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NATIONAL BUREAU OF STANDARDS REPORT

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PRELIMINARY REPORT

ON

A STUDY OF CHILD BEHAVIOR

IN RELATION TO SAFETY RELEASE DEVICES

FOR REFRIGERATORS

FOR USE OF NEMA
TECHNICAL COMMITTEE
AND NBS PROJECT STAFF ONLY

NOT FOR PUBLICATION
OR DISTRIBUTION

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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NBS PROJECT **NBS REPORT**

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PRELIMINARY REPORT

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Sponsored by

The National Electrical Manufacturers Association

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NBS

U. S. DEPARTMENT OF COMMERCE
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ABSTRACT

This preliminary report presents a summary of the findings of a study of children's behavior in relation to safety release devices for refrigerators under simulated conditions of entrapment. Two hundred and one children were tested and records were obtained of behavior in relation to six different devices. Behavior patterns in the problem situation covered a wide range, and a multiplicity of factors affected the degree of success attained. The most important factors affecting success are the age, height, and weight of a child and the degree to which he applies purposeful, properly directed physical and mental recources. A statistical analysis is not included in this preliminary report but will be available later.

1. INTRODUCTION

1.1 Background

During the past two years there has been increasing awareness on the part of the public and the Congress of the fact that every year a number of children perish as a result of entrapment in iceboxes, refrigerators, and freezers. As numbers go, these are few compared with accidental deaths from other causes, but the appalling spectacle of even a small number of helpless children suffocating under this condition has aroused widespread interest in the problem. Congressional interest took the form of requests to the industry to provide inside release devices so that refrigerators might be opened easily from the inside. Several hearings were held in connection with proposed legislation requiring inside safety release devices, culminating in the passage of Public Law 930 at the Second Session of the 84th Congress, signed by President Eisenhower on August 2, 1956. This Act requires "certain safety devices on household refrigerators shipped in interstate commerce" that would allow the doors of such refrigerators to be opened easily from the inside. It further requires the development of standards for such release devices.

Consideration of the problem indicated that it was not only an engineering problem, but also a problem in child behavior.

In 1955, a subcommittee of the House Committee on Interstate and Foreign Commerce requested the National Bureau of Standards to work with the refrigerator industry in developing performance criteria for safety release devices. The industry contact was the National Electrical Manufacturers Association. Because of the element of child behavior inherent in the problem, the aid of the Children's Bureau was enlisted. NBS and NEMA developed a set of performance criteria on which agreement was reached with the principal exception of the magnitude of the force efforts which children might be expected to exert in attempting to free themselves from entrapment.

Late in 1955, the Children's Bureau and NBS conducted tests on children in nursery schools in an attempt to gain information on this point. In this preliminary experiment, some 60 children between the ages of two and five were tested in an experimental enclosure--which simulated a refrigerator only with respect to inside dimensions. The enclosure was suitably camouflaged to represent a gay red "Santa Claus chimney." The children were urged to use, and rewarded for using, their utmost strength in competitive pushing against the door of the enclosure, from both sitting and standing positions. These tests indicated that a significant proportion of the young children tested failed to exert forces in excess of 10 lbs. From practical manufacturing considerations, it is difficult to design a release device which will respond to a direct push of this magnitude on a refrigerator door.

At a hearing on May 28, 1956, the Subcommittee recommended that another investigation be conducted at NBS with the cooperation of the Children's Bureau. The Subcommittee at this hearing indicated that the investigation should provide additional information on the force efforts of children, as well as information on child behavior in general with respect to release devices currently obtainable, the experiment to be carried out under conditions simulating actual entrapment as closely as possible. No studies had been made under such conditions, insofar as could be determined.

1.2 Purpose and Authorization

The purpose of the study was to investigate the behavior of children under conditions simulating entrapment in a refrigerator, using inside release devices currently available and to observe child behavior with respect to children's ability to utilize such devices. The investigation was recommended by the Subcommittee on Health and Science of the House Committee on Interstate and Foreign Commerce, and financed in large part by the National Electrical Manufacturers Association, who provided a sum of $15,000 for this purpose.

1.3 Organization of Staff

The project staff consisted of two Study Directors, and two assistants from the field of child psychology recruited by the National Bureau of Standards. The Study Directors were Mrs. Marion L. Faegre, formerly of the University of Minnesota staff, and, until recently, Consultant in Parent Education at the United States Children's Bureau, and Mr. Robert S. Wyly of the NBS staff. The two research assistants were Mrs. Norma Gordon and Mrs. Elizabeth M. Lee. In addition to Mr. Wyly, another engineer, Mr. John J. Lantz, was assigned to the project to aid Mr. Wyly in designing, constructing, and maintaining the equipment required for the study and to assist the Study Directors in whatever ways might be necessary. Numerous other persons at the National Bureau of Standards cooperated in the project in important ways, notable among these being Mr. Warren Richardson and Mr. William Smallwood, who were responsible for the photographic services, and Drs. William Connor and Norman Severo of the Statistical Engineering Section of the Applied Mathematics Division, who provided advice on the design of the experiment and who are presently engaged in making a statistical analysis of the results. Figures 1 to 3, inclusive, show members of the project staff and others who provided consultation services and assisted in analyzing the data.

One of the many qualms felt in connection with using children in this study was the possible harmful effect on them of being enclosed. If it had not been for the use to be made of the results, the originators of the plan would not even have considered testing children under fear-invoking conditions.

Reassurance was given by the pediatricians and the child psychiatrist who served as advisers. They mentioned, as well, that children must often be subjected to painful experiences in medical diagnosis. Parents themselves pointed out that children often inadvertently get into situations as startling as this one would prove to be, without any apparent untoward effects. The degree to which a child would be upset

FIGURE 1. Mrs. Marion L. Faegre and Robert S. Wyly, Co-directors of the project.

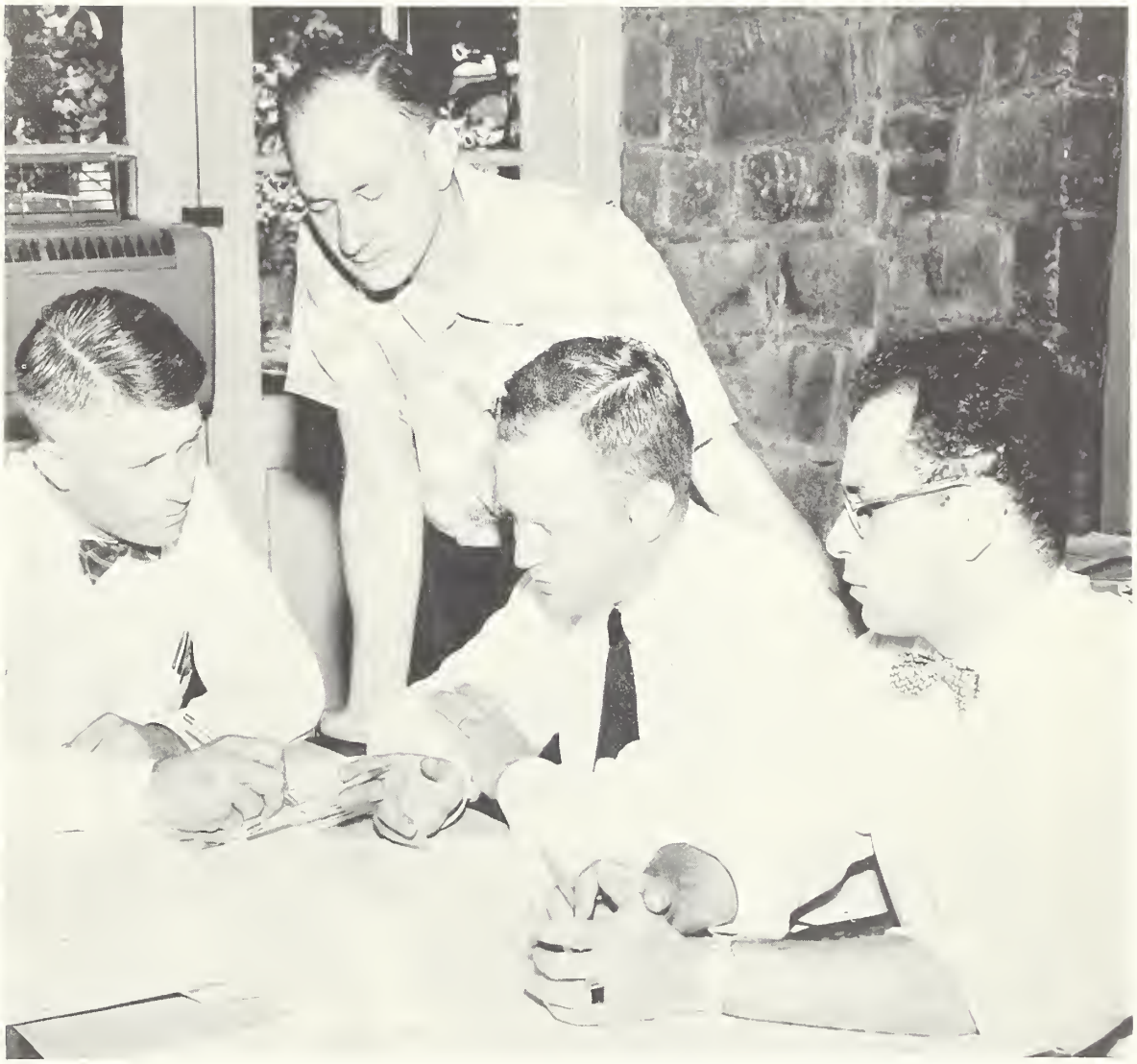

FIGURE 2. Robert S. Wyly and John J. Lantz, engineers, discuss problems with Dr. William S. Connor and Dr. Norman C. Severo, statisticians.

FIGURE 3. Mrs. Norma Gordon and Mrs. Elizabeth M. Lee talk over coding problems with Dr. William S. Connor and Dr. Samuel R. Pinneau.

is not so much a function of one situation as of the child's earlier experience. In other words, a child's reactions might well reflect his relationships with the people who have made up his world.

That young children recover very rapidly from a brief experience that makes them fearful or angry has been substantiated by research. In an effort to make the entrapment bearable, not only by the children but by the experimenters, a time limit was proposed. Three minutes was suggested as the maximum time that the children might safely be allowed to cry. Actually, no child was allowed to cry that long.

Especial care was taken to see that after-test experiences were pleasant and that the children left in a cheerful, relaxed frame of mind.

1.4 Contributions from Outside Consultants

In addition to having the cooperation of the Children's Bureau on this study, consultation was given by local experts in a number of fields. Dr. Katherine Bain and Dr. Marian M. Crane, pediatricians, served as liaison with the Children's Bureau and made a number of visits during the course of the study. They were also present at an all-day conference following the preliminary testing (described in 1.5 below) when contributions were made by the following individuals from outside the two Bureaus:

Dr. Nancy Bayley, Chief
Child Development Section
Laboratory of Psychology
National Institute of Mental Health

Dr. Reginald S. Lourie, Director
Department of Psychiatry
Children's Hospital
Washington, D. C.

Dr. Samuel R. Pinneau
Assistant Research Psychologist
Institute of Child Welfare
University of California.

Dr. Pinneau also spent two days with the project staff at the time of this conference, developing test procedure, and returned for a week's stay in September, working then with the statisticians deciding on the statistical problems involved in analyzing the data.

Dr. Lourie's statement, at the conference, that he believed the experience of being briefly enclosed in a small dark place would not be a harmful one, was relied upon by the project staff in making decisions relating to the length of time which could be tolerated safely by children entrapped in a dark enclosure, and to the general procedure to be used in handling the children who would participate in the tests.

Dr. Lourie visited the project later, and viewed the motion picture records. He returned again when the data were being analyzed and gave advice which was very helpful in drawing conclusions.

1.5 Preliminary Tests

A preliminary test series on 16 Subjects was begun on July 6, 1956, using the release device reacting to a minimum push of 18 lbs., which was identical to that referred to later in this report as "device D_1." On these first 16 tests, the interior of the playhouse was brightly lighted before the child entered and during the test period. Movies were made of several of these tests on standard film. On the first 11 tests, one or both parents accompanied the child to the test room and were near the playhouse when the child entered it. For the first 11 children, a small ledge on the rear wall of the playhouse was baited with

miniature marshmallows. Four of these 11 children removed the candy by reaching in without making a complete entry. They were then asked to paste a decal on an inside wall. One large boy of seven removed candy and pasted several pictures with only a partial entry and was then asked, "Do you think you could fit into the house?" Dr. Pinneau was the Experimenter with five other children, who were engaged in an elaborate game of hide-and-seek, which was begun on the lawn and continued into the test room. The children imitated the Experimenter after he had first used the playhouse as a hiding place. The door was not closed until after the child had used the playhouse as a hiding place several times.

Before formal testing was begun on July 24, the following techniques were adopted and plans completed for their implementation:

1. To limit the Subjects to two through five years of age

2. To test children on each device in blocks of 16 with an equal number of each age and sex

3. To use a Disney cartoon with sound effects as a lure, projected on a recessed screen on an interior wall (It was felt that this lure might have the most universal appeal to the Subjects.)

4. To test the children in complete darkness in order to more closely simulate the actual conditions of entrapment

5. To regard as maximum, three minutes of restriction for children who were moderately upset, and to release children earlier who were more upset, at the discretion of the Observer.

On July 23, four children, one in each age two through five years, were tested in the dark and the cartoon was used as the lure. These tests were conducted under the planned conditions for the purpose of gaining experience and facility with equipment and techniques before starting the tests which are presented later in this report.

2. DESCRIPTION OF TEST EQUIPMENT

2.1 Environment for Experiment

Considerable thought was given to the problem of a satisfactory environment for the experiment. Obviously, the ideal environment should approach that to which children are accustomed at home or at play. After due consideration, which will be treated in some detail later in the report, the choice of space in a building on the National Bureau of Standards grounds originally built as a private mansion was made. Two large first-floor rooms of the building, separated by a flagstone terrace, were assigned to the project--one room being used for office and reception quarters and the other for testing quarters.

2.2 Test Enclosure

The test enclosure consisted of a plywood structure somewhat resembling a child's playhouse, suitably decorated, complete with door, roof, and chimney. (See Fig. 14.) The inside dimensions of the compartment provided for the children to enter were, approximately, 40 inches high, 18 inches deep, and 25 inches wide. These dimensions were arrived at after making measurements of a number of currently available household refrigerators of 8 to 11 cu. ft. capacity, and are believed fairly to represent the maximum inside dimensions of refrigerator boxes excluding the space occupied by the freezing unit. A safety-glass panel was provided at the rear of the enclosure for the purpose of direct observation of the behavior of the children through a "snooperscope" which will be described later. Another safety-glass panel was provided at the top of the compartment occupied by the children while under test, for the purpose of taking motion pictures of the children from above. The walls of the playhouse extended upward about 16 inches above this glass panel to join the removable roof section and to house a 16-mm motion-picture camera and associated illumination equipment. (See Fig. 21.)

Included in the design of the playhouse were provisions for forced ventilation. A number of small holes were provided in the floor of the structure,

passages were provided joining the lower and upper compartments (the lower terminals of these passages being covered by grilles), and an air blower was incorporated in the roof structure to exhaust the air pulled through the lower and upper compartments. (See Fig. 14.)

Three different identical doors were provided into which different release devices and latches were incorporated. (See Fig. 20.) This greatly reduced the time required for changing from one release device to another as tests proceeded, since the change-over was largely reduced to the matter of substituting a door with the appropriate release device already positioned in the door structure. Provisions were also made on the door jamb to facilitate the change of door keepers which accompanied changing from one door to another. (See Fig. 22.) These provisions also included an adjustable spring-loaded plunger in the door jamb (See Fig. 22.) for the purpose of simulating gasket pressure and setting the desired releasing force on certain devices.

2.3 Devices Utilized

Three different release devices were furnished by the refrigerator industry for use in the experiment. Two of these devices were designed to operate on the application of sufficient direct force on the door panel. The third device was designed to operate by depressing a trigger mounted on the door panel near the latch edge of the door. Three additional devices were studied in the experiment, one of these being a modification of the trigger device submitted by the industry. The modification consisted of the utilization of a doorknob-like arrangement responding to turning in either direction, pushing, or pulling. Another of the additional devices consisted of a movable floor panel so designed that horizontal thrust in any direction caused the door to open. The third additional device was similar to the second, except that it was arranged, not to open the door, but to

give an indication on the dial of a gage of the amount of horizontal thrust exerted on the floor panel by the children while in the test enclosure. The various devices were designated D_1, D_2, D_3, D_4, D_5, and D_6. Further description of the various devices follows.

Device D_1 consisted of a hooking latch mechanism so designed that direct force of sufficient magnitude applied to the door panel caused the hook to disengage by cam action from the roller which served as the door keeper. (See door at extreme right in Fig. 20.) The most effective point of application for releasing force was at the latch edge. The required releasing force increased steadily with distance toward the hinge edge. Before removing the latch from the refrigerator on which it had been installed by the manufacture, force measurements were made, and observations taken on its operation in releasing. In addition, similar measurements and observations had been made on another similar, interchangeable latch furnished by the manufacturer. Preliminary measurements (on the refrigerator supplied for test) made of the releasing force applied near the latch edge of the door, with the latch and keeper unchanged in adjustment from that made by the manufacturer, showed that a force of 18 to 20 lbs. was required to open the door. In the tests on children made using the test enclosure described in 2.2 above, the latch mechanism included on the refrigerator furnished was used, and was adjusted to release with a force of 18 lbs. applied to the door panel at the junction of the inside edge of the door jamb and the door panel--in other words, at the closest point to the latch edge of the door accessible to a child. Observations of the latch mechanism, both in the refrigerator and in the test enclosure in which it was later incorporated, showed that the releasing action occurred in two stages. The first stage consisted of a partial disengagement of the hook accompanied by a slight outward movement of the door, this taking place with the

application of a force somewhat less than 18 lbs. If this force was removed, then the door showed a distinct tendency to move back into the fully closed position. On the other hand, if the force was further increased in magnitude to the full 18 lbs., the second stage of action occurred, this being final disengagement of the hook with full release. Final disengagement could occur only when the latch edge of the door moved away from the door jamb a distance of the order of 1/4 to 3/8 inch.

