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16. Abstract

The increase in air transportation depends not only on the technological progress and the availability of more and larger aircraft, but also on the corresponding increase in flight safety. Since, in most of the aircraft accidents, pilot error is a contributing factor, research concerning the medical and human factors must be expanded to include the new generation aircraft, in particular, to the jumbo jets and air buses which are the means of mass air transportation. Moreover, the medical aspects of airports must be adjusted to serve the increasing number of crews, passengers and patients. Means must be provided for first aid, quarantine and the prevention of infectious diseases through air transportation; and a disaster plan must be established for all major airports. Finally, the effects of mass air transportation on the environment must be considered in order to protect the quality of life.

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LIST OF ILLUSTRATIONS

MEDICAL AND PSYCHOLOGICAL ASPECTS OF MASS TRANSPORTATION

Transportation comprises one of the most dynamic elements in any society. The history of civilization and the history of transportation were always closely interrelated, since transportation assists in social development, and society, in turn, demands transportation. Starting within the first half of this century and accelerating greatly within the past twenty-five years, air transportation not only has surpassed other types of transportation (Fig. 1), but also has become a major element in world affairs as an expression of national policy, economy, and individual private endeavor.[1]

In accordance with statistical predictions, air transportation will increase annually at somewhat more than ten percent until the end of this decade. Hence, the air traffic volume will double in about 7½ years and it will triple in about 11½ years. This growth rate will depend on an equilibrium of the various forces which tend to drive it to higher levels by public demand for transportation facilities and a favorable economic climate, and the various forces which tend to impede its growth by technical limitations, political reasons, or certain social objections. The question is whether the upward trend can be expected to continue through another decade in spite of the possible restrictions.

The increase in air traffic does not simply depend on the availability of more, faster, and larger aircraft. Mass air transportation, just like any other mass transportation, is made possible only by the fact that a large number of people want and can afford to use the airplane as a means of transportation. As shown in Figure 2, this presently seems to be the case. In accordance with the figures published by the International Civil Aviation Organization, 289 million passengers used the aircraft in 1969, traveling 349 billion kilometers. In order to sell that many tickets, a number of requirements has to be met.

The first requirement of mass air transportation is safety. Accidents, in particular fatal flight accidents, must be prevented. Figure 3 provides an interesting illustration of the increase and present state of flight safety. The diagrams in the center and at the bottom of Figure 3 show that the number of fatal accidents has been drastically reduced during the time from 1952 to 1969. Depending on the criterion used, this reduction amounts to between 50 and 60%. In contrast, the top diagram shows that the number of fatalities increased during the same period of time. In the future even more passengers will be exposed to an accident. It follows that with the introduction of the jumbo jets and even larger aircraft, the accident rate of the scheduled air carriers must be reduced considerably below the present figure in order to decrease the number of persons killed. In accordance with data released by the National Transportation Safety Board, the so-called "pilot error" or other human factor deficiencies substantially contribute to about 50% of the accidents in air carrier operations and to about 85% in general aviation. The intensification of medical and human factor efforts associated with accident analysis and accident prevention are therefore of high importance in regard to the introduction of even larger airplanes: the stretched versions of our present transport aircraft, air buses, and jumbo jets. The increased number and new types of aircraft taken into operation complicate the problem further.

I. Airworthiness Aspects.

With the introduction of larger, faster, and more complex airliners, it is obviously necessary to consider the operational requirements of the flight crew. A picture of the flight deck of the

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Boeing 747 is shown in Figure 4. Principles of good management as well as human engineering must be incorporated in the philosophy concerning the pilot's role in the modern-day airliner. Just as the manager of a company must have visibility of the operation and its problems and future plans, the pilot of a modern-day airliner must have information relative to the aircraft's situation, rate of progress relative to its objectives, and any problems that may develop. The requirement for clear-cut, timely information in an easily understood format is equally necessary for both the manager and the pilot.[2]

The following examples are given to illustrate the airworthiness efforts for future aircraft:

A. All instrument approach and blind flight displays will be heads-up, or so placed that they are conveniently ahead of the pilot. All relevant information will be simplified and displayed in intelligible analog form with simple digital clarification readout.

B. All instruments will be properly lighted with no hidden instruments which require intensive study by the pilot under night IFR conditions just when his attention is most urgently needed elsewhere.

C. The current cluster of non-standard knobs, switches, displays, and other protrusions will be totally eliminated. A standardized cockpit based on the building block concept will exist which clearly provides the pilot with essential information and enables the pilot to transition between aircraft with negligible difficulty.

D. Vista vision cockpit windows will provide all crewmembers with true sky-scanning capability. Live television scanning to assist landing may be utilized, as may pictorial navigation devices.

II. Protection of Human Lives.

In the future decades, crashworthiness structures of air transport and other aircraft will be upgraded considerably. The following examples may illustrate certain of these projections:

A. All instrument panel and seat structures will be constructed of material which, within the range of occupant impact, will not yield fatal injury during impacts which do not demolish the aircraft fuselage. Universal restraint systems will be incorporated in all aircraft which can be adjusted to all sizes of persons. In addition, new restraints will not produce injury in pregnant women and will be quickly releasable following cessation of the impact.

B. Aircraft seats will be capable of absorbing deceleration forces throughout the crash impact profile, the latter limited by the loss of fuselage integrity. Consequently, the seat occupant will not receive deceleration forces which exceed his tolerances unless the accident is nonsurvivable. Moreover, all seats will be tied down to appropriately designed and strengthened floors in such a fashion that seats will not fail throughout the range of crash forces delimited by the fuselage integrity. Restraint systems must exceed human tolerances if they are designed to really protect the passengers. The seats will have to be positioned so as to minimize the acting G-forces.

C. In order to reduce the fire hazards often associated with aircraft accidents, the FAA is investigating various methods of preventing fires, including the use of thickened or gelled fuels. Moreover, protective hoods against smoke and radiant heat were developed for individual passenger use. At the present time this smoke hood, although felt practical for many emergencies, provides protection for only four to five minutes (Fig. 5). Research is underway to extend the period of protection by a small cartridge built into the hood containing compressed air.

D. Aeromedical scientists have evaluated cloth escape chutes and slides for passenger use in emergency evacuations. The next generation of such devices suitable for jumbo jets and supersonic transports should represent an improvement in these old-fashioned cloth structures (Fig. 6). The next generation devices should be highly compact, lightweight, of metal "solid-state" structures, rapidly deployable at the press of a button, and not affected by wind. One such device has already been reported on by the Civil Aeromedical Institute and others are in evidence.

