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WADC TECHNICAL REPORT 59-165

A SUPINE SEAT FOR HIGH-STRESS TESTING OF PRIMATES

L. EISEN, 1st/LT., USAF
R. S. ZEIGEN, CAPTAIN, USAF
AERO MEDICAL LABORATORY

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APRIL 1959

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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A SUPINE SEAT FOR HIGH-STRESS TESTING OF PRIMATES

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APRIL 1959

PROJECT NO. 7222
TASK NO. 71749

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

McGregor & Werner Midwest Corp., Dayton, O.
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FOREWORD

This report was prepared by the Anthropology Section, Biophysics Branch, Aero Medical Laboratory, Wright Air Development Center, under Project 7222, Task 71749, "Anthropology for Design," in support of the Unusual Environment Section, Psychology Branch, Aero Medical Laboratory, under their Project 7183, Task 71620, "Behavioral Effects of Unusual Environmental Conditions." Major Frederick H. Rohles and Captain Marvin E. Grunzke, of the Unusual Environment Section, coordinated this program with the Anthropology Section.

The Macaque supine seat and restraint harness, with surrounding inclosure, were designed by Lt. Eisen. Captain Zeigen made the required measurements on the Macaque, assisted by Mr. Kenneth W. Kennedy of the Anthropology Section. Mr. Kennedy also made many constructive suggestions concerning the rationale for the Macaque supine seat and restraint harness design. Captain Zeigen also suggested design modifications and interpreted the data.

Advice concerning the effects of acceleration was furnished by Captain Neville P. Clarke and Mr. Paul L. Yudkofsky, Acceleration Section, Biophysics Branch.

The squirrel monkey seat and restraint harness were designed by Lt. Eisen in conjunction with Mr. Yudkofsky. Measurements on the squirrel monkey were made by Mr. Frank P. Saul, formerly of the Anthropology Section.

Captain Zeigen had primary responsibility for writing the entire report.

The authors are grateful to Mr. H. T. E. Hertzberg, Chief, Anthropology Section, for his critical reading of the report and comments on its organization.

The animal experimentation reported herein was performed in accordance with the "Rules for Animal Care" established by the American Medical Association.

ABSTRACT

This study summarizes the design rationale of a supine seat and restraint harness, with surrounding inclosure, for high stress bio-science experiments with a Macaca cynomolgus monkey (Macaca iris). This configuration is intended for test under various abnormal stresses, including high g centrifuge runs. Testing and feeding of the subject in the inclosure will be accomplished to determine his reaction to these stresses. With minimum modification, the Macaque supine seat and restraint harness could accept any primate for ground tests or bio-experiments in space flight. A brief description of an earlier supine test seat and restraint harness for low-stress experiments using a squirrel monkey is included.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

ANDRES I. KARSTENS
Colonel, USAF (MC)
Asst. Chief, Aero Medical Laboratory

SECTION I

INTRODUCTION

During September 1958, personnel from ARDC met with civilian specialists at the University of Virginia to consider "biological payloads and bio-science experiments for space flight vehicles."* While experiments on man himself ultimately would be needed to determine his ability to perform under the stresses of space flight, preliminary tests on animals, especially on primates, would aid in suggesting programs for human tests, and at the same time would indicate possible limitations imposed on man's actions in space.

Initially, ground experiments simulating stresses experienced in space flight seemed desirable. As one element of this experimentation, plans were made to conduct high g centrifuge runs using a Macaca cynomolgus monkey (Macaca iris) as the test subject. For this purpose, a seat and restraint harness would be required which might also be used for other space-simulated, ground-level experiments. In order to appreciate the subject's reaction capabilities to abnormal stresses, this seat would have to be restricted by a surrounding inclosure containing testing and feeding devices.

Although the supine seat and restraint harness, with their surrounding inclosure, as discussed in this report, are designed for a specific subject, the Macaca cynomolgus, the same items can be adapted with a minimum of modification to accept any primate. Bio-science experiments in space flight vehicles could conceivably be conducted on primates using the protection system described.

SECTION II

SQUIRREL MONKEY SUPINE SEAT AND RESTRAINT HARNESS**

A. General

While various high stress animal centrifuge seats and restraint harnesses had been used in earlier experiments on monkeys, it was decided to model the Macaque seat as nearly as possible after that used for current human tests. Preliminary work along these lines actually was begun in August 1958 when a request

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* Banghart, Frank W., Editor, Biological Payloads in Space Flight, ARDC Technical Report 58-58, Contract AF 18(600)1792, Division of Educational Research, University of Virginia, Charlottesville, Virginia, November 1958, page i.