Device D_2 consisted of a permanent magnet near the latch edge of the door which made contact with a metal plate in the door jamb. (See middle door in Fig. 20.) Preliminary measurement of the releasing force required against the door panel of the refrigerator on which this device was furnished showed that at the junction of the door panel and the door jamb at the latch side of the door panel a force of 11 to 12 lbs. was required to open the door. When this device was incorporated into the test enclosure described under 2.2 above, the releasing force was set for 12 lbs. As in the case of device D_1, the releasing force increased with distance towards the hinge edge of the door. Device D_2 released positively when the required force was applied to the door panel. This could have been predicted since it is well known that the magnetic pull in a situation like this would decrease very rapidly with separation of the magnet and its strike plate which served as the door keeper in this device.

Device D_3 consisted of a hocking-action latch supplemented by a trigger release mechanism to which was connected a luminous ring placed on the door panel near the latch edge of the door. (See door at left in Fig. 20.) When the door was closed, the luminous ring was clearly visible from inside the enclosure and the manufacturer's name and trade-mark designation could be read clearly. The word "push" printed in the center of the ring was not legible, since the luminous

material did not extend into this area. Preliminary measurements of the force required at the center of the ring for triggering the device showed that a force of 6 to 8 lbs. was required, depending on the velocity of door closure and on the particular adjustment of the latch and strike, those measurements being made on the refrigeratur furnished by the manufacturer. Obviously, release could occur only when force was applied to the ring or the lever to which it was attached. Direct force on the door panel would not open the door. Release occurred positively when the necessary force was applied to the ring, this action taking place when the trigger mechanism retracted the roller used to engage the door keeper back to the point at which it disengaged from the keeper, at which time spring tension in the latch mechanism caused the roller to roll outward on a sloping surface of the keeper, thereby starting the door to swing open. In the tests made in the enclosure described under 2.2 above, the device was adjusted to release when a force in the range of 5 to 6 lbs. was applied at the center of the luminous ring at right angles to the door panel, with the exception that in 10 tests the releasing force was of the order of 8 to 10 lbs. However, these 10 tests were later repeated with a releasing force of 5 to 6 lbs.

Device D_4 consisted of a modification of device D_3. In this modification a steel shaft was extended horizontally from front to rear through the door panel, mounted on sleeve bearings just above the latching mechanism. Near the midpoint of the shaft a V-shaped piece of sheet metal was welded to the shaft and was extended down to engage the latching mechanism in such a manner as to act as a trigger when the shaft was turned in either a clockwise or counter-clockwise motion, or when it was pushed in or pulled out. Release occurred with a turning motion on the order of 30 degrees, or with a pushing or pulling movement on the order of 1 inch. A knurled knob of about 2 3/8 inches in diameter was mounted on the inner end of the

shaft and the luminous ring 2 1/4 inches in diameter (described in connection with device D_3 above) was attached to the face of the knurled knob. Measurements made on this device showed that the following forces and turning moments were required to release the door: a pull of 3.5 lbs., a push of 5.0 lbs., a clockwise moment of 4.2 in.-lbs., or a counterclockwise moment of 2.5 in.-lbs.

Device D_5 consisted of a combination of device D_2 with a floor panel floating on ball bearings. (See Fig. 24.) A steel plate attached to the center of the bottom of the floating floor panel carried a machined and polished conical cavity, the cone having a total included angle of 90 degrees. The inverted conical cavity rode on top of a brass sphere which in turn was firmly attached to the rearward end of a metal bar extending beneath the floating floor panel to the forward edge of the test enclosure and pivoted on bearings at its midpoint. (See Fig. 25.) The forward end of this "see-saw" bar was cut off in a plane about 20 degrees from the vertical and this surface polished. A similar mating surface was provided on the face of a steel plate attached rigidly to the lower part of the door panel midway between the latch and hinge sides of the door. When sufficient horizontal thrust occurred on the floor panel, this resulted in a slight horizontal movement which depressed the brass sphere riding below the conical cavity; this caused the rear half of the "see-saw" to move downward and the front half to move upward, the door being forced open as a result of movement of the slanting surface of the front end of the "see-saw" bar against its mating surface on the door panel. A horizontal thrust of approximately 12 lbs. on the floor panel loaded with a weight of 30 to 50 lbs. was sufficient to open the door. A special feature of this device was that a child standing on the floor panel and directing a thrust against the door panel would also be exerting an equal and oppositely-directed thrust on the floor panel. These two force efforts were then additive, and decreased the amount of

effort required to open the door as compared to the case when a thrust was directed at a side or rear panel. This was verified during the tests by securing the co-operation of a particularly advanced 5-year-old girl who was able to manipulate a pressure gage and to read the dial of the instrument accurately. Her report of forces registered while standing on the floor panel and pushing at various points with the instrument verified almost exactly what would have been expected from the construction of device D5. For instance, she reported a releasing force of 12 lbs. from pushing on a side panel, and 6 lbs. when pushing on the door next to the latch edge. Incidentally, this girl was a test subject who had just previously been successful in releasing herself from the test enclosure.

Device D_6 was identical to device D_5 insofar as the movable, floating floor panel was concerned. The essential difference was that instead of employing the door and latch used with device D5, the door and latch originally included in the D3 arrangement was used with the releasing trigger mechanism and luminous ring removed. In addition, a second "see-saw" bar was mounted through the lower part of the door in such a manner that horizontal thrust on the floor panel was transmitted through the first "see-saw", thence through the second "see-saw" which was attached to a force gage where it extended through the door panel, at which point the force was registered on the dial of the gage. A locking bar was provided beneath the floor panel (See Fig. 25.), with access behind the test enclosure, so that prior to a test, the floor panel could be immobilized in a centralized position, and could afterwards be activated at will by the testing personnel. The readings on the dial of the force gage were transmitted by a system of mirrors to the lens of a telescope mounted at a suitable location behind the

scenes, * so that an observer at that point could record the force efforts resulting from horizontal thrust on the floor panel. (See Figs. 18 and 19.) No child could escape by his own efforts from the test enclosure using device D_6, but his actions transmitted certain forces to the floor panel. These were recorded, the various other types of record were obtained on him, and, at the Observer's decision, he was released.

2.4 Photographic Equipment

A 16-mm motion-picture camera was mounted in the upper compartment of the test enclosure described under 2.2 above, shooting downward at a slight forward angle through the safety-glass panel separating the upper and lower compartments of the test enclosure. Illumination suitable for infrared photography was provided by four 50-watt light bulbs, in the four corners of the upper compartment, filtered by 4-X-4-inch squares of infrared photographic filters. Two vertically positioned plywood separators were used to divide the upper compartment horizontally into two subcompartments for illumination and one subcompartment for connecting the camera lens and the safety-glass panel which divided the upper and lower compartments. Each of the illuminating subcompartments housed two 50-watt light bulbs and two infrared filters, was 6 inches in width and 8 1/2 inches in depth, and extended from the front to the back of the test enclosure. The light bulbs were attached to removable covers which fitted over the subcompartments, each cover being provided with four 1-inch diameter holes for the purpose of ventilation. The filters were placed directly beneath the light bulbs, recessed into a wooden light

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* It was necessary for the telescope operation to be behind the scenes so that his presence would not be known to the children. The force gage and adjacent mirror arrangement on the door were not noticed by the children prior to the test, as a child and the gage and mirror were on opposite sides of the open door at that time.

shield covering the safety-glass panel which formed the bottom of the subcompartments. In this way, with suitable lightproofing around the filters and the door, the only illumination that entered the lower compartment when the door was closed was infrared, this being insufficient for the children to see anything by. A black felt hood was used to connect the lens of the camera to the top of the subcompartment formed between the illumination chambers and extending down to the safety-glass panel. This assured that white light from the light bulbs coming through the ventilation holes in the light chamber covers could not reach the camera lens. The air blower in the roof assembly provided ventilation for the children being tested in the lower compartment, and cooling for the light bulbs and filters, as a result of the passage of air through the light chambers. The felt connecting hood was designed so that its upper terminus could be secured around the camera lens by means of a heavy rubber fitting which could be slipped off easily to allow removal of the camera.

The motion picture camera was motor driven permitting photography the full time the subject was in the enclosure if so desired. The lens was a 15 mm wide angle covering as large an area as the construction of the test enclosure would permit. The lens opening was F2.8 and the distance set at about two and a half feet giving a depth of field of approximately two feet which covered the action of the Subject in the area of greatest interest. The motion pictures were taken with high speed infrared film on 100 ft. spools using a camera speed of 16 frames per second which permitted the taking of a maximum number of pictures per reel of film.

The problem of a standard technique to attract the children to enter the test enclosure voluntarily required considerable thought. Preliminary tests in which the children were asked to paste pictures on the interior or in which candy was placed in the enclosure did not seem to be satisfactory. Another technique was tried in preliminary tests, consisting of a game of hide-and-seek between the

Experimenter and the test subject. This seemed to have promising possibilities, but was abandoned because of the excessive amount of time it consumed. After a number of preliminary tests were made under these conditions, it was decided to project a miniature Walt Disney color cartoon on a frosted glass screen recessed into the side of the test enclosure. This proved quite attractive to the children, and was used throughout the tests from that point onward. A 16-mm projector was

(continued on page 15)

used to project the cartoon. The image was projected onto a vertical mirror at 45° to the line of projection, from which it was directed to the screen. A sound speaker was placed beneath the floor of the test enclosure. The location of the screen in the recess made it necessary for the children to get all the way into the enclosure in order to view the cartoon. A hinged shutter was provided to permit closing off the projected image at will and at the same time shutting off all light transmitted through the screen. The outside of the shutter carried another mirror at 45° to the line of projection for the purpose of projecting the cartoon onto another screen which could be viewed from outside the enclosure after completion of the test

A "snooperscope" was used by the Observer to view the children under infrared illumination while they were inside the test enclosure. This piece of equipment converted infrared light into white light so that the Observer could view the activities of the children. The field of view of the "snooperscope" was limited to about 8 inches in width, but by mounting the scope on a universal swivel, it was possible to observe the full area to be covered. This equipment was powered by a 6-volt automobile battery.

2.5 Sound-Recording Equipment

A tape recorder was used to obtain a direct report by the Observer who watched the child through the snooperscope. The same tape recorded all vocalization by the child. One microphone was provided at the rear of the test enclosure to pick up the vocalization of the child and another near the snooperscope to catch all comments made by the Observer. In one group of tests, a second tape recorder and microphone were provided so that the telescope operator might report readings of force which he observed on the dial of a pressure gage through the telescope.

2.6 Force-Recording Equipment

Two different approaches to the problem of forces exerted by the children were used. The first approach, used in connection with tests on device D_1, utilized an electronic gage designed to measure deflection and a recorder to obtain a permanent

record of the deflection. The latch keeper for device D_1 was attached at the mid-point of a steel bridge approximately 6 inches long, 1/8 inch thick, and 1 inch wide When the door was closed, the force with which the latch held the door closed caused a small initial deflection of the bridge and any thrust on the inside panel of the door caused an additional slight deflection of the bridge, which was registered on the recorder. By the use of a force gage, it was possible to calibrate the recorder trace directly in terms of force transmitted to the keeper.

The second approach, used in connection with device D_6, consisted of the use of a force gage attached to the outside of the door, two mirrors, and a telescope. The force of horizontal thrust on the floor panel was registered on the dial of the force gage and observed by an operator stationed at the telescope. This operator obtained the force record by speaking into a microphone attached to a tape recorder. This arrangement was described in some detail under 2.3 above.

3. TEST METHODS

3.1 Design of Experiment

The sampling procedure for the experiment was designed with the help of the Statistical Engineering Section of the Applied Mathematics Division, National Bureau of Standards. The items considered were (1) device, (2) experimenter, (3) sex of Subject, and (4) age of Subject. It was considered desirable to consider also a fifth item, socio-economic group. However, it proved impractical to include this factor because of the difficulties of securing children for test properly grouped according to the four other factors and at the same time grouped into the desired socio-economic group. This problem was further complicated by the fact that a significant majority of the available Subjects would be drawn from the higher socio-economic group. In order to include this factor it would also have been necessary for parents volunteering more than one child to make multiple trips to

bring their children on different days. The number of years of school attendance of both parents was listed, along with parents' occupations, which provided a rough index of socio-economic status.

Tests were set up for ages 2, 3, 4, and 5 years, with equal numbers of children in each age. Plans called for two groups of 16 tests each for each device tested, with change of devices after each 16-Subject group, which included two boys and two girls of each age. Insofar as practicable, each of the two Experimenters handled equal numbers of children of each age. Three Observers were used, but the distribution of the Observers among different ages and devices did not follow any consistent pattern. This was partly the result of a practical problem resulting from the fact that one of the Observers could be present only three days a week.

3.2 Sources of Test Subjects

A letter to the staff of the National Bureau of Standards was distributed, explaining the nature of the study in broad terms and inviting the cooperation of the staff through volunteering their children and grandchildren for the tests. The response was generous and gratifying, and most of the Test Subjects were obtained as a result of this letter. A number of Subjects were obtained as a result of a similar letter distributed to the staff of the Diamond Ordnance Fuze Laboratories, an organization located adjacent to NBS. Additional Subjects were obtained as a result of requests made of personal acquaintances and neighbors of project staff members and parents who had volunteered children for test earlier.

3.3 Records

A record card was kept on each child who was tested. Parents were asked to fill in their names, years spent in school, and occupation, and to give their children's names, sex, and birth dates. A staff member recorded on this card the date of test, device tested, and child's height and weight. A complete narrative

about behavior during the child's experience in the test enclosure was recorded on a tape as it was observed through the snooperscope. Time was recorded, at ten-second intervals, on this same tape by an Engineer. At the conclusion of the test, the Observer filled out a written summary of all the enclosure behavior regarded as pertinent.

After the test, the Experimenter filled out a report describing briefly the procedure followed, a brief personality description, and the reactions of the child before and after the test.

For the series of tests on device D_6, a verbal report of forces, exerted by the children and registered on the dial of a pressure gage, was recorded on tape during each test. This record was later correlated with the time record appearing on the Observer's tape record. In connection with tests on device D_1, an unsuccessful attempt was made to obtain force records by another method.

A movie record was made of the behavior of the first 42 Subjects and of the last 38 Subjects during their tests. It had been planned to obtain a movie record of each test. Unfortunately, insurmountable problems concerned with the procurement of the specially prepared and highly perishable infrared film required made it impossible to obtain the complete film record that had been planned originally.

3.4 Test Procedure

It was realized early in the planning stage that the ideal environment would approach that to which children are accustomed in the home or at play. However, it was also recognized that practical problems and the requirement for all possible haste in obtaining results precluded the possibility of conducting the experiment in children's homes or at nursery schools. Furthermore, the environment of a formal laboratory or office building did not appear to be desirable. These considerations dictated the choice which was finally made--that of space in a large building on the National Bureau of Standards grounds originally built as a private mansion. The

spacious, well-landscaped lawn surrounding the house, together with the large terrace in the rear of the building contributed much to the environment desired. Two rooms of the building, separated by a flagstone terrace, were assigned to the project. The room used as office and reception quarters had three entrances, one through the front door of the mansion and the large center hall, another opened onto the terrace, and the third opened directly onto the lawn. The other room was used as the test room, entrance normally being across the terrace from the side door of the reception room. In inclement weather, entrance to the test room was through the center hall.

In the office-reception room, toys, crayons, and coloring books were provided for the children, and magazines for the parents were placed in obvious view.

After greeting the mother (and/or father) and child, the Experimenter who was to handle the child during the test chatted with the parents and made friends with the child. She diverted the child's attention to the toys and most of the children played happily in the office-reception room until it was time for them to go with the Experimenter to play ball on the terrace and from there to the test room. The length of time the Experimenter spent with the child depended somewhat on the day's schedule of tests. Parents remained in the office while each child was individually taken to the test room. The separation from the parent sometimes required finesse, particularly in the case of younger children. It was a good deal easier to become acquainted with the children if the parents were occupied. The parents were given forms to fill out covering the needed information. Once they were "on their own", the children could almost invariably establish a satisfactory relationship with the Experimenter and go willingly with her to the test room. In only three cases were children so determinedly noncooperative that attempts to test them had to be abandoned.

After playing on the terrace, the Experimenter brought the child into the test room. After weighing and measuring the child, the Experimenter continued playing ball with the child, gradually leading him across the room in the direction of the playhouse. Many children were curious about the playhouse from the time they entered the room, but the attention of other children had to be drawn to it. The experimenter signalled to the Engineer behind the scenes when she considered the time was right to start the cartoon in the playhouse.

The sound track with its music and Donald Duck chatter often attracted the child into the playhouse. In some cases, the Experimenter would stimulate the child's interest in going in to see the movie by talking about the movie to the child. The film was projected onto a screen 5 X 8 inches recessed on the left anterior wall of the house, and the child had to go completely inside to see the cartoon. Sometimes, if it seemed necessary, the Experimenter bent down to look at the movie and told the child what was going on to further interest him in going inside.

As soon as the child was absorbed in the film, the Experimenter told him she was leaving to go back to the office, or otherwise tried to convey to him the idea that he would be alone. At that time, the Observer, who was all this time behind the playhouse observing the child through a mirror placed high on the wall of the test room, closed the playhouse door. Simultaneously the cartoon stopped, the playhouse became dark, the shutter closed on the screen, the sound- and force-recording equipment began to function, and the movie camera (concealed in the chimney) began taking infrared pictures of the child from above his head. The Observer viewed the child through the snooperscope and recorded her observations on tape. The operators who manned the recording equipment also put on tape appropriate comments with respect to time read from a stopwatch, to the force output of

FIGURE 4. Mrs. Elizabeth M. Lee greets a mother arriving with three children to be tested.

FIGURE 5. A mother and her three children are greeted by Mrs. Marion L. Faegre as they arrive for the test.

FIGURE 6. Mrs. Norma Gordon and a child enjoy ball play on the terrace before a test.

FIGURE 7. The playhouse as it appeared to the child before the test.

FIGURE 8. The experimenter, ready to comfort this child after the test, finds reassurance unnecessary.

FIGURE 9. This child after the test takes his experience seriously, but with composure.

FIGURE 10. A 2-year-old comes out tearfully.

FIGURE 11. After the test, this child quickly becomes absorbed in the color cartoon projected on screen outside playhouse.

FIGURE 12. At the conclusion of testing, four brothers and their sister enjoy seeing a second showing of the color cartoon.