E. Large aircraft which exceed the jumbo jet in size, the gigantic jets, are already on the drawing board. There may be two or three levels of passengers. We are studying the possibility of using already deployed inside metal tubular escape chutes which serve also as boarding stairs. It is conceived that with the press of a button the stairs fall flush, providing a smooth slide for rapidly evacuating the occupants.

F. Our research personnel tell us that very few restraint or flotation provisions are made for large numbers of passengers. Although all air transport airplanes are required to have flotation seat cushions and seat belts by regulation, little attention has been paid to the safety devices for pregnant women and infants. Such protective devices are now under development. Accordingly, future aircraft will have universal restraint flotation devices which can be applied to all age groups in any seat and used under all conditions (Fig. 7).

G. The FAA has started a series of experiments using a new simulator for studying escape problems and procedures associated with large transport aircraft (Figs. 8 and 9). The simulator consists of a platform which is 75 feet long and 20 feet wide. The platform can be loaded to capacity of 100,000 pounds, of which 45,000 pounds can be a live load. It can be tilted in pitch and roll attitudes of plus and minus 20 degrees from the vertical and can be raised 16 feet above the ground by a hydraulic lift. A two-story aircraft fuselage is being installed on the platform and studies of emergency escape will be accomplished in simulations of different roll and pitch attitudes. Involved will be 154 passenger seats, smoke generating equipment, and various lighting and sound effects. Of special value will be the opportunity to evaluate different emergency escape devices and different types of fuselage doors. For studying problems associated with aircraft ditching, inflatable pools will be positioned at appropriate locations beneath the simulator and occupants must escape through the provided means into the water. One of the most significant devices to be evaluated with this simulator is the new slide-raft combination as shown in Figures 10 and 11. Another is the determination of credit to be given concerning the number of persons for each Type-I door exit associated with a double-width slide. Also, an attempt will be made to obtain a correlation factor between trained vs. untrained subjects, as well as to obtain certain information bearing upon stewardess training levels.

H. The possibility has been suggested of the placement in major airports of exhibits of emergency escape devices together with operational techniques. For example, the emergency exits would be on exhibit and passengers could practice opening and closing these exits. In this way, the passengers waiting at major airports can familiarize themselves with standardized emergency equipment and escape briefing so that this time-consuming activity will not be placed to such a heavy extent upon the cabin attendants. Of course the cabin attendants of a specific airplane would give a short briefing on the unique features of the airplane, but the main briefing would already have been accomplished prior to passenger boarding, leaving the busy cabin attendant free to discharge her appropriate duties. The airport briefing could be accomplished by film or video tape.[3]

III. Certification of Airmen.

The increased use as a preferred means of transportation relates the aircraft to mass transportation. This concerns the air carriers (3,008 aircraft, 170 million passengers in the USA in 1969; ICAO: 289 million passengers without China and USSR) as well as general aviation. There is a steady increase in the number of general aviation aircraft, flight tours, and private pilots in the USA (Fig. 12). In 1969, 712,000 civil airmen held valid medical certificates. In the process of making application for medical certification (Figs. 13 and 14), they bring forward all of the infirmities and medical problems to which mankind is subject. We are confronted not only with diversity in diagnostic entities, but with the variable manifestations, the spectrum of severity that each disease or combination of diseases may depict.[4]

The complexity of the problem is puzzling. On the one hand, we find an increase of safety mostly due to improved aeronautical engineering. This, on the other hand, lures a lot of persons into the air who, psychologically or medically, may be only marginally fit to fly. However, unsafe pilots like unsafe drivers endanger the highways in the sky. Hence, the problem is to keep the unsafe persons—commercial pilots, private pilots, and passengers—off the air while at the same time opening up the airways to mass transportation. The number of petitions denied by the Administrator, FAA, and their medical classification are shown in Figure 15. We will deal with the commercial pilots first. The complexity of the modern airliner, in particular the wide-bodied jets and the SSTs, together with the increased traffic density, novel flight pattern, and national or international peculiarities may demand a higher degree of mental and physical response than is needed in our current aircraft. This would indicate the need for higher psychophysiological fitness and, accordingly, for high psychological and medical standards.

At this point, we can make the case that sudden, partial, or total incapacitation of a crew member is more likely to prove disastrous to the aircraft and passengers. Therefore, questionable or borderline findings in the vital organ systems (under dynamic loadings) will not be acceptable. From a medical standpoint, wishing to err on the conservative side, this reasoning would make a certain amount of sense, and therefore would likely be accepted. From the operator's and flying public's standpoint, however, the question might well be raised that if such a case can be made for the jumbo-jet and SST crews, then why not impose it on all commercial pilots as an additional measure of flight safety? If we were working in a completely objective aviation system, the forces resisting such action would be minimal; but unfortunately the one in which we work is heavily burdened with political, economic, and prestige constraints, such as seniority or merit system not based on medical facts alone. These ever-present biases, along with the assumption that the "state-of-the-art" of aviation medicine is fairly imprecise, amplify the inherent difficulties.[5]

However, we must look at the jumbo-jets as another trend in air transportation leading toward more complex and larger public vehicles operating in environments containing potential hazards of increasing lethality. It must be pointed out in this connection that the science and practice of preventive medicine hold great promise to alleviate many of the mass transportation problems. Accepting this trend, it is our primary responsibility to periodically review and update our aeromedical standards and procedures by which we can optimize the reliability of the human component in the system and, at the same time, maximize the safety of air operations.

One of the most pressing needs is to find improved means of detecting early coronary heart disease in pilots.[6] Also, means for determining biological dependency on alcohol should be developed and studies of intermediate vision requirements by pilots are indicated. The aeromedical community would indeed be short-sighted if it did not incorporate any advances in this area toward improving the health and fitness of airmen, at the same time setting better records for flight safety.

In addition to an adequate aircrew selection and training program, the care of the passengers, which will include a substantial number of handicapped or ill persons, has to be considered. Physiological indoctrination, first aid, and medical care of patients will be required by airport personnel and the stewardesses, who will have to work much more independently in the widebodies and stretched jets than in conventional aircraft. Attention should also be paid to the prevention of a panic in case of unusual situations, be this a hijacking or a flight emergency, and the aircrew personnel must be prepared for dealing with panicking passengers under these conditions.

IV. Air Traffic Controller Health.

The air transportation growth in the last four years and forecasts for the future indicate that air traffic will increase at a greater rate than the present or programmed traffic control system can handle. An increasing number of terminal areas are already experiencing unusually long delays in receiving and dispatching aircraft.

