Automotive Crash and Field Demonstration Conference, it brought over a hundred persons to Holloman for a three-day session and featured research papers and discussion, demonstration of safety devices, actual automotive crashes, and impact tests on such facilities as the Bopper and the Daisy Track. Professor Ryan of the University of Minnesota demonstrated the bumper and the roll-over structure he was working on under contract. Another highlight was the first use of one of the laboratory's recently-acquired bears as a test subject, on a twenty-g Daisy Track deceleration run. This in itself was bound to attract attention, because the bears' arrival just a few days before had already received an unwelcome wave of publicity, and also because of the mere fact that an early press story concerning the conference had mistakenly announced a pig experiment instead. An official release clearing up the latter point gave rise to the classic

headline (conceived, of course, by Colonel Stapp): "Pig Tale Disproved by 'Bear' Facts."[72]

This release failed to mention that the bear (having shown no outward ill effects of the ride) was later sacrificed in order to look for possible internal injury. Yet that detail, too, was soon featured on the front page of the Alamogordo Daily News and at least mentioned in other papers as well. Indeed some of the publicity about the conference was just plain unfavorable. One visitor, in particular, was highly offended when another prepared release was politely but firmly taken out of his hand by a young lieutenant at the Center's Information Services Office. The release in question was quite innocuous; it contained a statement by Indiana Congressman John V. Beamer, another attendant at the conference who highly praised the entire car crash program, and it also made brief reference again to the bear experiment. But it could not be distributed publicly until cleared by higher headquarters. The visitor out of whose hand it was lifted then poured out his grievance in angry terms to the Alamogordo Daily News, which included it in the same feature story that openly discussed the bear's death.

The local paper--whose general treatment of the Center has been extremely cordial--threw in for good measure the complaint of a Chicago reporter that he had been "bounced off the base" soon after he arrived to cover the conference. In effect, there

had been some undeniable confusion as to whether or not press coverage would be allowed, involving higher headquarters as well as different units of the Air Force Missile Development Center. It was also true that in the end all reporters who so desired, whether from Chicago or from Alamogordo, were permitted to attend. And it is possible that even the less favorable publicity may have done some good, indirectly, by reminding people of the conference and of its basic theme--automotive safety.[73]

One reason why the bears' arrival attracted wide attention was that they reached the Air Force Missile Development Center just after the Soviet Union shot off a dog in Sputnik II. There was speculation that perhaps the United States Air Force planned to outdo the Russians by placing not a mere dog but a great big bear in orbit. Actually, of course, there was no such intention; yet it was not far-fetched to make at least some connection between bears at Holloman and travel through space. G-forces are g-forces, whether experienced on the highway in an auto crash, in emergency escape from aircraft, in landing on Mars, or in returning again to Earth. Patterns and orders of magnitude naturally vary in all these cases, but the cases do have some points in common. Thus with the same test facilities, and within the same program of deceleration and impact tests, the Air Force Missile Development Center's Aeromedical Field Laboratory has made contributions toward the solution of an extremely broad

range of operational problems. This is in addition to the service it has performed in compiling basic research data on human and animal g-tolerances. The study of deceleration and impact, along with the Aeromedical Field Laboratory's research on windblast and on such branches of space biology as cosmic ray hazards and subgravity, must therefore be listed among the truly significant accomplishments of the Center.

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# GLOSSARY

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| AFB | Air Force Base |
| AFMDC | Air Force Missile Development Center |
| AMAL-NADC | Aviation Medical Acceleration Laboratory, Naval Air Development Center |
| ARDC | Air Research and Development Command |
| Cmdr. | Commander |
| DD | Department of Defense |
| DF | Disposition Form |
| HADC | Holloman Air Development Center (redesignated Air Force Missile Development Center as of 1 September 1957) |
| HAFB | Holloman Air Force Base |
| Hq. | Headquarters |
| Ind. | Indorsement |
| Ltr. | Letter |
| R & D | Research and Development |
| RDB | Research and Development Board |
| Subj. | Subject |
| USAF | United States Air Force |
| WADC | Wright Air Development Center, Wright-Patterson Air Force Base, Ohio |

# INDEX