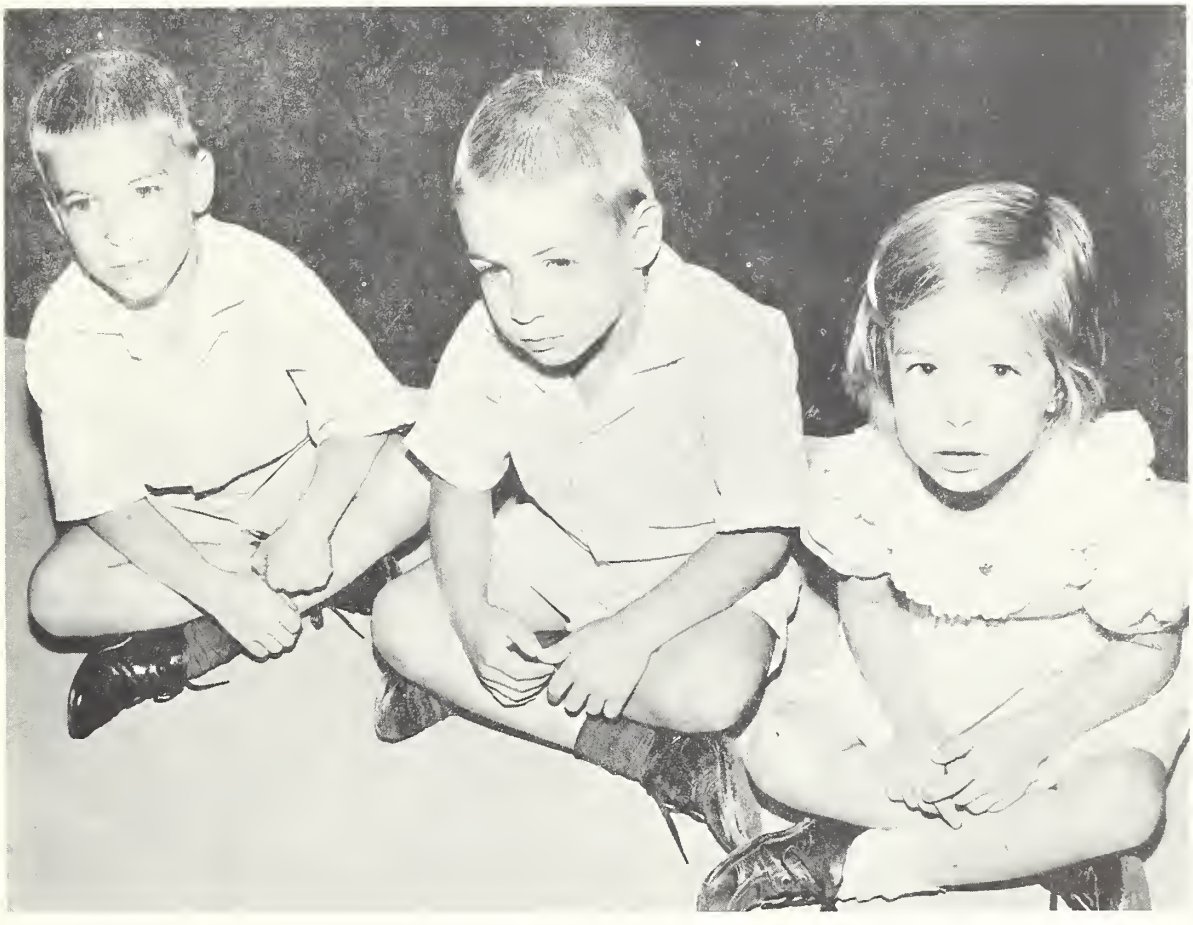

FIGURE 13. After testing, these children are viewing the Disney cartoon.

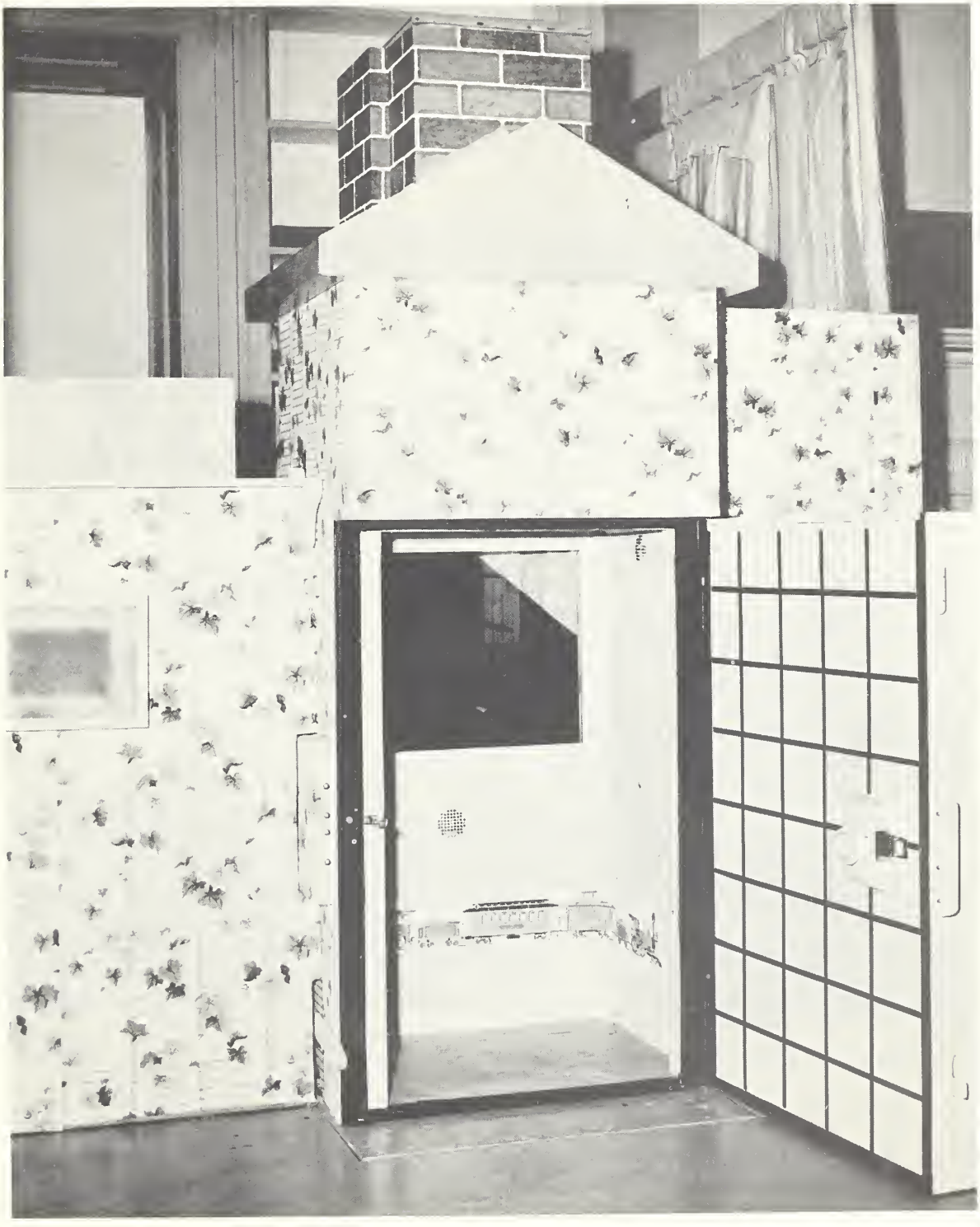

FIGURE 14. "Playhouse" test enclosure.

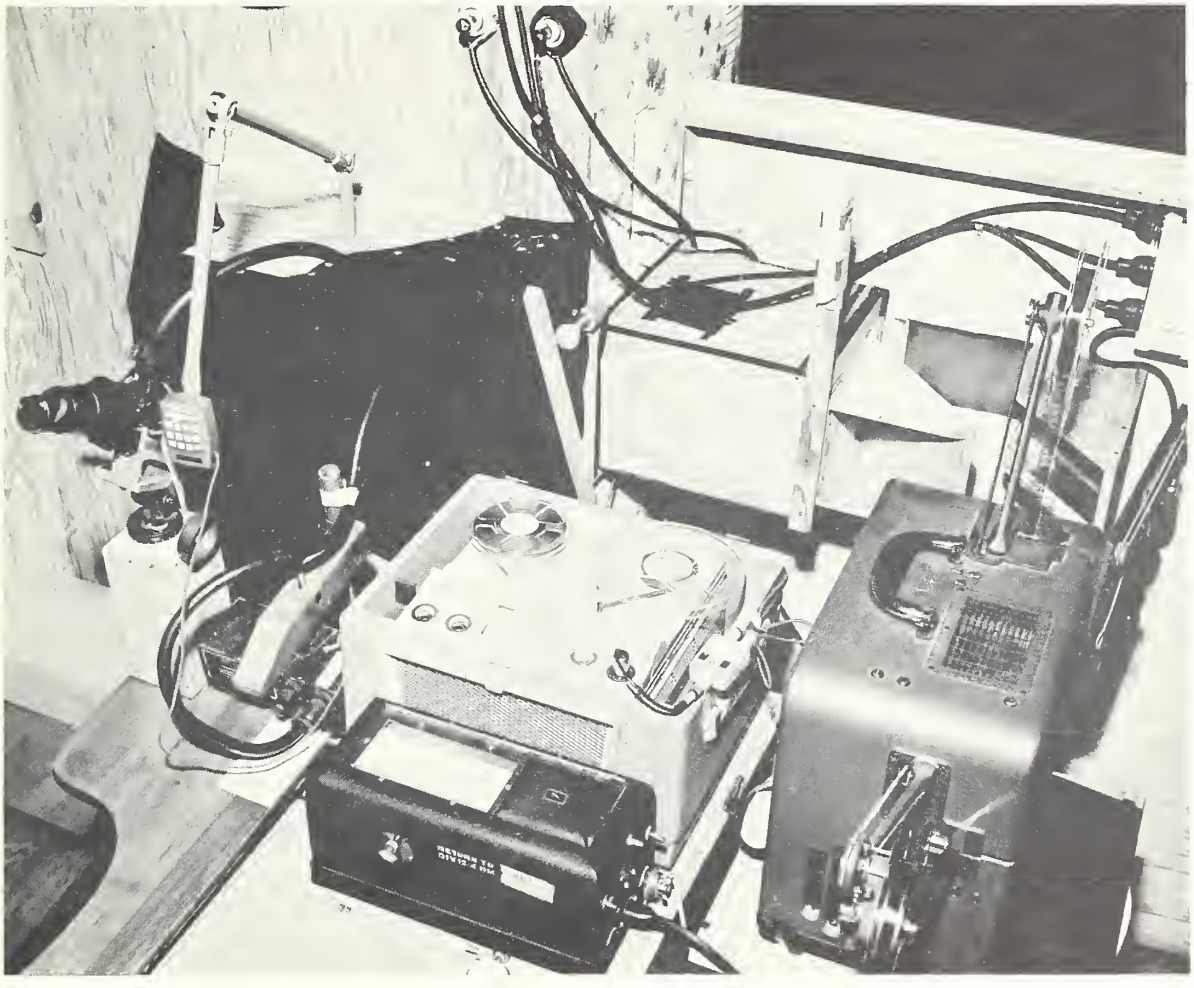

FIGURE 15. Equipment behind the test enclosure to obtain behavior records.

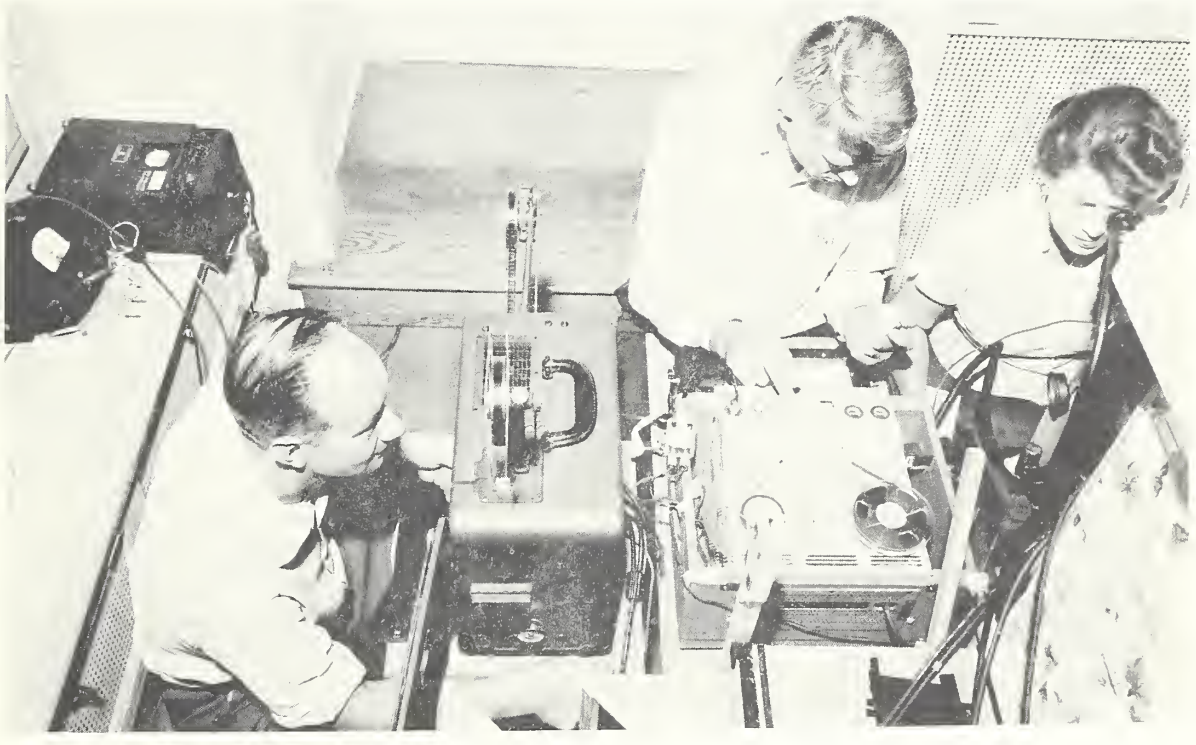

FIGURE 16. Projectionist, time-sound coordinator, and observer during a test.

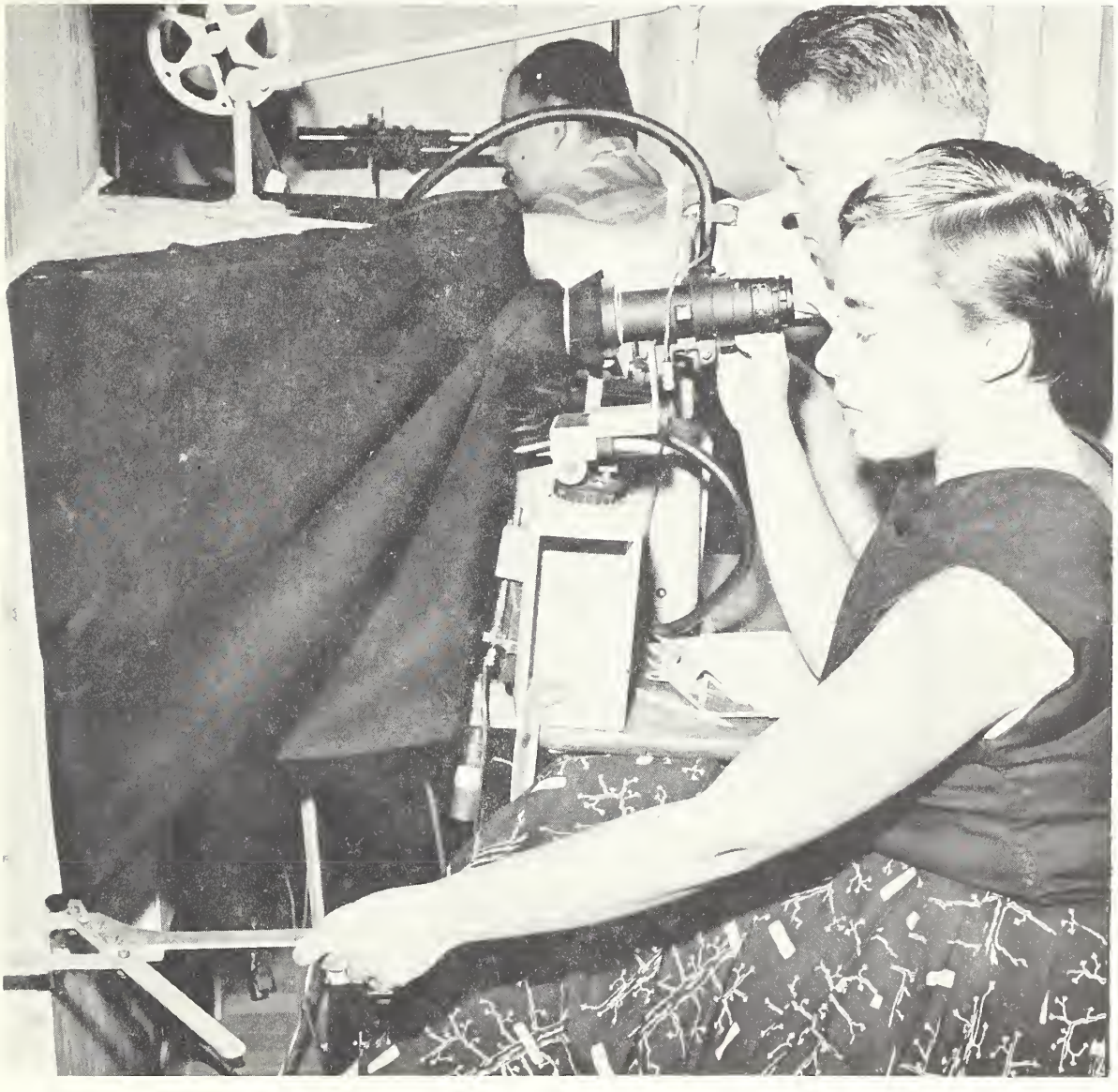

FIGURE 17. Observer at Snooperscope, hand grasping lever used to close enclosure door.