Through 1977, FAA forecasts sharply rising demands for airspace by air carriers and general aviation and declining use by the military. Total aircraft operations at airports with FAA traffic control service will rise from 55.9 million in fiscal year 1969 to an estimated 174.2 million in fiscal year 1981, an increase of approximately 212 percent.[7]

Increased air traffic volume with a greater proportion of larger aircraft will clearly require new approaches to air traffic control in the future. Present deficiencies will become progressively worse unless strong measures are taken.

In order to cope with the air traffic problem, the number of air traffic controllers was sharply increased during the past three years (Fig. 16).[8] Moreover, the FAA initiated a research and health program which began to operate early in 1966.[9] While affording all the advantages which an employee health program can bring to those who participate in its benefits, it was also designed to develop experience data which would serve to determine environmental stress levels and prevent the stress effects of control work upon the air traffic controllers.

The concept that control work is stressful—sufficiently stressful to warrant special handling and recognition for men in this line of work—is not new. The recognition of the demands which this work can generate encourages us in seeking to develop an objective standard which will accurately measure the effects of stress upon the human organism generally and also more specifically upon the controller in the working situation. Such measurements can serve to answer the question as to whether air traffic control work warrants specialized career benefits to compensate for the cumulative effects of stress that over the years may exact a toll in terms of declining health and individual personality changes.

The Sixteen Personality Factor Test (16PF) is used by FAA scientists to select psychologically healthy controllers.[10] The 16PF is inherently perhaps the best constructed test of personality inventory now available for this purpose. The 16PF is constructed to cover the whole range of personality characteristics, normal and abnormal, but we are largely interested in getting at the troublesome aspects of a controller's personality. At the same time, it should be realized that the 16PF, unlike many clinical tests, does allow for the description of a normal personality.

Experience with the test over the past five years, with cases of many types, has convinced us that the test is the most useful personality inventory for predicting the success of an air traffic controller or his possible failure. It is obvious that this simple test is only one means among others to be used in the ATC selection procedure.

The incidence of stress-type illnesses among the controller population has previously been compared with that of the airman population and also with figures for the total Air Force population, Air Force officers only, and Air Force pilots.[11] Stress type illnesses such as coronary heart disease, hypertension, diabetes, peptic ulcer, and analogous disorders occur at significantly higher rates in the controller population than in these control groups with which the controllers have been compared. Further studies of ATCs in towers and terminals are in progress and an attempt will be made to incorporate their findings into a comprehensive employee health program.

Finally, the assignment of physicians and ancillary medical personnel to staff small medical clinics to be established in each expanded center commencing in the early part of 1971 will facilitate the examination of controllers under the ATC Health Program. This measure will establish effective medical surveillance to the actual working interface, thereby affording better medical care for the controller population, while at the same time enabling the medical service to better identify and appraise the beginning and development of stress effects in controllers through the close observation which the assignment of medical officers in large working facilities will guarantee.

V. Airport Aeromedical Survey.

Today the nation's airports need similar attention. Many airports are saturated at peak-hours; terminals have become strained; and it is becoming increasingly difficult to reach the airports. In about three years a considerable number of the world's major airports will each have to accommodate over 20 million passengers and about the same number of nonpassengers per year.[12]

For the non-passenger, the airport may be a kind of "no-man's land." The visitor may be in a much more precarious state than is the case with the ticketed passenger, because the airlines will usually take responsibility for ticketed passengers who experience medical problems. The non-passenger visitor, however, must fend largely for himself should he become ill in an airport with no airport medical facility.

It must be anticipated that the number of handicapped, sick, or border-line cases—psychologically and medically—will increase at least proportionately with the increment of passengers. There is a good possibility that the relative and absolute number of such persons will increase out of proportion, this being typical for most mass phenomena. The notion that only healthy and physically fit individuals can travel by aircraft has long been relegated to the limbo of false assumptions; and the introduction of the jumbo-jets, their advertisement and catering to the people, undoubtedly will encourage the not quite so healthy and fit specimens of the population to follow suit. The potentially large number of patients will require an intensification and improvement of medical facilities in flight and at airports and the development of related medical standards.

Although the airlines do provide to a greater or lesser extent technical emergency evacuation and first-aid training, the stewardess is often considered a "hostess in the sky." The aeromedical experts are contemplating the assessment of whether or not at a future date these persons should be certificated so that the traveling public is assured of a minimum level of competence equivalent to that necessary to safely evacuate the supersonic transport or other future aircraft. This intensification of training may be necessary in view of the increased demands on the professional skills of the flight attendants.

The Aeromedical Applications Division in the Office of Aviation Medicine of the FAA spearheaded a survey of 34 major airports in order that facts could be obtained concerning the significance of on-site occupational medicine programs. In reviewing the survey forms, airports have been observed which have parking facilities for passengers located at considerable distances from the passenger terminal. These have necessitated physical stresses upon passengers, particularly the elderly, infirm, and those handicapped. Furthermore, airports have been seen to have no arrangement in the interior whereby these persons can readily get about. In some terminals wheel chair personnel have a particularly difficult time, especially in the toilets and getting from the ticket counter to the flight waiting area.

The survey inquired into the nature, and the number of airport toilets, and it has been found that these have not kept up with the growth of passengers and spectators. The number of toilets must be predicated on passengers plus spectators plus employees and adjusted upwards accordingly. Food handlers should have separate toilet facilities.

As a result of the non-standardized airport interior-flow patterns for passengers, some confusion almost inevitably occurs as the passenger finds himself in an unfamiliar airport. This is a particular problem for the naive, the elderly, the handicapped, and certain others.

It has been found that many airport terminal seating facilities and airline waiting-room seats are inadequate in number for the passenger population. This is compounded by the visitors who accompany the passengers and may be particularly bothersome to pregnant women and women with small children.

The handicapped person, whether in a wheelchair, one legged, blind or otherwise indisposed, is considerably discommoded in many airports. He cannot readily move from the check-in counter to the flight gate. If visually limited, he has difficulty reading the flight announcements. If readily fatigued, he often has limited seating arrangements. Not infrequently, he cannot utilize the extant toilet facilities because the local architect who designed their features did not give consideration to their utilization by handicapped persons.

Occasionally, a given flight is cancelled. This means that its complement of passengers must return to the ticket counters. This will result in increased confusion and an impairment of the efficiency of flow of passengers scheduled for succeeding flights. Adequate waiting-room accommodations for these recurrent eventualities will assist in the efficiency of handling the increasing numbers of passengers.