**Yudkofsky, Paul L., Primate Responses to Prolonged Low Magnitude Accelerations and to Sudden Withdrawal of these Accelerations, Technical Report in preparation, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. (Pertinent information verbally communicated to Capt. Zeigen.)

was received to design a supine seat and restraint harness for testing reactions of a squirrel monkey (Saimiri sciureus) under prolonged low accelerative forces (2 g) on a small-animal centrifuge. It is evident that the problems encountered in designing a low-stress seat would not be as complicated as those met in developing one for high stresses. Nevertheless, the experience gained in designing the initial seat was of considerable value in developing the more sophisticated one.

B. Low-stress Supine Seat and Restraint Harness

The squirrel monkey seat, not having to withstand extreme stress, was fabricated of 3/8-inch plywood. An upper torso restraint harness was sufficient and was attached to the seat by snap fasteners. The monkey's legs were restrained with loosely tied tape. The netting, following the curvature of the frame, was so fastened as to permit adjustability of net tautness (Fig 1).

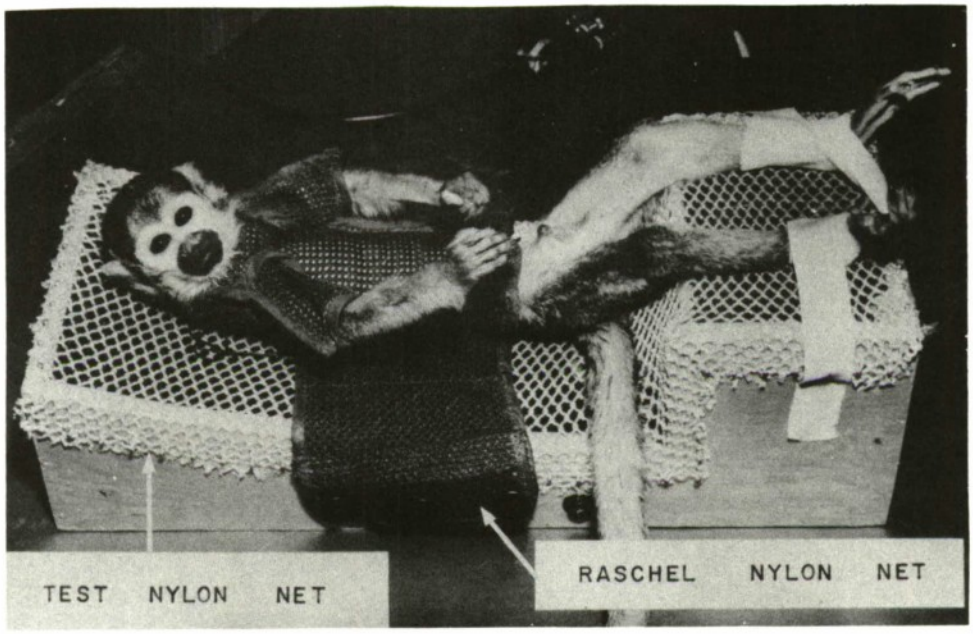

FIGURE 1 - SQUIRREL MONKEY RESTRAINED IN SEAT

Although from Figure 1 and2*it is seen that two types of nylon mesh were used, a light and a dark colored one (white and sage green), this did not affect performance. The white loose mesh was an experimental fabric only and has not been commercially produced. The green mesh is listed under USAF Specification MIL-C-8061(USAF), dated 13 February 1953, titled "Cloth, Nylon Raschel Knit." The green mesh has a breaking strength in both directions of

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* The snap fasteners had not yet been installed when Figure 2 was taken.

200 pounds per linear inch minimum. It elongates and conforms to the body, thus providing a shock-absorbing material. The same Raschel knit mesh which was used for one of the squirrel monkey seats and for both restraint harnesses has been tested on the human centrifuge and has supported a 3200-pound force (a 200 pound man at 16 g).