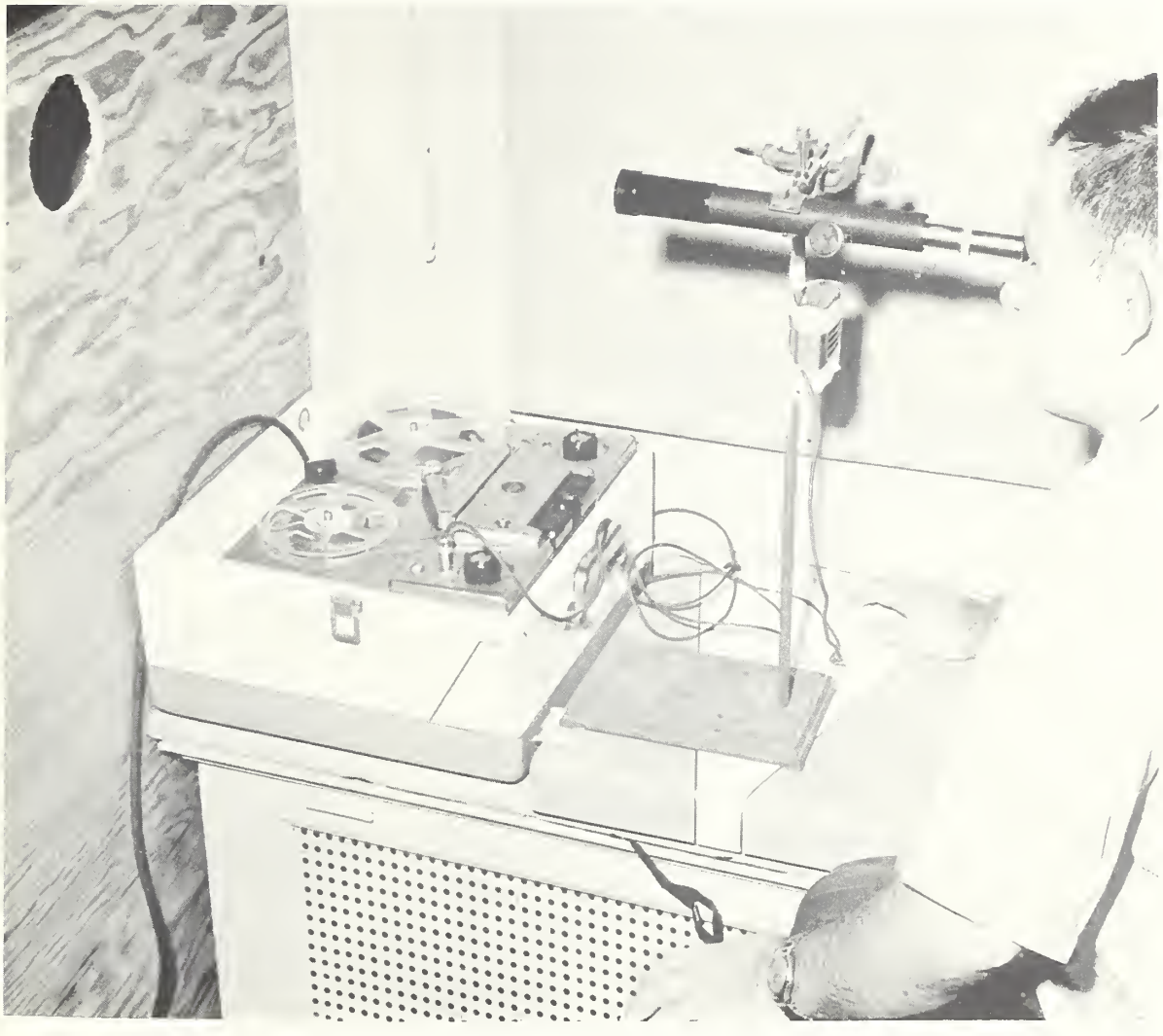

FIGURE 18. Operator using telescope and tape recorder to obtain a record of force efforts registered on pressure gage.

FIGURE 19. Pressure gage and mirror on exterior of door.

FIGURE 20. The three separate, interchangeable doors provided for facilitating changeover from one release device to another.

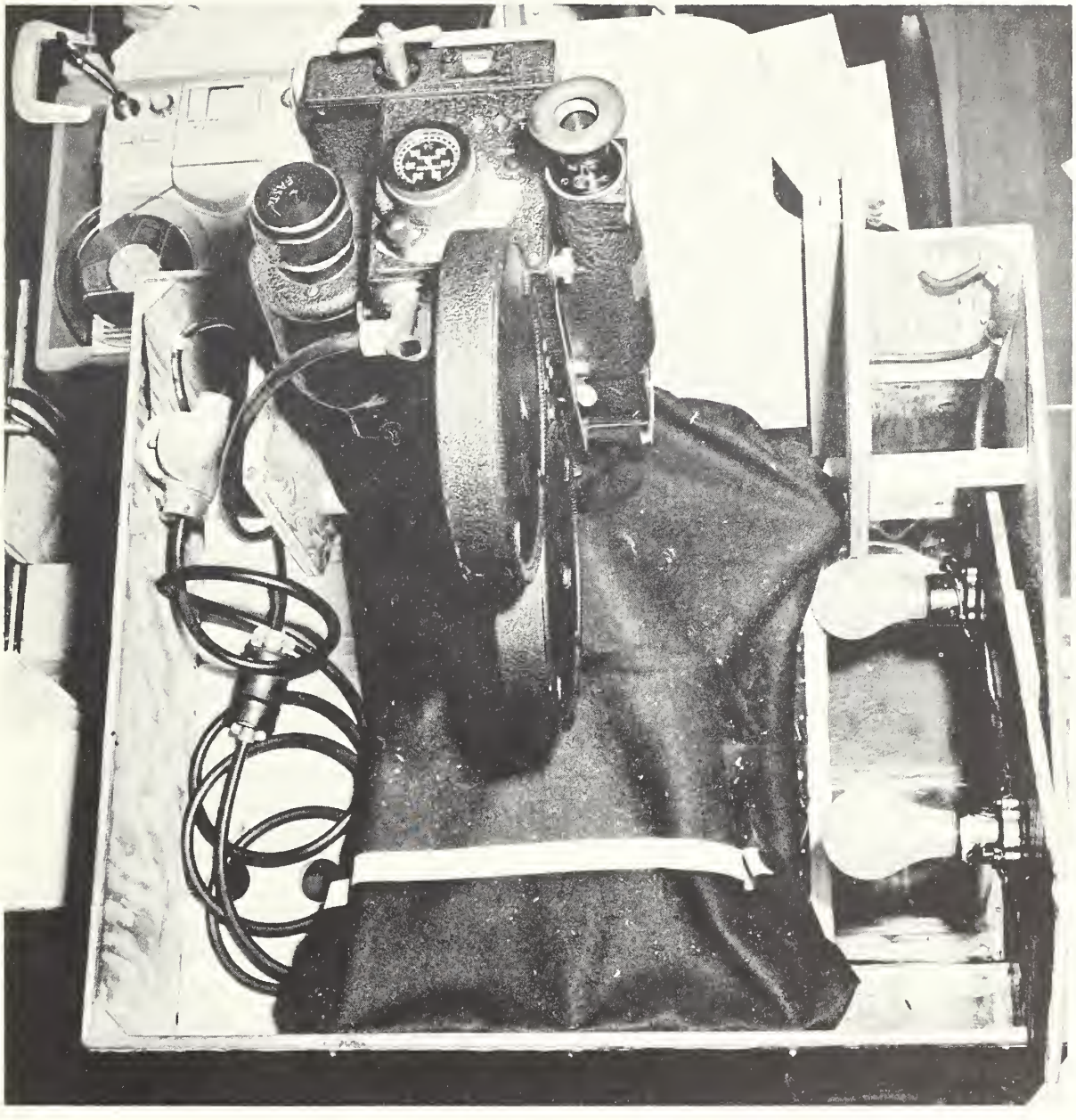

FIGURE 21. Motion picture camera and lighting equipment used for obtaining infrared pictures of children in test enclosure (during actual testing the camera was concealed beneath the roof assembly; see fig. 14).

FIGURE 22. Assembly in door jamb to which door keepers for different release devices were attached (molding has been moved to right to show assembly).

FIGURE 23. Construction detail of knob release responding to push, pull, or turn.

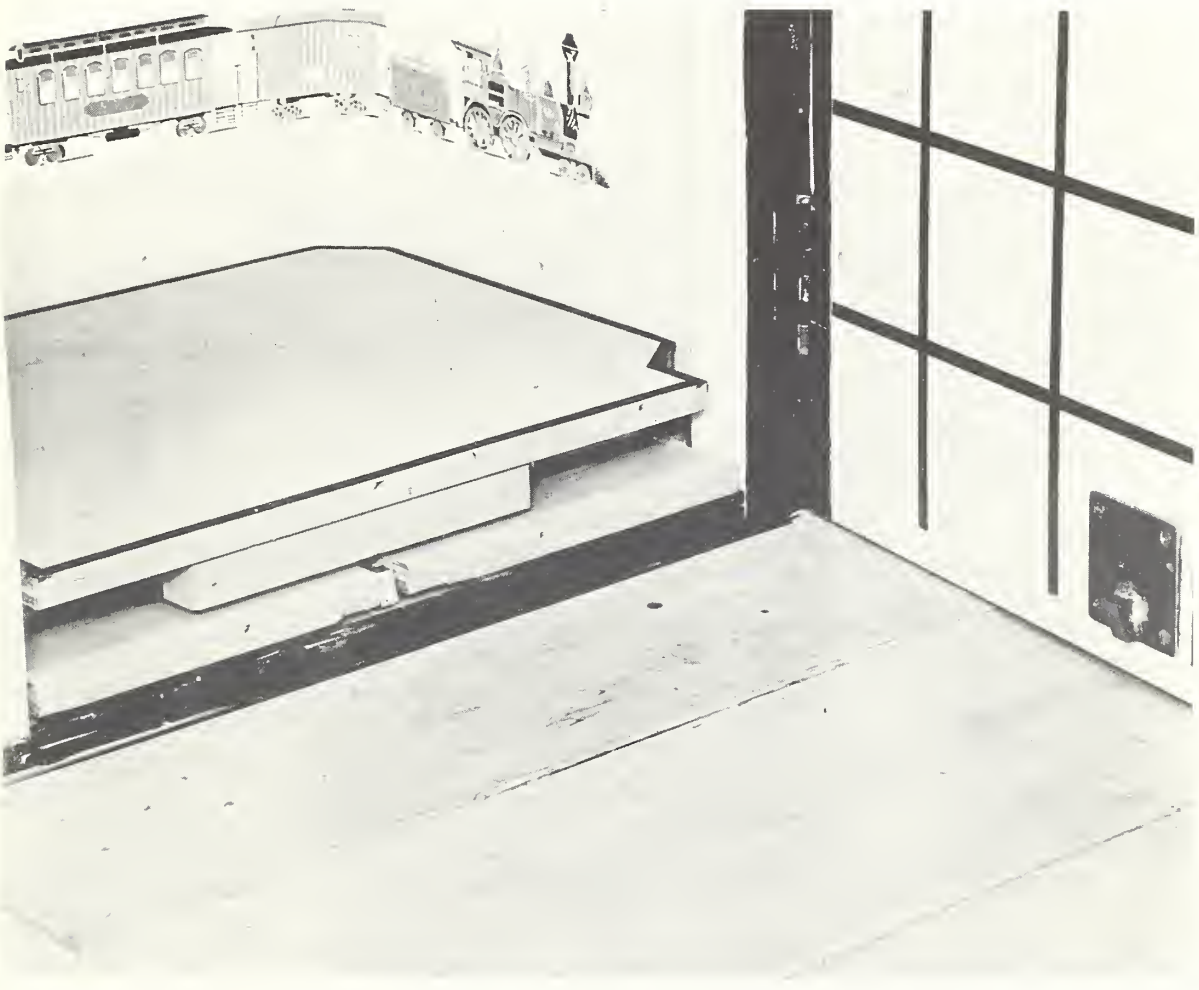

FIGURE 24. Movable floor panel designed to respond to horizontal thrust.

FIGURE 25. Construction detail of movable floor panel, illustrating ball-and-cone assembly and ball-bearing tracks.

the child, and to such other items as appeared to be pertinent. If the child did not effect his own release, the Observer determined from the child's behavior when it was time to let him out. Her determination was formed on the basis of the amount of effort he was putting forth and on the degree to which he was becoming disturbed.

The moment the door opened, either by the child's releasing himself or by his being released by the Observer, the Experimenter was there ready to greet him and comfort him. At this point, the cartoon was continued on another screen visible from outside the playhouse. The child was then invited to see the cartoon or to bring his parents into the test room to see the cartoon and playhouse. This seemed to be an effective way to calm the Subject, take his mind off his brief experience in the playhouse, and help him carry away a happy impression of his visit. The exact procedure employed after the test depended on the age of the child and whether his siblings or other children were in the waiting room.

4. RESULTS

4.1 Description of Sample

A total of 201 tests was made in the formal testing program. Six devices were tested. Table 1 indicates the distribution of tests according to device.

Originally, three devices had been submitted by the refrigerator industry for testing. Later, three additional experimental devices were added. The last device, D_6, was included primarily for obtaining force records.

The sequence of testing is indicated in Table 2. For methodological reasons, the testing of these devices was staggered. Originally, a third series of tests was intended on devices D_1, D_2, and D_3. However, after the completion of two series of tests on these devices, enough information was obtained so that a third series of tests seemed unnecessary. It was then possible to include the experimental devices and still complete the testing program within the allotted time.

The total sample included 100 girls and 101 boys. The range of age is 21 to 71 months, the average age being 46.7 months. The accompanying tables will describe the sample according to average age, height, and weight. Also included in these tables are data relating to parental background. The children tested represented 157 families. The sample is not representative of the general population, being heavily weighted in the direction of higher educational and occupational level. However, inspection of the tables indicates that the groups tested on each device are sufficiently similar so that the results obtained on each device tested can be compared. Time has not permitted a thorough statistical analysis of the sample. Table 1 shows the distribution of tests by device.

Table 1. Distribution of Tests by Device

Device	Tests
	Number
D_1	31
D_2	32
D_3	41*
D_4	50**
D_5	16***
D_6	31
Total	201

* Tests made on device D_3 totaled 41 because of a necessary duplication of several tests arising from maladjustment of the releasing force.

** Tests made on device D_4 totaled 50 because of the need for obtaining infrared movies for which film was unobtainable while the first 32 tests on D_4 were being conducted.

*** Tests made on device D_5 totaled only 16 because of time limitations and confusion as to which of the two releasing principles combined in this device was responsible for release when children released themselves.

Table 2 shows the time sequences of tests, indicating at what points in the test schedule changes of devices were made. No systematic rotation of devices was applied in the tests on devices D_4, D_5, and D_6 because of time limitations and the fact that these were experimental devices in a different category from the first three devices, provided by manufacturers.

Table 2. Sequence of Tests by Device

Device	Series	Children Tested
		Number
D_1	1	16
D_2	1	16
D_3	1	26*
D_3	2	15
D_1	2	15
D_2	2	16
D_4	-	33
D_5	-	16**
D_6	-	31
D_4	-	17***
Total		201

* Twenty-six tests were made on D_3 in series 1 because the first 10 tests were inadvertently made with the device improperly adjusted with respect to required releasing force. Although there was no evidence that this affected the results in these particular tests, they were, nevertheless, repeated, which gave a total of 26 tests instead of 16.

** Only 16 tests were made on device D_5 because two different releasing principles were in operation, which created confusion in some cases as to which principle was utilized by the Subject when he was successful in releasing himself.

*** These additional tests were made on device D_4 for the purpose of obtaining a motion-picture record, for which infrared film had not been available earlier.

Table 3 describes the sample in terms of average height, weight, age, and parents' education. The fact that the number of Subjects tested on device D_5 was small in comparison to the numbers tested on other devices may, in part, account for the divergence of the values associated with this subsample from the general average for the other subsamples.

Table 3. Description of Sample

Device	Total tested	Average weight	Average height	Average age	Parents' education average	Sex	
						Boys	Girls
	No.	Lbs.	In.	Months	Years	No.	No.
D_1	31	35.2	40.5	46.8	29.5	16	15
D_2	32	35.2	40.0	46.4	29.4	15	17
D_3	41	34.7	40.2	46.7	30.7	22	19
D_4	50	35.1	40.3	46.5	28.2	25	25
D_5	16	38.6	41.1	48.2	25.6	7	9
D_6	31	37.1	40.1	46.8	29.0	16	15
Totals	201	----	----	----	----	101	100
Averages:	---	35.6	40.3	46.7	29.0	---	---

Table 4 shows the age distribution for each of the six devices, as well as the age distribution for the total sample.

Table 5 shows the distribution of parents' education for the children tested on each device.

Table 6 shows the grouping of father's occupation for the children tested on the six devices.

Table 7 gives the distribution of father's occupational groups by age for the children tested on each device.

Table 8 shows the distribution of tests for each device, by Experimenter.

Table 4. Age Distribution in Months

Device	Total Tested	Age in Months									
		18 to 30		31 to 41		42 to 54		55 to 65		66 to 78	
	No.	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
D_1	31	6	19.3	3	9.7	13	41.9	5	16.1	4	12.9
D_2	32	7	21.9	4	12.5	11	34.4	5	15.6	5	15.6
D_3	41	7	17.1	9	21.9	9	21.9	12	29.3	4	9.7
D_4	50	8	16.0	12	24.0	11	22.0	18	36.0	1	2.0
D_5	16	2	12.5	4	25.0	5	31.2	1	6.2	4	25.0
D_6	31	5	16.1	9	29.0	5	16.1	7	22.6	5	16.1
Totals	201	35	----	41	----	54	----	48	----	23	----
Averages	---	--	17.4	--	20.3	--	26.9	--	23.9	--	11.4

Table 5. Distribution of Total Years of Parents' Education

Device	Children tested	Education in Years				
		16 to 20 years	21 to 25 years	26 to 30 years	31 to 35 years	36 to 40 years
	No.					
D_1	31	-	4	13	13	1
D_2	32	-	6	14	8	4
D_3	41	-	4	16	16	5
D_4	50	4	11	14	18	3
D_5	16	-	10	6	-	-
D_6	31	2	4	13	12	-

Table 6. Description of Sample by Father's Occupation

Device	Tested	Occupational Group	
		Professional	Nonprofessional
	No.	No.	No.
D_1	31	12	19
D_2	32	16	16
D_3	41	31	10
D_4	50	24	26
D_5	16	6	10
D_6	31	16	15
Totals	201	105	96

Table 7. Description of Sample by Age, by Father's Occupational Group

Device	Father's Occupation Group									
	Professional					Nonprofessional				
	Age of Subject					Age of Subject				
	2	3	4	5	6	2	3	4	5	6
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
D_1	3	-	8	1	-	3	3	5	4	4
D_2	4	2	6	1	3	3	2	5	4	2
D_3	6	8	5	10	2	1	1	4	2	2
D_4	3	6	5	10	-	5	6	6	8	1
D_5	-	3	1	-	2	2	1	4	1	2
D_6	1	6	3	5	1	4	3	2	2	4
Totals	17	25	28	27	8	18	16	26	21	15

Table 8. Distribution of Tests by Experimenter

Device	Experimenter 1	Experimenter 2
D_1	14	17
D_2	13	19
D_3	18	23
D_4	22	28
D_5	8	8
D_6	15	16
Totals	90	111

4.2 Factors Affecting Success

The ability of children to utilize successfully a safety release device seems to be very much affected by age and the physical growth and accompanying development taking place as children become older. Height and weight seem related to success as a factor associated with age. For example, many large three-year-old children are less capable of succeeding than smaller four-year-old children.*

Table 9 presents the results of the testing of children's ability to utilize release devices as affected by such basic factors as age, sex, height, weight, and parents' education and occupation. Also included in this table are data on the effect of the Experimenter and Observer on the results. Included in the values shown in Tables 9 and 10 are the results of tests on device D_6, the device which no child could utilize for escape. The classification of success or failure for the 31 tests using this device was made on the basis of whether the child was known to have exerted at least a 12-lb. force on the door panel as registered by the pressure gage. Because of the incomplete record on these 31 tests and because of possible inaccuracy

* According to the statistician, simple correlations between age, height, and weight, in the sample used in this study, are as follows: weight and height - .84; weight and age - .74; height and age - .92.

in the forces registered, this classification is not as meaningful or precise as it should be for comparison with the results of tests on the other five devices about which there was no question as to success or failure. In any further use of the data following the issuance of this preliminary report, it is considered preferable that no classification of the data on device D_6 by success or failure be made.