The movement of large numbers of people on international airways intensifies the danger of carrying contagious diseases from one country to another. Examples are the recent epidemics in the East which could be spreading if preventive measures are not taken. Similarly, diseases threatening fruit, crops, and livestock must be controlled. In 1967 the World Health Organization recommended the use of automatically-dispensed pesticides (dichlorvos) for inflight disinsection of passenger-carrying aircraft.

There are, however, questions about the complete safety of the chemicals used under all operational circumstances in regard to passenger reaction, or whether toxic effects absent at sea level might appear at higher cabin altitudes. The FAA in cooperation with the Public Health Service has recently conducted experiments and answered these questions.

Passengers having contagious diseases will flow at an increasing rate through airports. In order that persons who might be susceptible to various acute contagions, such as influenza, smallpox, poliomyelitis, and other conditions depending upon geography and season (for example, typhoid fever or cholera), routine medical immunizations will be a significant factor in the future.

The geo-political jurisdiction, including coroner or medical examiner jurisdiction, must be considered with respect to airport medical services and assistance during airport air disasters. An airport disaster plan must be developed, integrated with all elements of the airport and surrounding community which will be concerned, and updated annually, or as required by changing circumstances. Some of the 34 airports surveyed were found to have no disaster plan which involved the medical support aspect. Some of the airports had given considerable attention to the development of a disaster plan including the incorporation of information involving medical personnel, these plans not infrequently having evolved subsequent to an on-site disaster.

Temporary morgue facilities must be ultimately provided at all airports expecting mass air transportation. These facilities must be of an adequate capacity to handle the potential numbers of fatalities which can result from a full complement of fatal victims contained in the largest aircraft utilizing the airport. The accident investigator and victim identification teams may require up to three or more days of investigative time prior to their release of the bodies. Prior planning and designation of space for this need prevents problems at a future date.

Following this detailed survey of 34 of the world's major civil airports, the International Quarantine, Airport Medical Service, and Flight Sanitation Subcommittee of the Aerospace Medical Association provides data supporting the following conclusions:

A. Each airport should have a designated Chief Medical Officer;

B. When the airport employees exceed 3,000, or when the passengers per year exceed 2,000,000, an on-site airport medical service is desirable;

C. Of the 34 airports surveyed, 32 are forecast to meet the minimum standard for establishment of an airport medical service; and

D. An "Airport Medical Design Guide" which provides information on aeromedical and human factors aspects of the airport operation should be assembled and promulgated.

VI. Effects on the Environment.

The growth of civil aviation during the past decade has been accompanied by world-wide concern about the adverse effects upon the environment. There can be no doubt that air transportation has brought about environmental changes, such as changes of the scenery through the construction of airports, supporting facilities, connecting roads, highways, etc. However, these changes generally are less dramatic than those brought about by other means of mass transportation, in particular, the automobile. As a matter of fact, it has been claimed that the aircraft is the one vehicle which spoils the environment the least (Fig. 17) and that certain unpleasant by-products, such as engine smoke, some air pollutants, and chemicals released through the combustion process, will be better controlled in the future.

It seems that the most obvious environmental effect of aircraft operation is engine noise.

The new generation aircraft may produce even higher noise levels under flight paths or to the sides of runways. If more frequently operated, they will probably bring longer periods of relatively high noise to neighborhoods adjacent to airports.

Noise is receiving increasing attention from airframe and engine manufacturers, airport operators, government agencies, and the public. Its arousal of communities surrounding airports will become a major obstacle to the growth of aviation unless solved.[13]

Current research on human reaction to aircraft noise is being expanded. With increased air traffic and introduction of new kinds of aircraft, it is of the greatest importance to have more accurate information about human response to different characteristics of noise and to a total environment in which noise may be an important negative element.

Among the various sources of noises, aircraft noise has been the most publicized. It is this noise source which has substantially contributed to the public reaction against modern traffic noise. It has been pointed out in this connection that the fear of airplane crashes enhances the annoyance factor. Fearful people who live in the vicinity of airports go through a continuous tension which is closely related to the actual noise level. There is reason to assume that the maximum tolerable jet noise covers the range from 95 to 105 PndB. A variety of experiments is being used to assess the effects of noise on individuals and communities. The results obtained so far show that, while certain performances—in particular, fine motor coordination and related psychomotor activities—are susceptible to impulsive noise, medical effects produced by flyover or sonic booms are extremely rare and difficult to prove. In comparing subsonic daytime noises (100 dB) with 1.7 psf booms at night, the reaction was more favorable toward the boom than to the subsonic noise. With the exception of much higher over-pressures generated close to the ground, the infrequent sonic boom appears to be less annoying and the habituation more evident than most people realize.[14] Studies of human responses to impulsive noises are presently in progress at the Civil Aeromedical Institute at Oklahoma City (Figs. 18, 19, and 20).

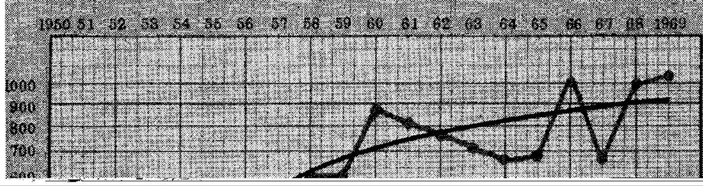
At any rate, noise is still a problem and could be one of the restrictions of mass air transport if it cannot be solved satisfactorily. Solutions will be even more important in the future around V/STOL terminals and under such flight corridors. Supersonic commercial air transport possibly will add to sideline noise the annoyance of the sonic boom. At present, prospects are not readily apparent for significant reductions in the intensity of these noises. Any solution to the aircraft noise problems must include the development of quieter engines, the establishment of ment, waste our reserves and national resources, and thus add to human misery in the long run.