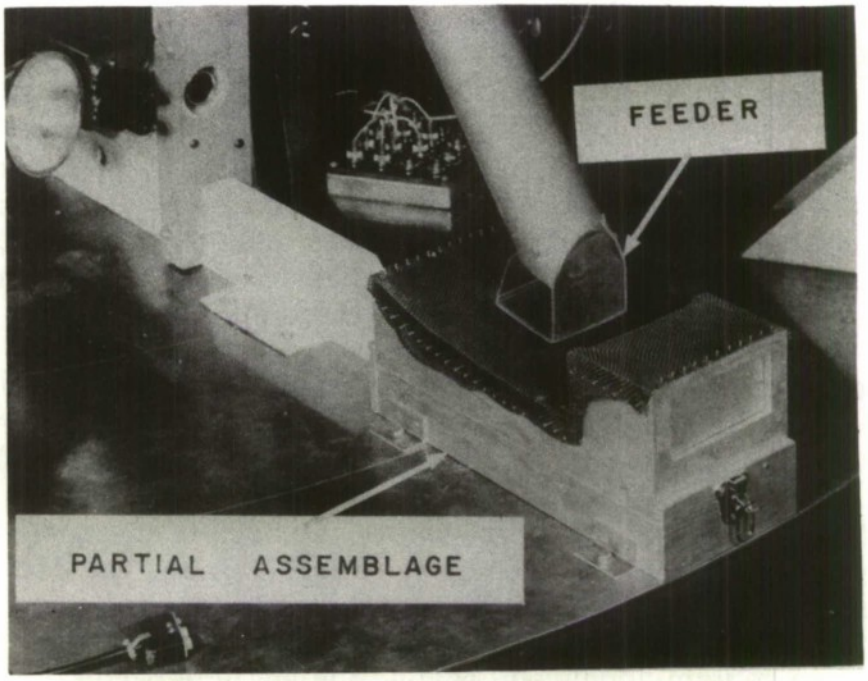

FIGURE 2 - PARTIAL ASSEMBLAGE SHOWING FEEDER ARRANGEMENT

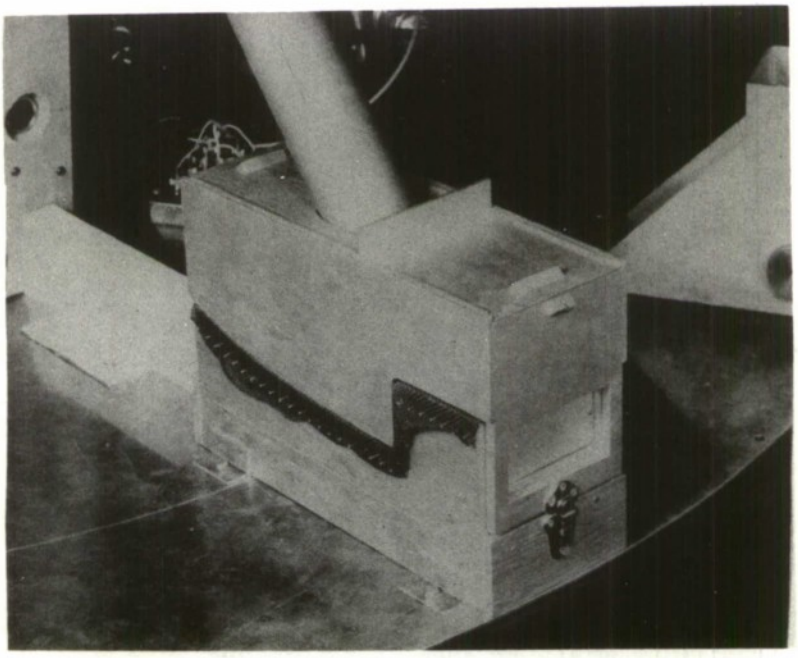

FIGURE 3 - COMPLETE ASSEMBLAGE

A gravity chute was incorporated into the upper portion of the seat inclosure to provide food for the subject (Fig 2). This inclosure was fixed to the seat with luggage fasteners (Fig 3). Two seats with restraint harnesses of this design functioned efficiently in tests runs. On one occasion, the seats without monkeys or harnesses were unintentionally stressed to 45 g. No adverse effects were noted.

C. Problem Areas

1. The harness, designed from initial measurements of a squirrel monkey, provided a poor fit in both lengths and circumferences. As a result, it had to be modified for the subject. From this, it was evident that considerable adjustability would be needed for the Macaque harness, especially so since Macaques other than that measured would be used for the tests.