Table 9. Children's Success in Utilizing Safety Release Devices

(a) As affected by child's age

Age	Tested	Success		Failure	
Months	No.	No.	Percent	No.	Percent
18 to 30	35	5	14.3	30	85.7
31 to 41	41	16	39.0	25	61.0
42 to 54	54	28	51.8	26	48.2
55 to 65	48	34	70.8	14	29.2
66 to 78	23	14	60.8	9	39.2
Totals	201	97	----	104	----

(b) As affected by child's sex

Boys	101	49	48.5	52	51.5
Girls	100	48	48.0	52	52.0
Totals	201	97	----	104	----

(c) As affected by child's weight

Weight lb.					
20 to 25	11	2	18.2	9	81.8
26 to 30	43	11	25.5	32	74.5
31 to 35	49	26	53.0	23	47.0
36 to 40	52	29	55.7	23	44.3
41 to 45	32	19	59.3	13	40.7
46 to 50	7	4	57.1	3	42.9
51 to 55	4	3	75.0	1	25.0
56 to 60	3	3	100.0	0	----
Totals	201	97	----	104	----

Table 9. Children's Success in Utilizing Safety Release Devices - cont.

(d) As Affected by child's height

Height in.	Tested	Success		Failure	
30 to 35	32	6	18.8	26	81.2
36 to 40	67	26	38.8	41	61.2
41 to 45	79	50	63.2	29	36.8
46 to 50	22	14	63.6	8	36.4
51 to 55	1	1	100.0	0	----
Totals	201	97	-----	104	----

(e) As affected by total parents' education

Years					
16 to 20	6	5	83.0	1	17.0
21 to 25	39	26	66.7	13	33.3
26 to 30	76	35	46.0	41	54.0
31 to 35	67	24	35.8	43	64.2
36 to 40	13	7	53.8	6	47.2
Totals	201	97	----	104	----

(f) As affected by parents' occupation

Occupational group					
Professional	105	45	42.8	60	57.2
Nonprofessional	96	52	54.2	44	45.8
Totals	201	97	----	104	----

(g) As affected by experimenter

Experimenter					
No. 1	90	42	46.6	48	53.4
No. 2	111	55	49.5	56	50.5
Totals	201	97	----	104	----

(h) As affected by observer

Observer					
No. 3	119	53	44.5	66	55.5
No. 1	38	20	52.6	18	47.4
No. 2	44	24	54.5	20	45.5
Totals	201	97	----	104	----

It is evident that no one factor can be predictive of success, except the correlated factors of age, height and weight. No effect on success because of sex is apparent. However, the child's reactions in the test enclosure very definitely affected his ability to escape. No significant difference is apparent due to Experimenter or Observer.

The fact that almost half of the children tested (97 successes in 201 tests) made their escape from the enclosure is closely related to the relatively greater success of the older children (who were also heavier and taller, in general) in utilizing release devices, as noted elsewhere. The relative degree of success achieved by the total sample is very slightly greater than noted above if the tests on device D_6 are not considered, there being 83 successes in 170 tests in that case.

Whether or not the individual Experimenter had any bearing on the children's success or failure with escape devices becomes of great interest in the light of personality differences and consequent unavoidable variations and modifications of manner, approach, and technique.

Regrettable though it is that the number of children, and also their age and sex, could not be evenly distributed between the two Experimenters, the results obtained by the two Experimenters show close correspondence, as shown in tables 9 and 10.

A minor question arises in connection with device D_6: Whether some children may have been disturbed by a feeling of insecurity because of very slight horizontal motion that occurred when they stepped on the movable floor panel. It seems barely possible that some children were afraid to move, in much the same way that some young children hesitate to get onto scales to be weighed. If there were such instances, fear associated with the slight movement of the floor panel may have interfered with efforts to escape.

Table 10. Success in Relation to Experimenter

Device	Age	SUCCESS		FAILURE	
		Experimenter No. 1	Experimenter No. 2	Experimenter No. 1	Experimenter No. 2
	years	No.	No.	No.	No.
D_1	2	-	-	1	5
	3	1	-	1	2
	4	-	2	6	4
	5	3	1	-	1
	6	-	2	2	-
D_2	2	-	-	2	5
	3	1	3	-	-
	4	5	3	2	1
	5	1	4	-	-
	6	1	3	1	-
D_3	2	-	-	4	3
	3	1	-	2	6
	4	1	1	2	5
	5	-	3	6	3
	6	1	-	1	2
D_4	2	1	1	2	4
	3	1	4	2	5
	4	4	7	-	-
	5	10	6	1	1
	6	-	-	1	-
D_5	2	-	1	-	1
	3	2	1	1	-
	4	2	1	1	1
	5	1	-	-	-
	6	1	3	-	-
D_6	2	-	2	3	-
	3	2	1	5	1
	4	-	1	1	3
	5	2	3	1	1
	6	1	2	-	2
Totals		42	55	48	56

The classification of age by years from 2 to 6, inclusive, used in Table 10 and in several tables appearing later represents the corresponding age groupings by months used in Tables 4, 7, 9, 12, and 15.

4.3 Effect of Device on Success

The construction and operation of the devices tested have been explained in the description of equipment under Section 2.3. Considering all children tested, grouped according to device only, Table 11 summarizes the success associated with the different devices. (See Table 11.)

According to this table, device D_5 had the highest rate of success. Since only 16 children were tested on this device, there is greater uncertainty in the percentages pertaining to this device than for devices D_1, D_2, D_3 and D_4. More than half of all the children tested on devices D_2 (65.6%) and D_4 (68.0%) released themselves. A much smaller proportion of children succeeded in releasing themselves in tests on devices D_1 (29.0%) and D_3 (17.1%).

The success of 45.1% for device D_6 is not reliable to the same extent as the values given for devices D_1, D_2, D_3 and D_4. The discussion under 4.2 pointed out that the maximum efforts of some children tested on device D_6 may have been classified incorrectly.

Table 11. Effect of Device on Success

Device	Tested	Success		Failure	
	No.	No.	Percent	No.	Percent
D_1	31	9	29.0	22	71.0
D_2	32	21	65.6	11	34.4
D_3	41	7	17.1	34	82.9
D_4	50	34	68.0	16	32.0
D_5	16	12	75.0	4	25.0
D_6	31	14	45.1	17	54.9
Totals	201	97	----	104	----

Table 12 lists successes and failures on each device for the various age groups. The following statements are based on the data presented in this table.

1. None of the children in the youngest age group (18 to 30 months) was successful in utilizing devices D_1 or D_2, both of which required a direct push on the door. Also, in the next older age group (31 to 41 months) none of the 3 children successfully utilized device D_1. This device required 50% greater force for release than did device D_2. In tests on device D_2, all of the 4 children tested in the 31-to-41-month age group released themselves.

2. In all age groups where any successes occurred in tests with devices D_1 and D_2, a higher degree of success was associated with device D_2. Device D_1 required an 18-lb. push at the latch edge of the door; device D_2 a 12-lb. push at the same edge. In making comparisons of results from tests using devices D_1 and D_2, it should be noted that the releasing action associated with device D_1 required an effort of a more sustained nature than was the case for device D_2. The construction features responsible for this difference are explained in some detail under Section 2.3. Short bursts of force result from the banging and slapping of the less-purposeful and more-random efforts frequently observed in the behavior of 2-year-old and 3-year-old children. The fact that such momentary force efforts were less effective in opening the door on which device D_1 was used may be a factor in the lower proportion of successes with this device.

3. To open the door in the tests in which device D_3 was used, it was necessary to push a luminous ring. On tests in which device D_4 was used, it was necessary to manipulate a knob which reacted to clockwise or counterclockwise turning or to push or pull. A greater proportion of children in each age group was successful in releasing themselves in tests using device D_4 than in tests using device D_3. This may be partly explained by the fact that a doorknob and its operation are familiar to most children.

Table 12. Effect of Device* on Success for Different Ages

Age	Device	Tested: No.	Success: No.	Failure: No.
	1	6	0	6
18 to 30 months**	2	7	0	7
	3	7	0	7
	4	8	2	6
subtotal	--	28	2	26
	1	3	0	3
31 to 41 months	2	4	4	0
	3	9	1	8
	4	12	5	7
subtotal	--	28	10	18
	1	13	3	10
42 to 54 months	2	11	8	3
	3	9	2	7
	4	11	11	0
subtotal	--	44	24	20
	1	9	6	3
55 to 78 months***	2	10	9	1
	3	16	4	12
	4	19	16	3
subtotal	--	54	35	19
Totals	--	154	71	83

* Tests using experimental devices D5 and D6 are omitted. For reasons stated elsewhere, the results would not have reliable meaning if compared with the results of the tests using the four other devices.

** The youngest child tested was actually 21 months.

***The oldest child tested was 71 months.

Table 13 enumerates the success data on all devices. The actual ages of the successful children are indicated and compared with the total sample. The range and distribution of the ages of the successful group can be obtained from inspection of this table.

Table 13. Distribution of Successes by Device

	Age in Months			
	Device D_1	Device D_2	Device D_3	Device D_4
	42	34	41	24
	50	36	44	28
	54	38	47	35
	56	39	62	36
	61 (2)	41	63	38 (3)
	63	42	65	43
	69	43	71	44
	71	46		45
		48 (2)		46 (2)
		49		47 (2)
		50		48
		56		50
		58		51
		61		54
		62		56 (4)
		63		57 (2)
		67		59
		68		60
		69 (2)		61 (3)
				63
				65 (5)
Average Age of Successes	58.6	51.8	56.1	50.6
Average Age of Sample	46.8	46.4	46.7	46.5
No. Below Average Age	1	8	2	12
No. Above Average Age	8	13	5	24
No. Successes	9	21	7	36
No. Tested	31	32	41	50

4.4 Types of Behavior

Under conditions simulating, to a degree, the entrapment of children in refrigerators, behavior of wide variety appeared among the Subjects. To be suddenly and unexpectedly confined in a very small dark place, even without the added discomfort of a limited air supply, is a discomfiting experience. The patterns of children's reaction to this experience in the present study range all the way from complete passivity, with no attempts whatever to use their mental or physical resources, to violent activity, either purposeful or undirected. A few children sat quietly for as long as 15 minutes, apparently waiting for the movie, with no evidence of perturbation during or after their stay in the enclosure; others, also few in number, became panicky and emotionally upset as soon as they found themselves shut in, and by their agitation hampered what ability to get out they might otherwise have displayed. All manner of in-between behavior was observed.

The most noticeable factor associated with children's ability to make successful use of the escape devices was age. Two-year-olds to a great extent reacted helplessly, showing no grasp of the problem situation in which they found themselves. They broke down and cried, floundering hopelessly or raging, apparently in the hope that someone would help them out of their predicament. They did not always appear as frightened as did some of the older children. In other words, helpless behavior is appropriate in a 2-year-old. By the age of 3 and 4, when children have developed to the point of being aware of the many dangers that lie in wait around them, they may become really frightened, or even terror-stricken.

How a child reacted to being enclosed not only differed greatly according to age but also was affected by personality and background experience. The brief time spent with a child did not give sufficient familiarity with him so that any hypothesis concerning the effect of his personality on his behavior in the enclosure could be formulated. Certain behavior patterns could be noted.

Most of the children remained oriented toward the door, and a great many of them used considerable energy in a proper direction of effort. Some children began to work purposefully at getting out of the playhouse as soon as the door closed; their behavior was task-oriented and appropriate to the situation. In other words, if there was a knob they soon directed their effort to it; if they were confronted by a blank door, their efforts were purposefully directed to the door. As the results indicate, age is a definite variable affecting the appropriateness of behavior.

Another, and intelligent, type of behavior was the expenditure of time and energy in searching for a "way out." This exploratory behavior sometimes preceded direct physical effort, but many times the very calm child confined his efforts to feeling along the edges of the door, as though groping for a clue, and made no other effort except when a knob or latch was present.

Some children's efforts, if they could be so called, were almost completely random and diffuse, and produced no results whatever. In these cases the children seemed much disturbed by the small size and darkness of the playhouse. Other efforts were ineffective either because the children did not use enough strength to secure release, or because they misdirected their energy. For example, some children stamped up and down, others knocked on the door or the walls. They seemed incapable of coordinating their behavior to effect a successful solution to the problem. Still others gave vent to loud calls, shouts, or screams, which they obviously expected would be effective in bringing help from someone outside.

In another variety of behavior, children became upset and helpless. These children cried very hard and made no effort at all to get out. They clenched their hands, twisted their fingers, or covered their faces with their hands. Some assumed an almost rigid posture of fear while screaming.

Speaking in very broad terms, trapped children react in a wide variety of ways, ranging from showing calmness and control to becoming panicky. The effectiveness of any safety device must depend upon these facts. The equipment and technique of this study were not like the real situation in which a child might become entrapped. In the real-life situation, only fragmentary information exists as to what children are doing before they are actually entrapped, what play situations precede their entrapment, and consequently how they might react when they became entrapped. No information exists as to what type of child is most likely to get trapped in a refrigerator.

In paragraphs (a) through (d), below, some results of observations on specific types of behavior are presented.

(a) Vocalization -- By far the greater number of children vocalized at some time during their entrapment. As would be expected, older children were less apt to cry, though they called out as often as younger ones. Some older children remained completely quiet, as they might have done in a hide-and-seek situation. Some were quiet, evidently because they were waiting for the movie to show again.

While a few children cried all the time they were enclosed and made no physical effort to extricate themselves, others cried continuously along with the physical efforts they were making. In Table 14, the small number of children who cried while making an effort to utilize device D4 may be the result of the speed with which many children released themselves by means of this device. (See Table 15.)

Despite efforts to give the children the impression that they were alone when the door of the playhouse closed on them, the type of calls and shouts to which many children gave vent indicated that they expected to make themselves heard. (See Table 16.)

Table 16 indicates the nature and distribution of the several types of vocalization exhibited by children tested on the six devices. The numbers in the columns do not necessarily total horizontally equal to the number of tests made because some of the children made two or more types of vocalization, and some made no vocalization.

That children's calls were more often to their parents than to the Experiment suggested that while they knew their parents were well out of hearing distance, their natural tendency, at the ages studied, was to call their mother or father when in trouble. This was as true of 5-year-olds as of younger children.

Table 14. Crying in Relation to Effort

Device	Tested	Continuous, with no physical effort	Continuous, with physical effort	Interrupted, with no effort	Interrupted, with efforts interspersed	Interrupted, with physical effort
	No.	DISTRIBUTED BY DEVICE				
		NO.	NO.	NO.	NO.	NO.
D_1	31	4	10	4	2	-
D_2	32	2	10	4	5	-
D_3	41	5	13	2	4	2
D_4	50	7	6	2	-	-
D_5	16	-	1	2	-	1
D_6	31	2	13	3	2	1
Totals	201	20	53	17	13	4
Age*	No.	DISTRIBUTED BY AGE				
2	35	13	14	2	2	-
3	41	3	13	7	4	2
4	54	3	13	5	3	1
5	48	1	10	2	1	1
6	23	-	3	1	3	-
Totals	201	20	53	17	13	4

* The classification of age by years used in this table is based on the classification by corresponding month intervals used in Tables 4, 7, 9, 12, and 15.

Table 15

Total Time Spent in Enclosure by Children Who Successfully Utilized Release Devices*

Age	Less than 10 seconds	10 to 29 seconds	30 to 59 seconds	60 to 119 seconds	120 to 179 seconds	180 to 239 seconds	More than 240 seconds	Total
DISTRIBUTED BY AGE								
Months	No.	No.	No.	No.	No.	No.	No.	No.
18 to 30	2	1	-	2	-	-	-	5
31 to 41	5	2	3	5	-	1	-	16
42 to 54	15	5	1	6	1	-	-	28
55 to 65	20	4	3	4	3	-	-	34
66 to 78	5	3	2	2	1	-	1	14
Totals	47	15	9	19	5	1	1	97
DISTRIBUTED BY SEX								
Sex								
B	22	8	3	13	2	-	1	49
G	25	7	6	6	3	1	-	48
Totals	47	15	9	19	5	1	1	97
DISTRIBUTED BY DEVICE								
Device								
D_1	2	4	1	-	1	-	1	9
D_2	7	3	2	7	2	-	-	21
D_3	1	2	1	3	-	-	-	7
D_4	27	3	2	2	-	-	-	34
D_5	9	2	-	1	-	-	-	12
D_6	1	1	3	6	2	1	-	14
Totals	47	15	9	19	5	1	1	97

* Certain values shown in this table are based on results of tests using device D_6, classified as successful according to the criterion explained under 4.2 above, and hence are subject to the same comments as given there.

Table 16. Vocalization

Device	Tested	Talks or Calls out	Cries	Screams
	No.	No.	No.	No.
D_1	31	10	13	11
D_2	32	11	21	2
D_3	41	23	32	17
D_4	50	9	18	6
D_5	16	3	4	4
D_6	31	12	18	11
Totals	201	68	106	51

Table 17. Reactions of Children in Playhouse

Device	Tested	Calm	Moderately upset	Very upset	Panicky
	No.	No.	No.	No.	No.
D_1	31	8	11	8	4
D_2	32	9	10	11	-
D_3	50	7	11	19	4
D_4	41	29	11	8	2
D_5	16	10	2	4	-
D_6	31	6	7	13	5
Totals	201	69	52	63	15

(b) Reactions in Playhouse -- Inspection of the values in Table 17 indicates that the greatest proportion of children reacted calmly to device D_4, the device which many children seemed to consider as a doorknob, the use of which was familiar to them. These data also indicate that relatively few children reacted calmly to device D_3, this device being the one to which many children directed the wrong type

of effort, possibly because of unfamiliarity with the use of any similar item. Also, relatively few children reacted calmly to device D_6, this being the device which was not designed to permit children to release themselves.