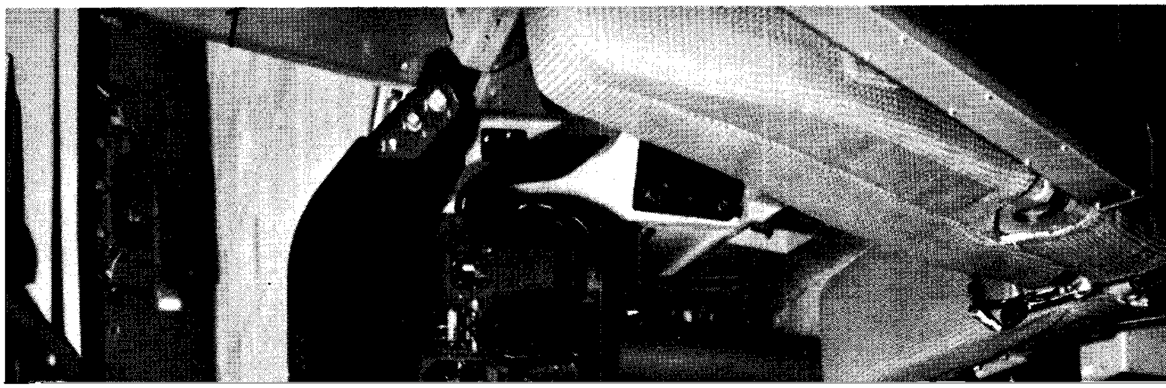
Some believe that it is not realistic to expect the growth of new technologies to continue at the present rate. Logic as well as circumstance suggests that the various restrictions mentioned earlier are real. Available means and tools to advance mass air transportation are not being used appropriately. An analysis of 61 survivable aircraft crashes made by the Flight Safety Foundation in 1967 indicated that nearly half of the 1037 fatalities and serious injuries which occurred could probably have been prevented by the use of improved restraint systems. Conferees at the December 1967 USAF-Industry Life Support Conference held at Las Vegas, Nevada, concluded that "human tolerance to accelerative forces is much greater than the forces generated during some of today's 'non-survivable' accidents. We have 40–G people riding in 20–G aircraft, and sitting in 9–G seats and restraint systems."[15] There may also be political and social restrictions to mass air transportation which must be considered. The assumption that more and more percent of our population want to travel by air may be falacious. Presently only about 20 percent of the U.S. population has ever traveled by air; in order to cater to the remaining 80 percent, transportation must be inexpensive, that is, less expensive than air transport can afford to be. If nations and populations, in particular the rich and highly technologized ones, do not increase at the statistically predicted

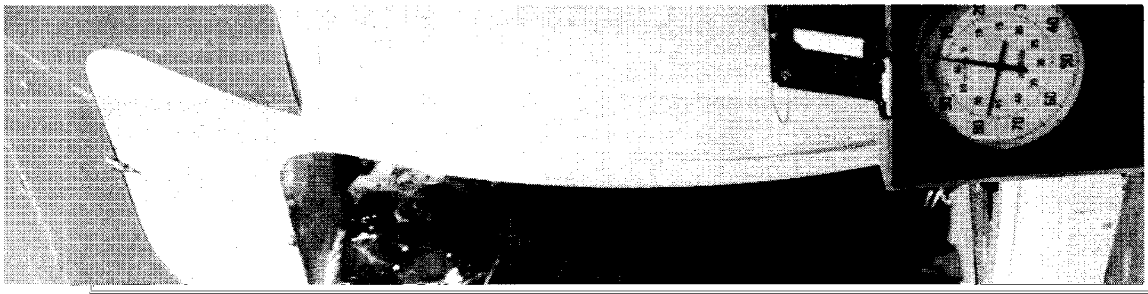
DIAGRAM 1

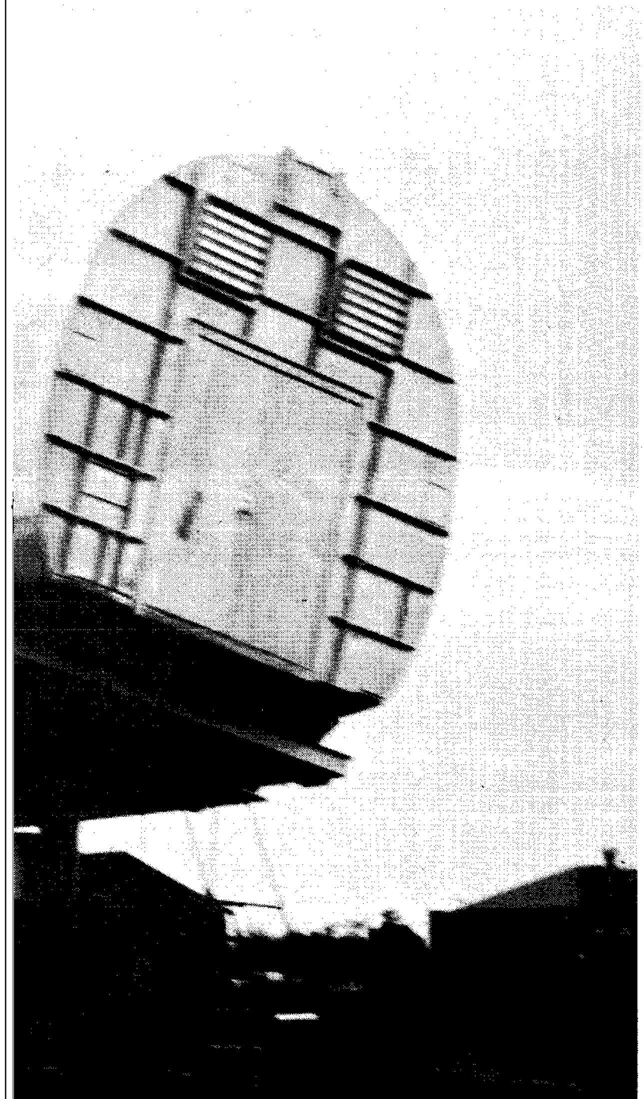
DIAGRAM 10

FATAL ACCIDENT RATES FOR PASSENGERS ON WORLD SCHEDULED SERVICES, INTERNATIONAL AND DOMESTIC 1950-1969









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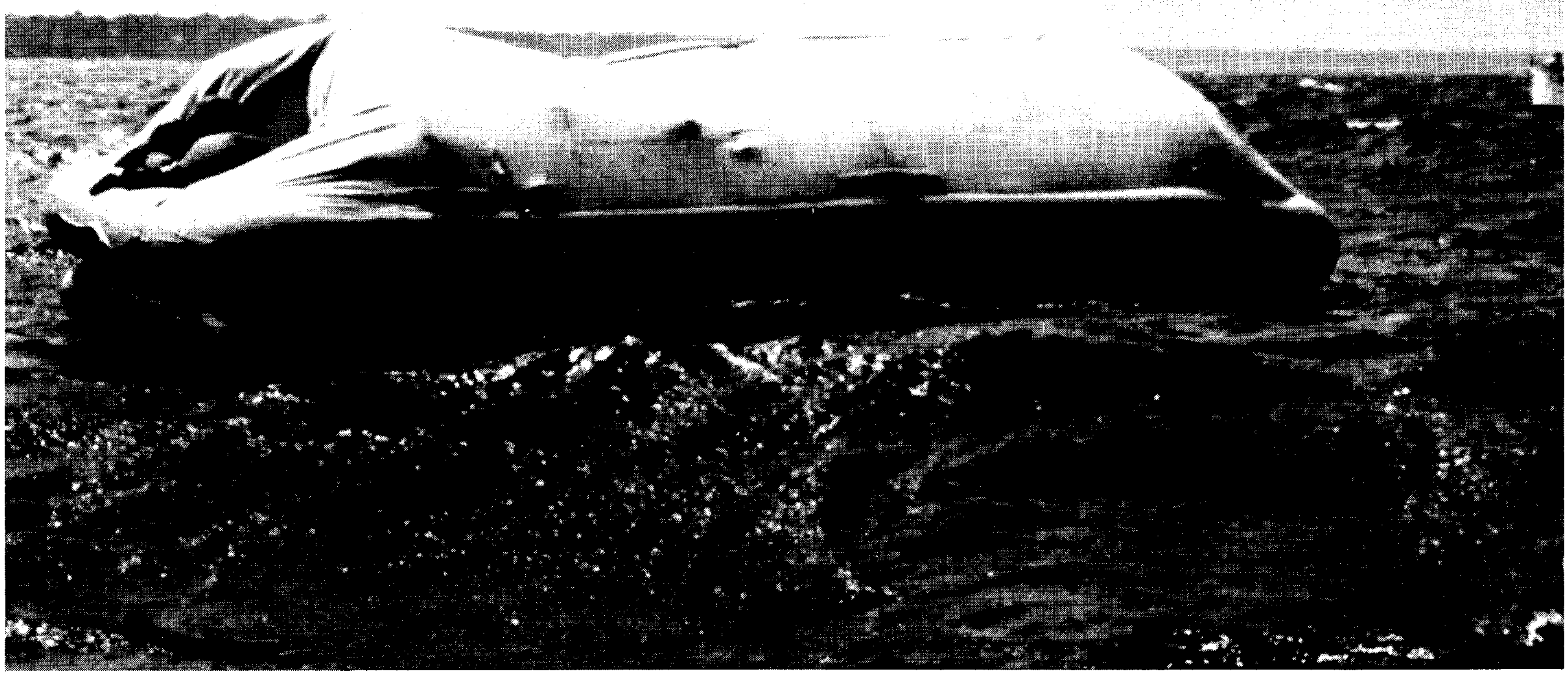
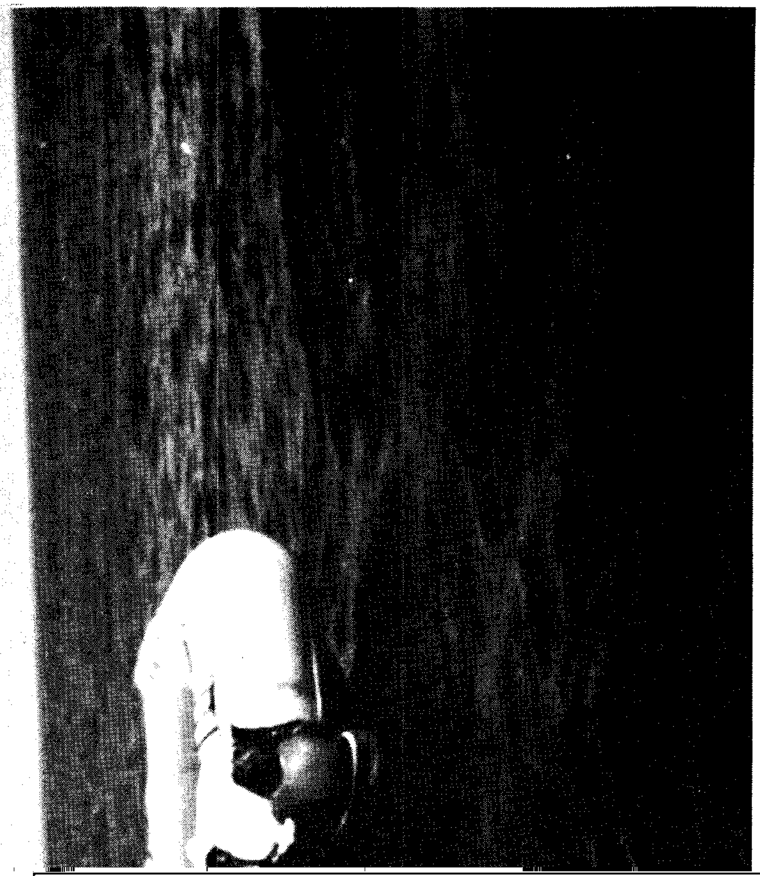
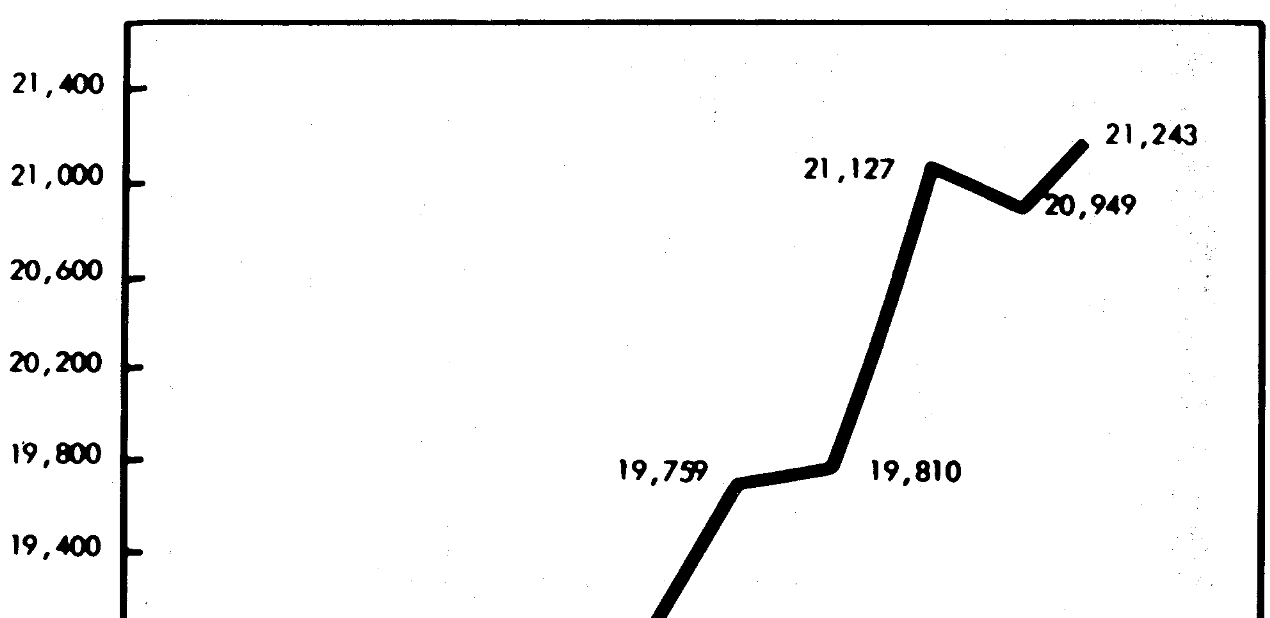


FIGURE 11. Combined slide/lifeboat with protecting cover developed by the B. F. Goodrich Company.



nd lifeboat developed by B. F. Goodrich Company.