No correlation between reaction and device is evident for those children who became moderately upset. The fact that a relatively large number of children became very upset in their reactions to device D_3 may be explained in some cases by their frustration following failure in attempting to open the door by pulling on the device, this being an improperly-directed effort.

The fact that relatively more children became very upset or even panicky in their reactions to devices D_3 and D_6 than to the other devices is consistent with the finding that relatively fewer children reacted calmly to these same two devices. However, it should be noted that actually only a few children became panicky under any of the conditions set up.

(c) Types of effort -- What a child did to extricate himself from the playhouse bore a strong relationship to his age, not considering the oldest group. The proportion of children who pushed at the door, or pushed, pulled, or turned the luminous knob or ring increased steadily with age up to age 6. This oldest group showed a performance in this respect about the same as the 2-year-old group. A possible reason for this is that a number of older children seemed to be waiting for a continuation of the cartoon rather than doing anything about getting out of the enclosure. However, in all age groups, the successful children gave much more attention to the above mentioned types of effort than did the unsuccessful ones. (See Table 18.)

Knocks, slaps, or bangs occurred much more often than kicks at the door or walls. These activities often generated considerable force, but for such brief periods as to prove ineffective.

(d) Examination of the interior -- In the interest of considering a type of release that would be highly effective, the question of whether or not children actually examine the interior of the enclosure becomes of moment. (See Table 19.)

The oldest age group directed the most attention to examining their surroundings, and the youngest groups the least. The 3-year-old group directed more attention to examining their surroundings than did the 2-year-old group, and the 4-year-old group directed more attention to examination than did the 3-year-old group. However, the 5-year-old group performed in this respect only slightly better than the 2-year-old group.

In general, the older children looked around, felt along the walls or door jambs, examined the luminous knob or ring, or looked up at the ceiling. Some of the children who appeared the most curious did several of these things, carefully appraising their unseen surroundings in terms of what opportunities they seemed to offer for escape.

4.5 Force Efforts

In the tests on device D_1, a number of force records were obtained as a result of activities of the children while being tested. However, these records are not complete and in some cases are unreliable, hence they are not presented in this report. This unfortunate circumstance was the result of two things. First, the plywood structure of the playhouse was subject to yielding in its entirety whenever any substantial force effort was directed at any of the enclosing panels, and this yielding was transmitted as a force indication, even if, for example, the child jumped up and down on the floor panel. Because of the fact that the calibration was in terms of force transmitted to the door keeper as a result of direct force on the door panel, the type of effort directed at other panels gave a record without meaning. Second, the recorder responded well to very short-duration forces such as might occur with knocking and slapping efforts, and failed to register accurately the most effective type of effort, such as a steady push of appreciable time duration.

Eventually, this defect was corrected, but not until all tests on device D_1 were completed. Time did not permit the proper development of this method of measuring forces.

Knocking, kicking, or slapping efforts frequently registered forces in excess of the amount required to open the door if the effort had consisted of a steady push. The inertia of the door and the friction in the latch and releasing mechanism were important factors preventing release with short-duration force efforts. Some children directed efforts against the door in which device D_1 was installed sufficient to initiate releasing action. This was shown by the fact that the door opened a fraction of an inch, but these efforts were either not great enough in magnitude or were of too short duration to complete the release, whereupon the door snapped shut again as soon as the force was removed from the door panel.

Reasonably satisfactory force data were obtained in tests using device D_6, where horizontal forces exerted on the movable floor panel were registered directly on the dial of a pressure gage, observed through a telescope and recorded on sound tape.

Table 20 gives the maximum horizontal components of forces registered by the 31 children tested on device D_6. Because of the particular construction of this device, the force values given in Table 20 represent horizontal forces irrespective of point of application. If, for example, a child jumped up and down without touching the door or any side panel, a horizontal force component might be registered.

The force efforts shown in Table 20 are classified in terms of "success" or "failure" because it was considered desirable to include the results of these 31 tests in the total sample; and these data appear listed as "success" or "failure" in a number of other tables relating to success on all devices tested.

Table 18. Success* in Relation to Type of Effort

Type of Effort	SUCCESS						FAILURE					
	Age of Subjects**						Age of Subjects**					
	2	3	4	5	6	All	2	3	4	5	6	All
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Pushes	2	8	14	12	10	46	10	7	9	4	1	31
Knocks or bangs	-	5	4	8	1	18	10	4	5	6	5	30
Slaps	-	3	1	3	2	9	4	6	5	1	2	18
Kicks door	-	-	-	1	-	1	4	3	4	1	-	12
Pulls luminous knob or ring	1	-	1	2	-	4	2	5	-	4	1	12
Pushes luminous knob or ring	-	-	-	5	1	6	-	-	-	-	-	--
Turns knob or ring	1	3	11	14	-	29	1	1	2	3	-	7
Totals	4	19	31	45	14	113	31	26	25	19	9	110

* Certain values shown in this table are, in part, based on results of tests using device D_6, classified as success or failure according to the criterion explained under 4.2 above, and hence are subject to the same comments as given there.

**The classification of age by years used in this table is based on the classification of age by corresponding month intervals used in tables 4, 7, 9, 12, and 15.

Table 19. Success* in Relation to Examination of Interior

Type of	SUCCESS						FAILURE					
	Age of Subjects**						Age of Subjects**					
	2	3	4	5	6	All	2	3	4	5	6	All
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Looks around	-	3	1	2	4	10	6	4	9	3	4	26
Feels along walls	1	1	1	2	2	7	3	3	7	1	1	15
Feels door jambs	1	-	1	2	2	6	4	3	6	2	3	18
Examines luminous knob or ring	-	-	-	3	-	3	-	5	3	5	1	14
Looks up	-	1	-	2	4	7	1	6	8	1	2	18
Other	1	2	1	2	-	6	-	-	2	-	-	2
Totals	3	7	4	13	12	39	14	21	35	12	11	93

* Certain values shown in this table are, in part, based on results of tests using device D_6, classified as success or failure according to the criterion explained under 4.2 above, and hence are subject to the same comments as given there.

**The classification of age by years used in this table is based on the classification of age by corresponding month intervals used in tables 4, 7, 9, 12, and 15.

Table 20. Maximum Horizontal Forces Exerted by Children Tested on Device D_6

Test No.	Age	Sex	Maximum force	Approximate time of occurrence	Total time in enclosure	Success*
	years		lbs.	seconds	seconds	
158	2	B	14.5	40 to 50	65	Yes
169	2	B	14.5	30 to 35	35	Yes
175	2	B	19.0	0 to 10	15	No
176	2	B	16.7	0 to 10	25	No
147	2	G	14.5	50 to 60	83	Yes
148	2	G	0.0	0 to 10	65	No
164	2	G	10.0	100 to 110	140	No
168	2	G	13.4	80	80	No
146	3	B	12.3	10 to 20	80	No
150	3	B	6.8	60 to 70	200	No
170	3	B	9.0	40 to 50	195	No
172	3	B	14.5	30 to 40	45	No
154	3	G	16.7	50 to 60	80	Yes
160	3	G	5.6	170 to 180	250	No
171	3	G	7.9	60	65	No
163	4	B	17.3	60 to 64	64	Yes
155	4	B	23.4	20 to 30	30	Yes
156	4	B	11.2	100 to 110	150	No
157	4	B	15.6	105	105	Yes
159	4	B	10.0	240 to 250	335	No
152	4	G	12.3	180	180	Yes
153	4	G	19.0	130 to 140	140	Yes
167	4	G	10.5	0 to 10	95	No
151	5	B	16.7	40 to 50	55	Yes
161	5	B	19.0	0 to 10	345	No
162	5	B	16.7	30 to 40	110	Yes
166	5	B	22.3	130 to 137	137	Yes
149	5	G	29.0	20	30	Yes
165	5	G	10.0	70 to 80	87	No
173	5	G	22.3	0 to 10	10	Yes
174	5	G	29.0	0 to 10	10	No

* "Yes" means that at least 12 lbs. of force was applied to door. "No" means either that less than 12 lbs. of force were applied to door, that the maximum effort was applied elsewhere than on the door, or that insufficient information is available to determine the point of application. Certain comments with respect to this classification are made under 4.2

The age classification adopted in table 20 is based on the assumption that a child at least 20 months of age but less than 36 months is 2 years old, a child at least 36 months of age but less than 48 months is 3 years old, etc.

Figure 26 is based on the data in table 20 for the 31 cases as a group without respect to age or sex. The ordinate for each plotted point represents the percentage of the children who exerted a horizontal force on the floor panel in excess of the value represented by the corresponding abscissa. For comparison, the other plotted points represent the performance of children tested on devices D_1, D_2, and D_5 where it was possible for them to release themselves. In device D_1, for example, it is known that the successful children exerted a force of at least 18 lbs. on the door panel and those in device D_2 exerted a similiar force of at least 12 lbs. In device D_5, it is certain that the successful children exerted at least 6 lbs. against the door panel, if their releasing efforts were directed at the door, or more if their releasing efforts were directed elsewhere. If it is assumed that the values plotted for device D_6 represent fairly the maximum horizontal force potential of children irrespective of point of application, then the extent to which the performance of the children on devices D_1, D_2, and D_5 fails to measure up to their potential performance is indicated by the magnitude of the downward displacement of the D_1, D_2, and D_5 points below the general line of the D_6 points. Figures 27, 28, 29, and 30 show the same type of data for each age group. These are based on samples in the range of 4 to 8 Subjects only. However, inspection of figures 27-30, inclusive, suggests that the ability of children to direct their maximum force potential against the door panel tends to increase with age, 2-year-olds having the poorest showing in this respect and 5-year-olds the best showing.

The force data presented in Table 20 and Figures 26-30, inclusive, are not precise because of the lack of complete film records on all tests and the lack of time to develop certain refinements in instrumentation. These circumstances prevented making a thorough correlation of force efforts with behavior. However, it is believed that the data presented in Table 20 and in Figures 26-30, inclusive, do have predictive value in indicating the nature of the problem. Incomplete as they are the data seem to justify the qualitative conclusions drawn.

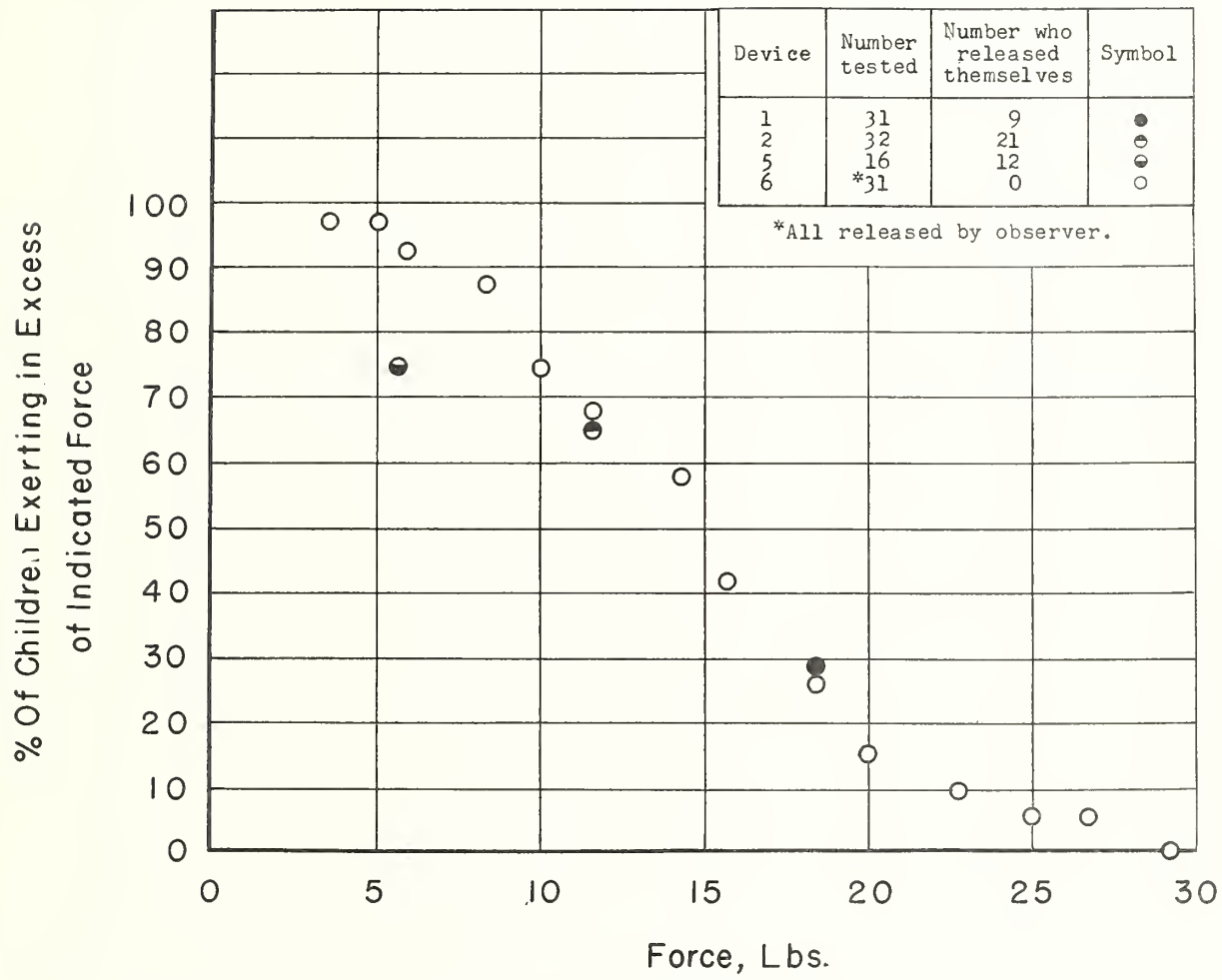

FIGURE 26. Horizontal components of forces exerted by children, ages 2 through 5 years.

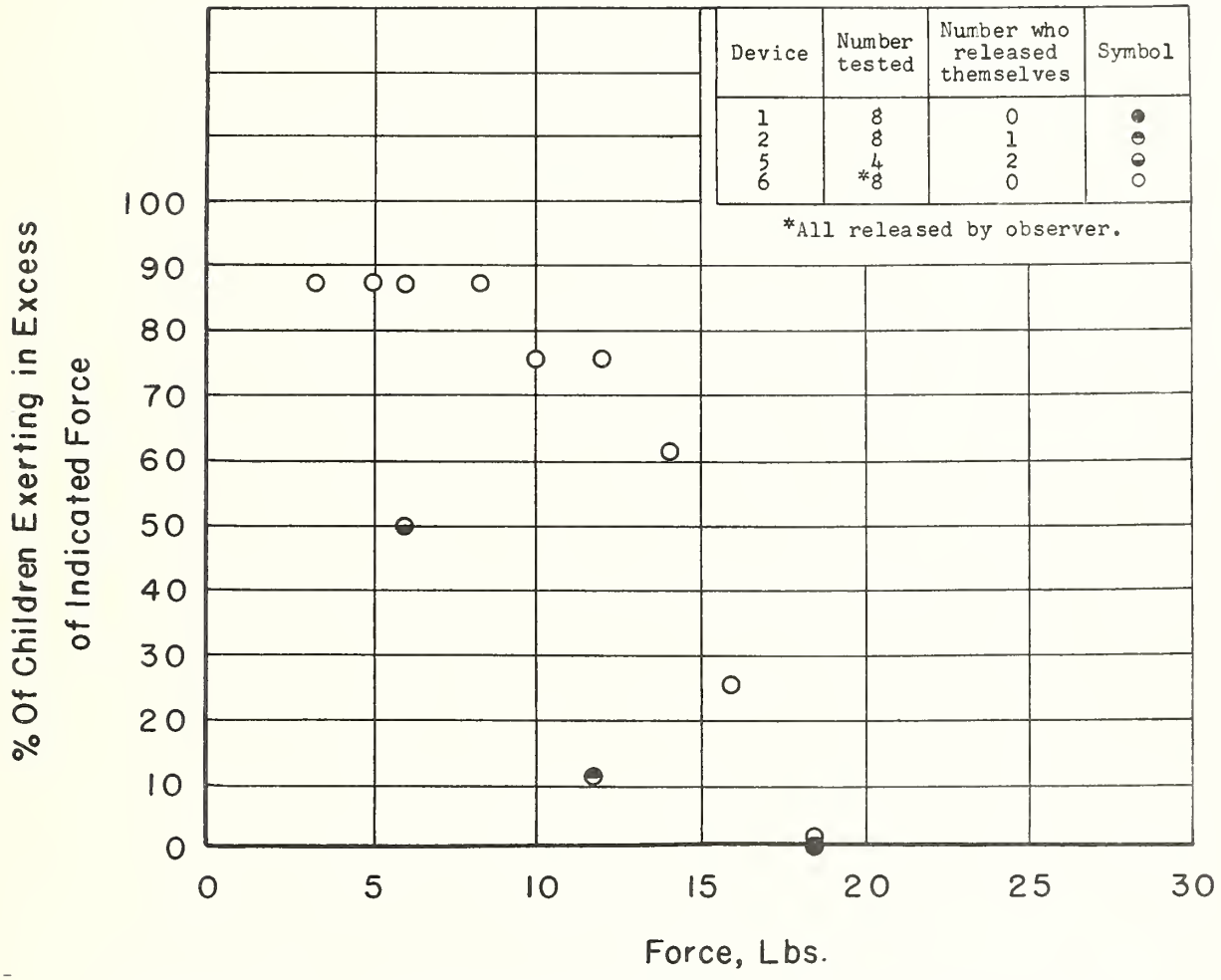

FIGURE 27. Horizontal components of forces exerted by children, age 2 years.