CONTROLLER STAFF 1967 – 1970



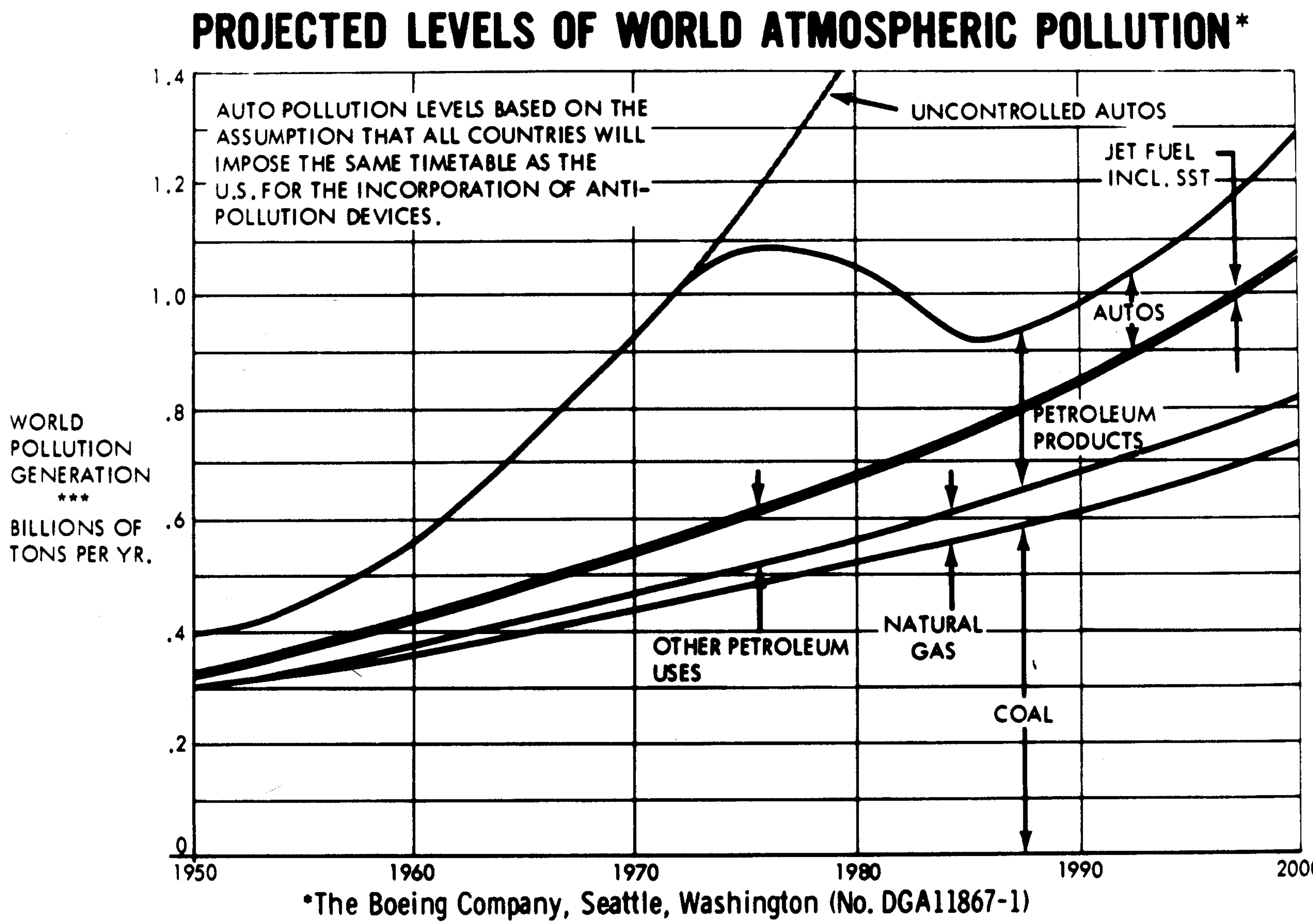


FIGURE 17. Projected levels of world atmospheric pollution.

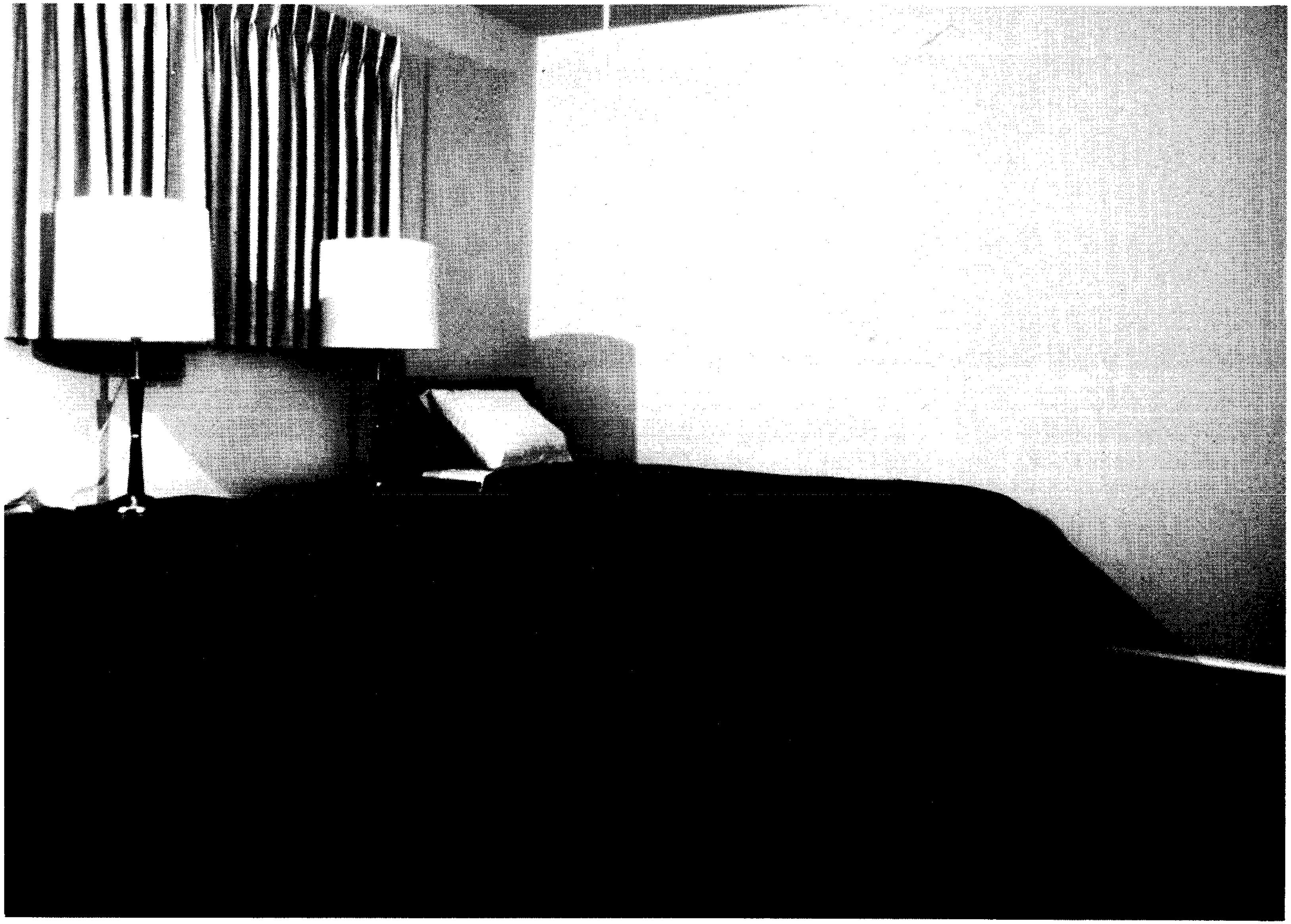
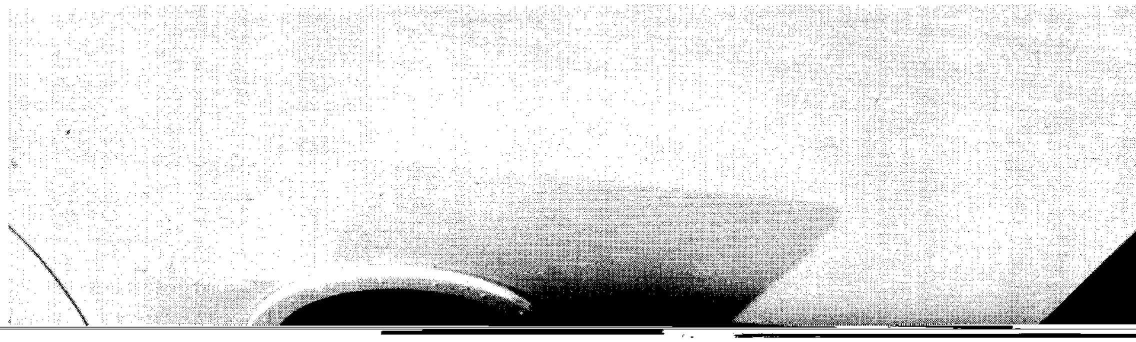
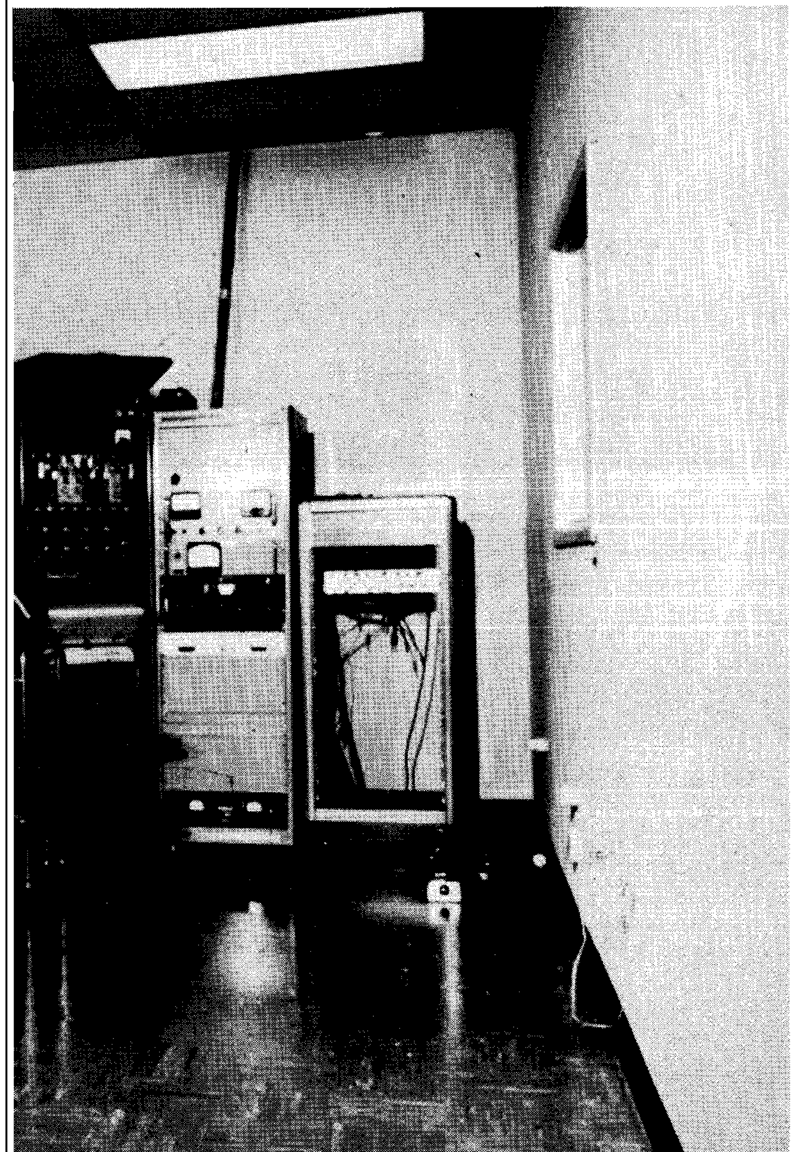


FIGURE 18. Bedroom for studies of human responses to impulsive noises at the Civil Aeromedical Institute, Oklahoma City, Okla.





es at the Civil Aeromedical Institute, Oklahoma City, Okla.