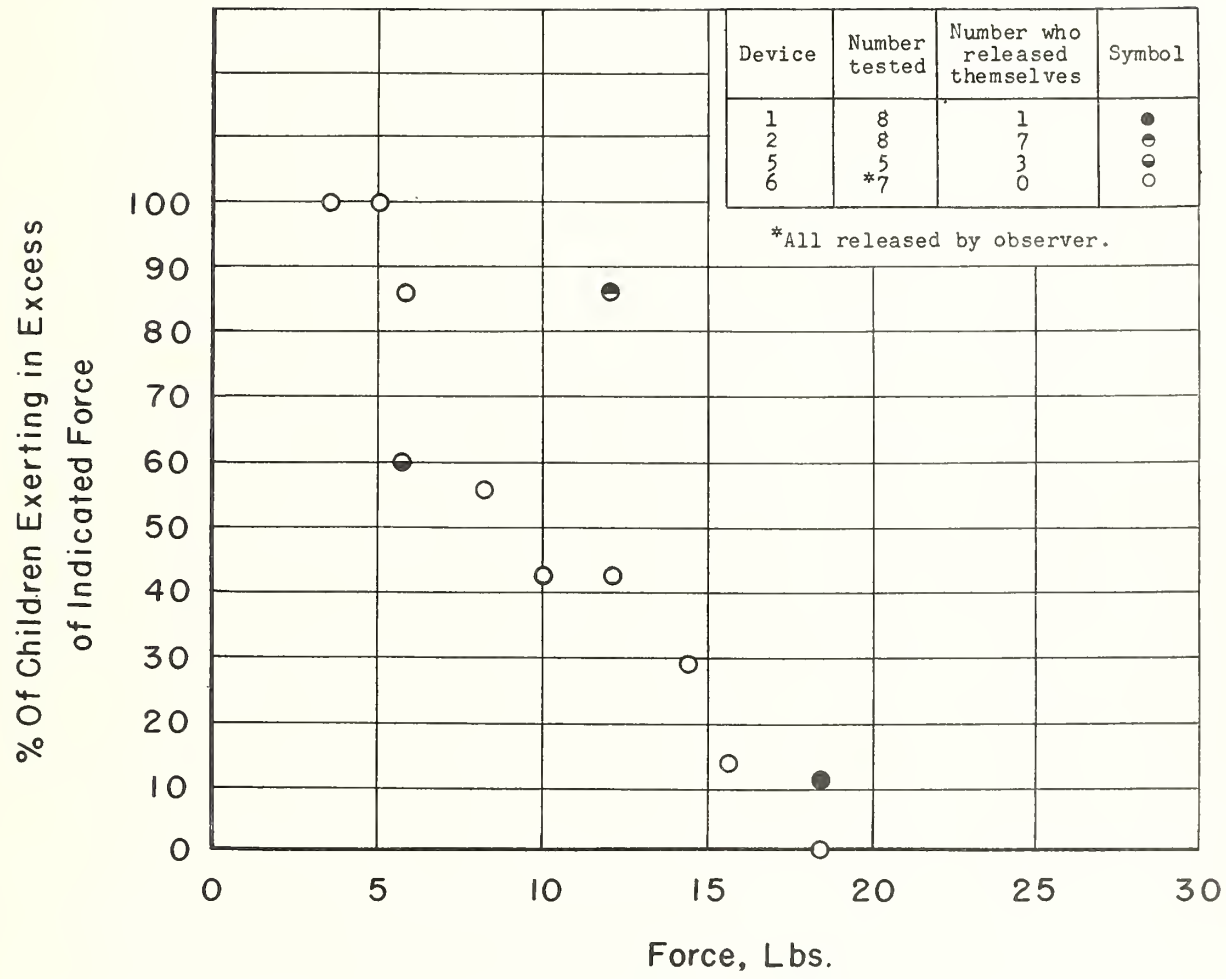

FIGURE 28. Horizontal components of forces exerted by children, age 3 years.

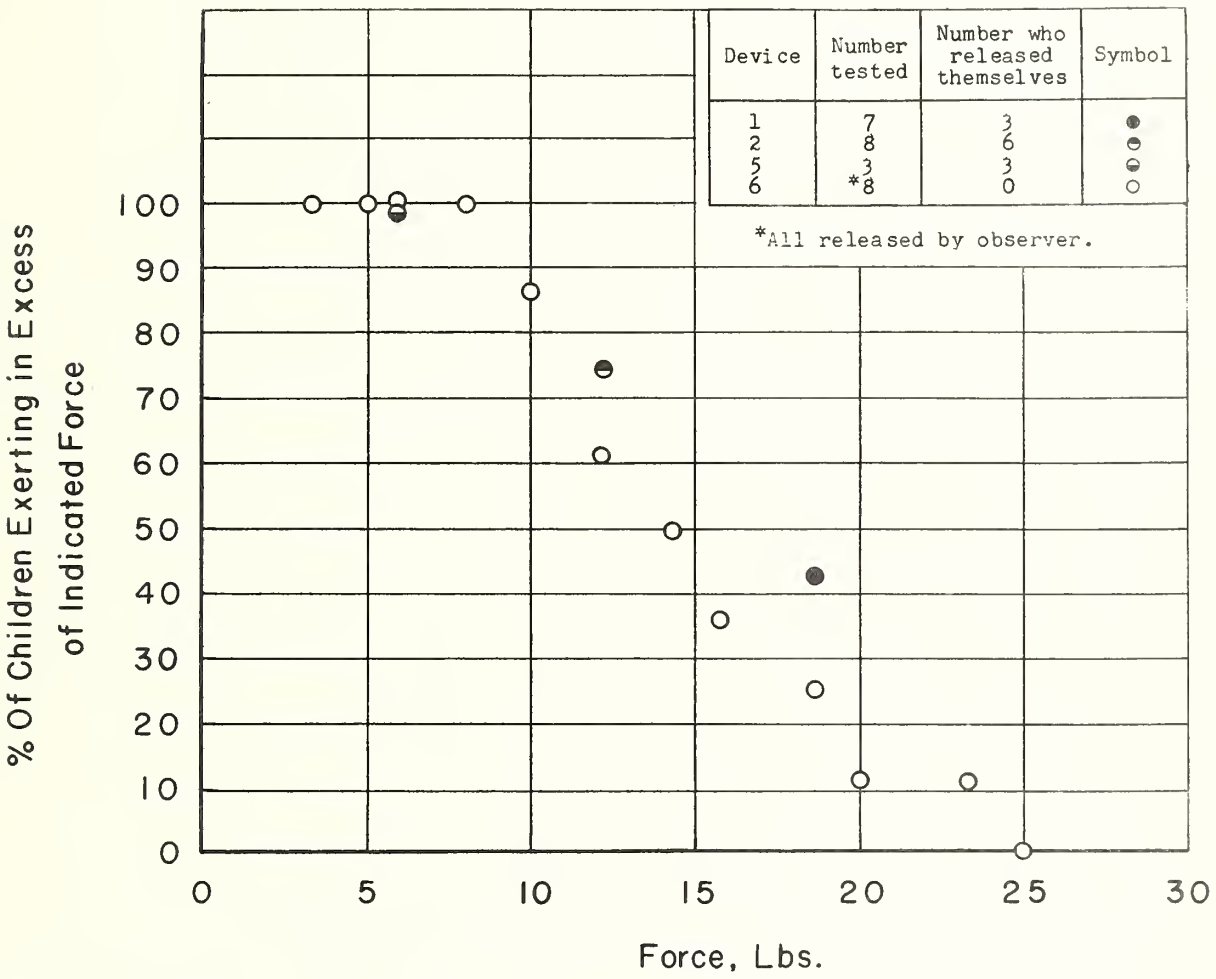

FIGURE 29. Horizontal components of forces exerted by children, age 4 years.

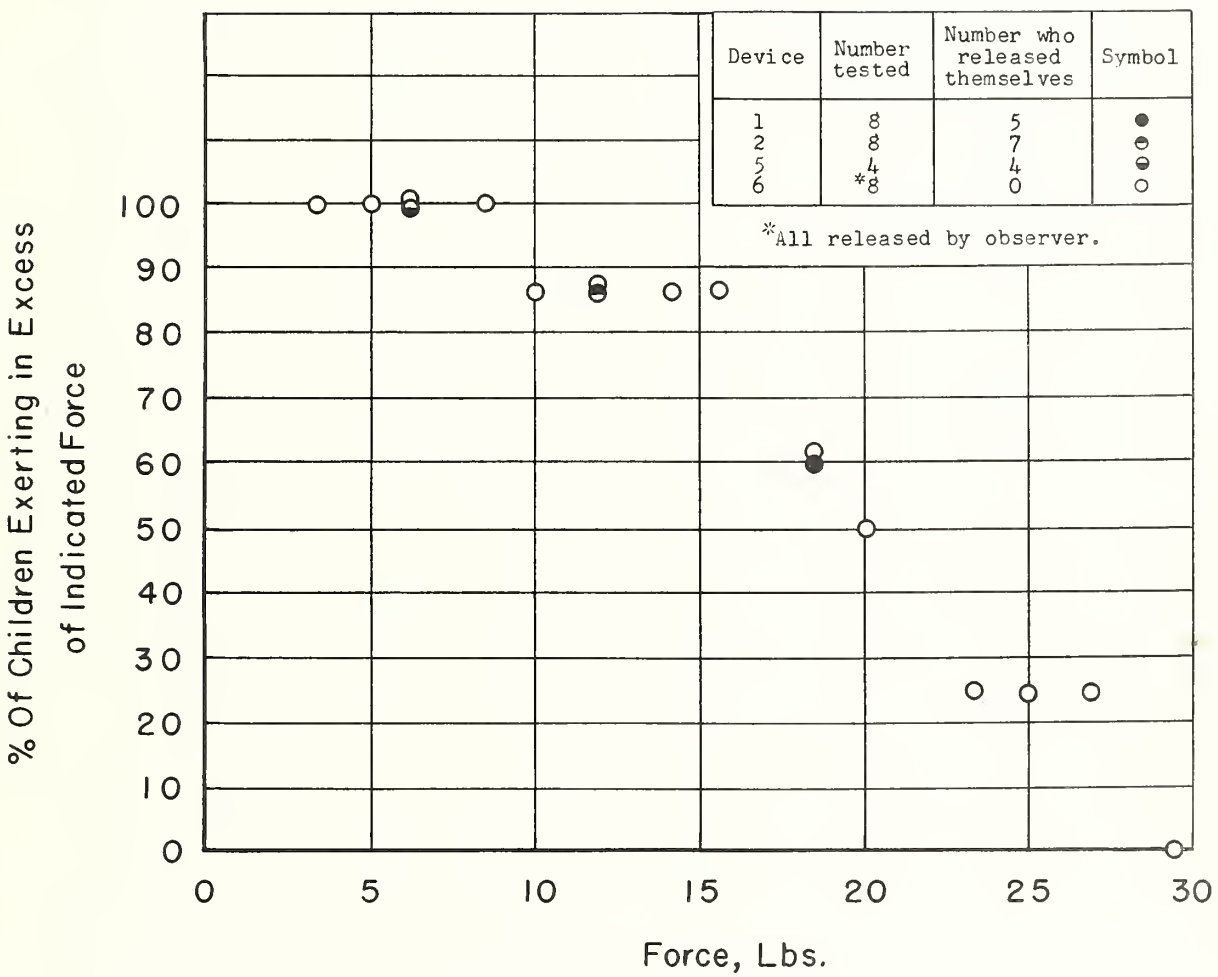

FIGURE 30. Horizontal components of forces exerted by children, age 5 years.

CHILDREN PUSHING ON DOOR

I. Successful Efforts

FIGURE 31. Boy opens door on first push (5 years).

FIGURE 32. By shoving with his buttocks, boy releases himself (4 years).

FIGURE 33. Girl stands waiting before movie screen, then bends down and pushes with both hands. Picture shows door opening (5 years).

CHILDREN PUSHING ON DOOR

II. Types of Strenuous Effort

FIGURE 34. Boy pushes shoulder against door, left of center (5 years).

FIGURE 35. Boy, backing up, rams door with shoulder push (5 years).

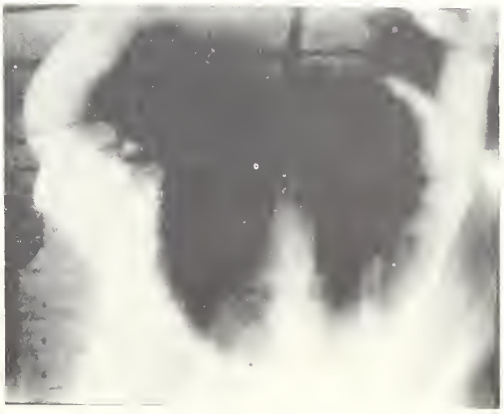

FIGURE 36. Boy stretches body to put force into a two-hand push on door (3 years).

CHILDREN PUSHING ON DOOR

III. Purposeful Efforts

FIGURE 37. Girl pushes on door from squatting position (3 years).

FIGURE 38. Girl makes a firm two-arm push on door (2 years).

FIGURE 39. Same girl directs all further efforts at side wall (2 years).

CHILDREN HANDLING LUMINOUS RING

FIGURE 40. Girl pulls ring with right hand, bracing herself with left hand on door (5 years).

FIGURE 41. Girl touches ring gingerly, without further exploration (2 years).

FIGURE 42. Boy thumbs luminous ring ineffectively (2 years).

ILLUSTRATIONS OF REACTIONS TO DOORKNOB

FIGURE 43. After approaching knob with left hand, girl continues to hold it, but makes no attempt to use it to release herself (2 years).

FIGURE 44. Boy with hand on knob, thumb at center, fails to use knob effectively (2 years).

FIGURE 45. Sitting in corner, boy reaches for doorknob. turns it clockwise to release himself (3 years).

ILLUSTRATIONS OF REACTIONS TO DOORKNOB

FIGURE 46. Girl grasps underside of doorknob, turns counterclockwise, releasing herself on first try (4 years).

FIGURE 47. Boy's hand is too small to grasp the doorknob effectively (2 years).

FIGURE 48. Girl grasps doorknob with left hand, turns it clockwise, promptly releases herself (5 years).

ILLUSTRATIONS OF REACTIONS TO DOORKNOB

FIGURE 49. Boy approaches knob with left hand after squatting in corner (3 years).

FIGURE 50. Same boy later grasps doorknob in both hands, turns it clockwise to release himself (3 years).

FIGURE 51. Boy uses both hands, pushing knob while turning it clockwise, opening door (3 years).

ILLUSTRATIONS OF REACTIONS TO DOORKNOB

FIGURE 52. Boy reaching, from far corner, for doorknob (5 years).

FIGURE 53. Same boy, as he later grasps doorknob and releases himself.

EXAMPLES OF CHILDREN IGNORING THE DEVICE

FIGURE 54. Boy has withdrawn to corner (4 years).

FIGURE 55. Boy's palms are outspread on door at chest level (2 years).

FIGURE 56. Boy rubs eyes with left hand, slapping door above luminous ring (2 years).

SAMPLES OF VIGOROUS KNOCKING BEHAVIOR

FIGURE 57. Boy, intending to knock, makes a fist (5 years).

FIGURE 58. With clenched fist, same boy completes knock on door (5 years).

FIGURE 59. Kneeling, girl raises hands shoulder high to slap door (4 years).

SAMPLES OF VIGOROUS KNOCKING BEHAVIOR

FIGURE 60. Left hand in mouth, boy knocks with right fist (5 years).

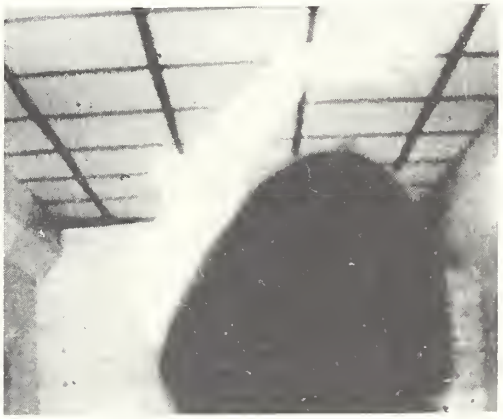

FIGURE 61. Boy, later quite upset, tentatively touches door with back of hand (4 years).

FIGURE 62. After long wait, boy knocks on wall opposite movie screen (5 years).

EXAMPLES OF EXPLORATORY BEHAVIOR

FIGURE 63. Girl completes exploration of door. Starting from hinge side, she felt across top and down latch edge to floor (5 years).

FIGURE 64. Boy, searching for release, feels mounting plate (4 years).

FIGURE 65. Boy reaches up to touch ceiling with both hands, after exploring with one (4 years).

FIGURE 66. Position of girl's hand suggests she is groping for a release device (5 years).

FIGURE 67. Boy's hand returns again and again to mounting plate (5 years).

SERIES SHOWING TWO-YEAR-OLD BOY REVOLVING IN THE ENCLOSURE

FIGURE 68.

FIGURE 72.

FIGURE 69.

FIGURE 71.

FIGURE 70.

FIGURE 73. He waits, facing movie screen, crouching.

FIGURE 74. After waiting in above position, he turns head without changing body position and taps door gently several times.

FIGURE 75. He continues tapping door lightly with finger tips.

EXAMPLES OF DISORIENTATION

FIGURE 76. Boy pushes on hinge edge of door (2 years).

FIGURE 77. Sitting with back to hinge edge of door, girl slaps forcibly with open palms at screen and back walls simultaneously (5 years).

FIGURE 78. Boy pushes hard on movie-screen wall (5 years).

FIGURE 79. Boy, distraught, makes many hand-to-face movements, intermittently clasping and unclasping fingers (3 years).

FIGURE 80. Boy retreats to wall farthest from screen and rubs eyes many times (4 years).

FIGURE 81. Boy's right thumb goes to his mouth repeatedly (4 years).

5. CONCLUSIONS

1. Children's behavior takes a variety of forms under conditions simulating entrapment in a refrigerator. These are discussed in section 4.4 of this report.
2. Considering the total sample, no device tested approached 100% effectiveness.
3. None of the devices used in testing children in this investigation was designed in such a way as to insure release under all conditions as, for example, in connection with the following types of behavior:
   (a) Pushing efforts directed at the door when the proper effort would have been to use a knob or trigger device
   (b) Efforts which consumed time and energy in a search for a release mechanism on a door which reacted only to a push
   (c) Efforts directed at some surface other than the door
   (d) Cases of no effort whatsoever, or of efforts of a random and diffuse nature
   (e) Efforts of a proper type, but applied with insufficient force, or for an insufficient period of time to effect release
   (f) Improperly directed efforts to manipulate a release mechanism.
4. The correlated factors of age, weight, and height appear to have an important effect on the success of children in utilizing a release device. This suggests that weight, height, physical abilities, and behavior patterns of the youngest age groups for which protection is to be provided should be considered in designing a release device.

5. The specific type of behavior exhibited by any particular child under conditions of entrapment is a very important factor affecting success. This suggests that the behavior of the children who, when entrapped become helpless or disorganized, should be considered in designing a release device. This type of behavior was observed, in this investigation, most frequently in 2-year-old children, and to a lesser degree in 3-year-old children.

6. Limited experience in design of experimental devices carried out in this investigation seems to indicate that it would be possible to build release devices reacting to a very low order of force. However, the expense involved and other possible objectionable features might preclude adoption.

7. The test results indicate that the most effective devices which seem to be practical are:

   (a) A luminous knob release reacting to push-pull-turn (ideally, also to deflection). Such a knob, it appears, should resemble the smaller domestic-type doorknobs in size and shape. In addition, the turning moment to effect release should not exceed that for modern domestic doorknobs. The turning moment for the doorknob device used in this investigation has been given in section 2.3 of this report.

   (b) A push-type door which reacts to a low order of force. This type of device should release positively and quickly on application of short-duration force to overcome lag or sticking caused by friction or inertia. Data on the performance of children tested on push-type doors in this investigation have been presented in section 4.3 and elsewhere in this report.

8. The present study has opened up a new field of investigation, and has indicated the existence and general nature of unsolved problems in the field of child safety, especially in regard to psychological aspects. The results in no way preclude the possibility of further study in child research centers.

9. The results of this investigation appear to have given sufficient information to be useful in the development of criteria for a standard for release devices providing a reasonable degree of protection.

6. LIST OF TABLES

7. ACKNOWLEDGEMENTS

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8. APPENDIX

1. SUCCESS IN RELATION TO HEIGHT AND WEIGHT

In the body of this report frequent mention has been made of the correlated factors of age, weight, and height as factors affecting success. Figures 1, 2, 3, and 4 of this appendix show the height and weight of each child tested on Devices D_1, D_2, D_3, and D_4, respectively, without reference to age. These figures clearly distinguish between success and failure.

Inspection of these data fails to indicate a clear distinction between the general height-weight curves for the successful and non-successful children. It appears that there is a greater concentration of failures in the lower left areas of these figures, and a greater concentration of successes in the upper right areas, although there are several exceptions to this general trend. Probably this is partly explained by the fact that in general the younger children were the most likely to fail on all devices, and that most of the younger children were the smallest. No distribution curves for weight and height have been made for the successes and failures within each age group. This should be considered worthy of doing in connection with any further analysis of the data.

2. EXPLANATION OF DISCREPANCY IN AGE CLASSIFICATION

In several tables presented in the body of this report, the age classification used is in terms of month-intervals. It was intended that these intervals would be of equal widths. Inadvertently, some intervals turned out to be 11 months and others 13 months in width. When this discrepancy was noted, there was not sufficient time to permit re-working of the data on which the affected tables were based. However, in the opinion of the statisticians, this unevenness in interval width does not appear to affect the conclusions in any substantial way.

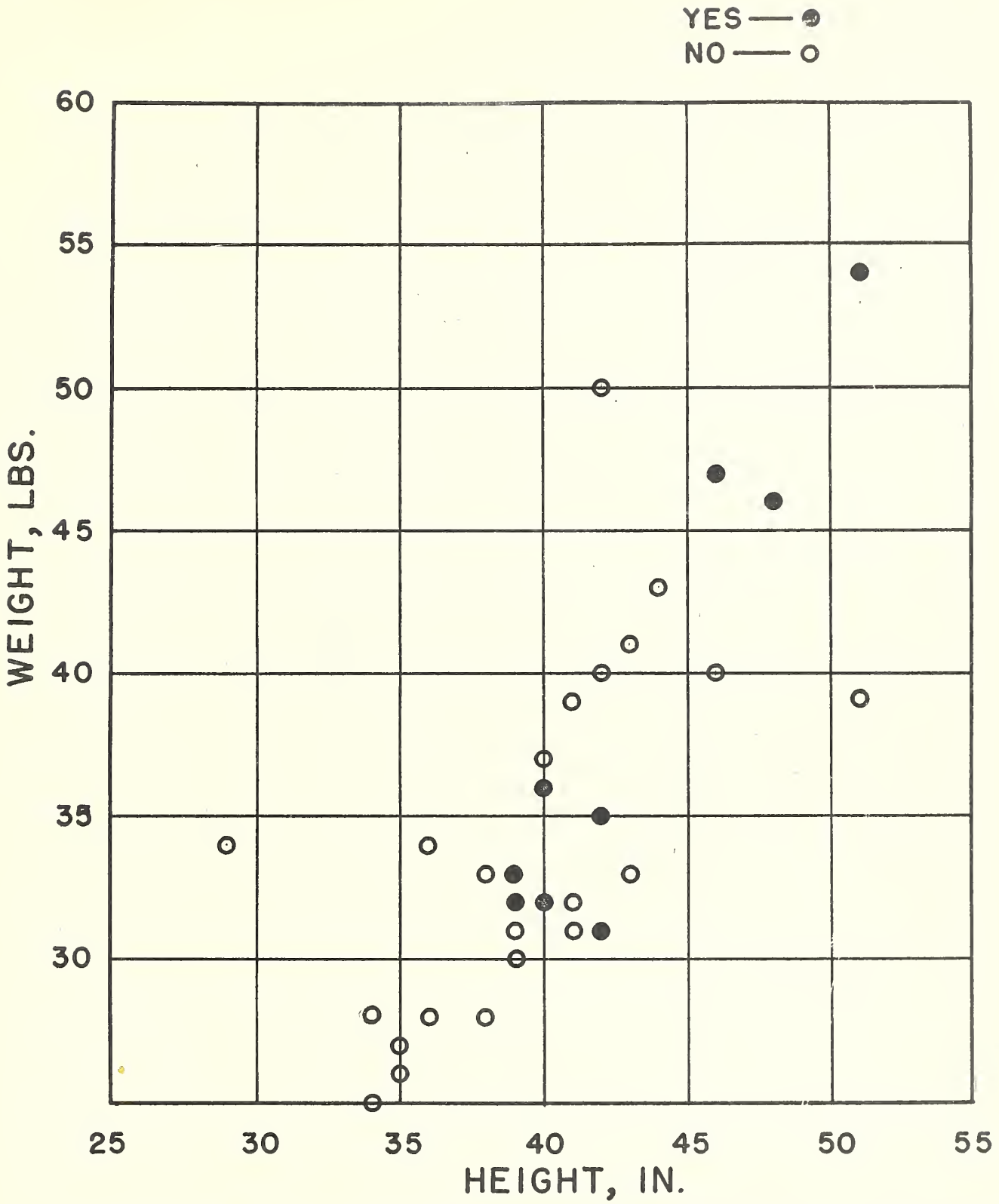

FIGURE 1. SUCCESS IN RELATION TO HEIGHT AND WEIGHT FOR ALL AGES TESTED FOR DEVICE D_1

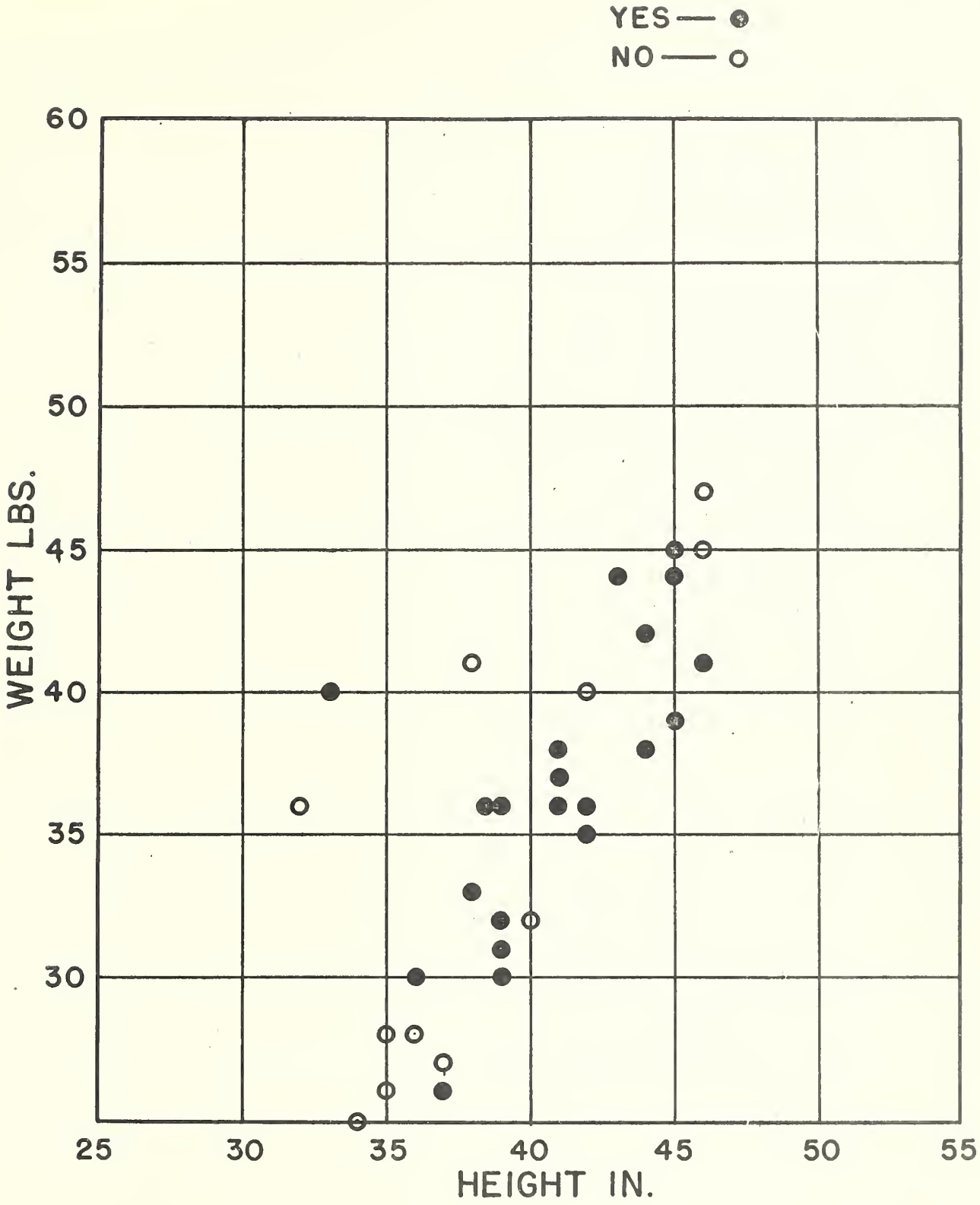

FIGURE 2. SUCCESS IN RELATION TO HEIGHT AND WEIGHT FOR ALL AGES TESTED FOR DEVICE D_2

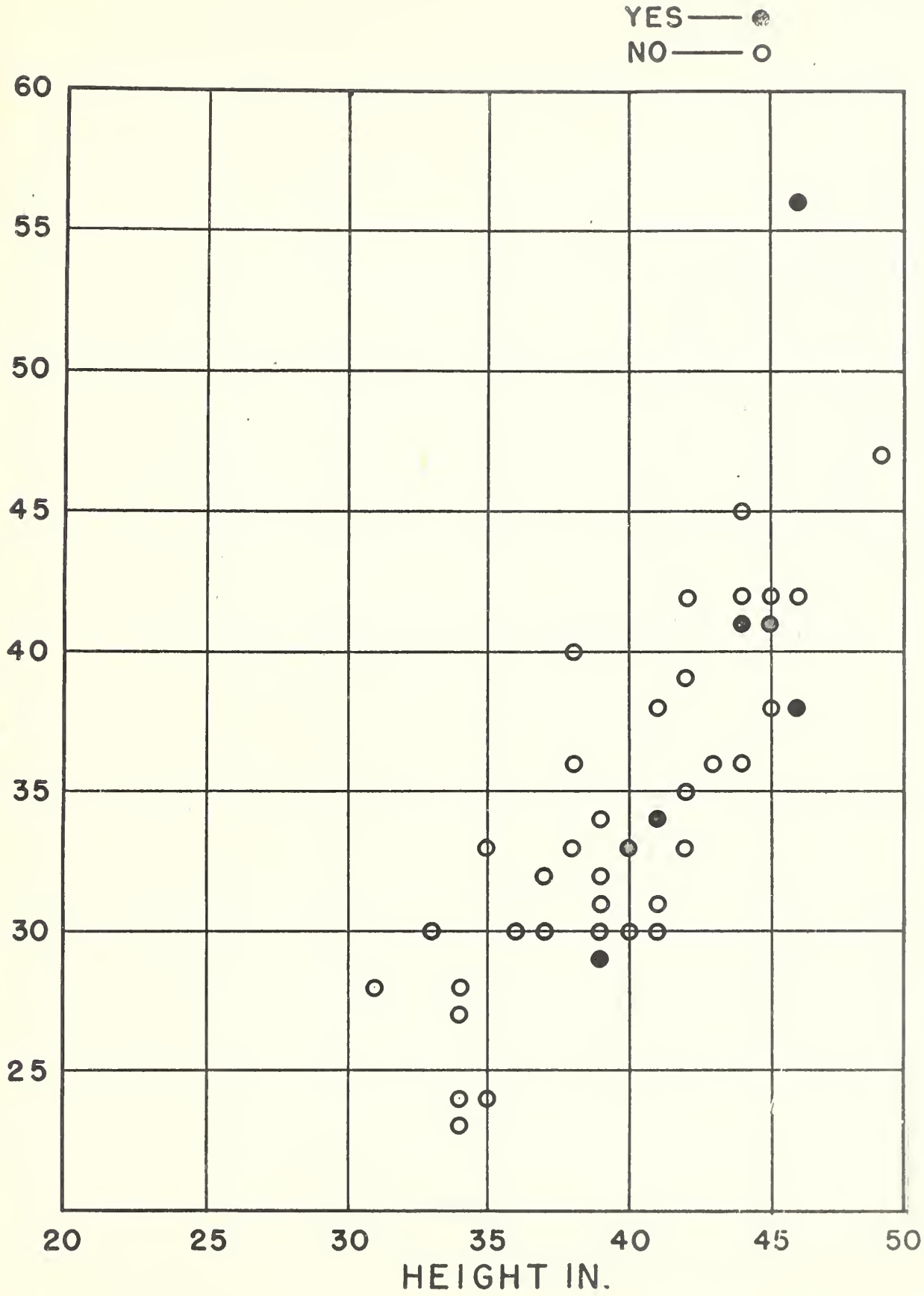

FIGURE 3 SUCCESS IN RELATION TO HEIGHT AND WEIGHT FOR ALL AGES TESTED FOR DEVICE D_3

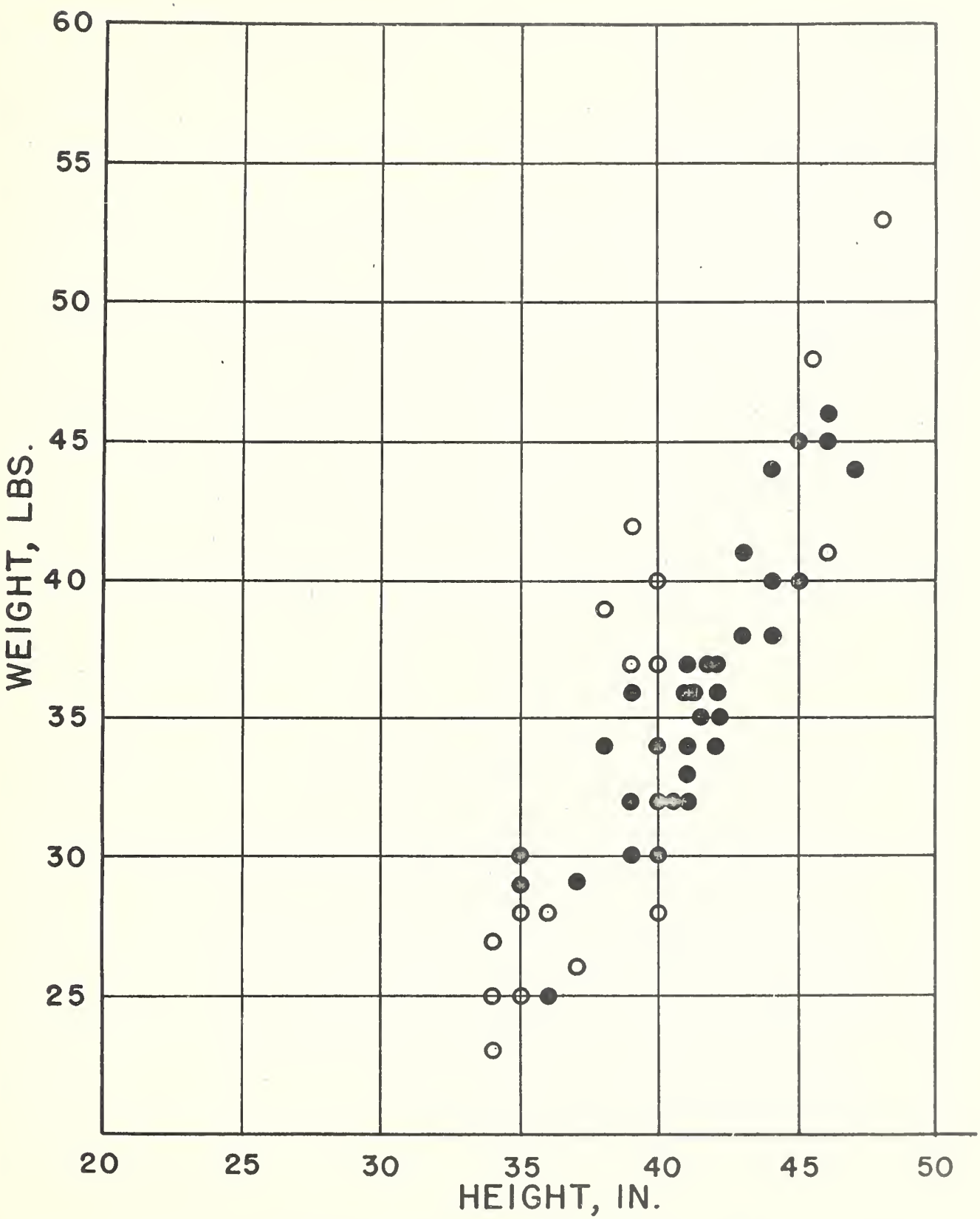

FIGURE 4. SUCCESS IN RELATION TO HEIGHT AND WEIGHT FOR ALL AGES TESTED FOR DEVICE D_4

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