2. A second problem area related to the support given the bent legs behind the knee (popliteal surface). The netting alone did not provide adequate support in this region, curving inwards, because of the tension applied (Fig 4). To counteract this problem, a dowel was placed immediately under the netting across the width of the frame at the 90° juncture where the back of the knee was supported. Thereby, the depression of the netting was corrected and the desired flat surface was provided.

3. Another problem appeared because the angle between the seat back and leg support was 90°. The net did not follow the seat frame bent at this angle and pressed upward into the region where the monkey's sacro-iliac region would normally have lain. This forced the subject's lower back and buttocks into an upward arc, preventing the torso and thighs from assuming the desired configuration (Fig 5). No correction was made of this problem inasmuch as it did not interfere with the tests being conducted.

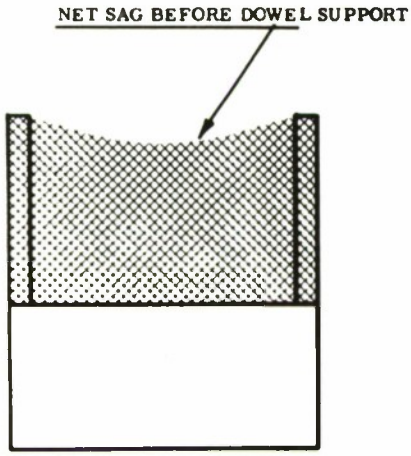

FIGURE 4 - NETTING BEHIND KNEE - LOOKING REARWARD FROM SUBJECT'S HEAD

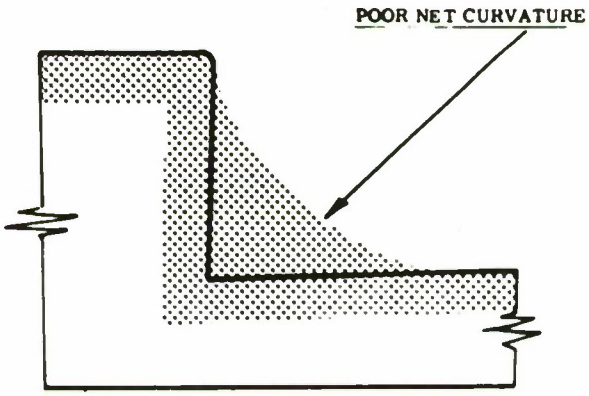

FIGURE 5 - NETTING IN SACRO-ILIAC REGION - SIDE VIEW

4. The allowances for feces disposal under prolonged periods of testing were inadequate. For one or two days, feces elimination would be of minor concern. In the squirrel monkey seat, the netting in the buttocks region was so cut as to produce a hole four times that of the normal spacing of the weave. This procedure was sufficient for the test conducted, but would be inefficient for extended experiments. To overcome this problem, the net could be removed in the location of the buttocks with spaced rollers being introduced in its place, thereby permitting the feces to fall into a container. Such a method of course would require a relatively dry stool.

5. It was found that a cutaway (scooped) neck was needed to prevent the harness from compressing the neck of the subject and perhaps occluding blood vessels in this area.

SECTION III

MACAQUE SUPINE SEAT AND RESTRAINT HARNESS

A. General

The experience gained from the low stress supine seat and restraint harness was useful when the request was received for a more sophisticated seat and harness. The new purpose was to subject a Macaca cynomolgus to forces twelve times that of gravity, and directed (1) from head to foot, (2) from foot to head, and (3) perpendicular to the longitudinal axis of the body. A surrounding inclosure was needed to incorporate devices which could test the monkey's reactions to these abnormal stresses. These devices were to include a light panel, a telegraph key actuator and a feeder.

B. Method of Measuring the Macaque

Initially, two sets of measurements were made on a mature, adult Macaca cynomolgus available in the Aero Medical Laboratory. Separate dimensions were taken for the seat and for the harness.* Since the Macaque was anesthetized with ether and his body completely limp, all measurements pertinent to the harness were loosely taken to preclude a tight fit when the subject was active.

The arc measurements were taken at points where restraint straps would be most suitably fixed to restrict movement of the subject as well as to restrain him adequately. These became the points of taper for the full torso restraint harness which was designed and which has the appearance of a loosely fitting suit.

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* Sketches and tables of measurements taken on the Macaque and detailed drawings of the supine seat and restraint harness, with surrounding inclosure, are included as an appendix to this report.

C. Seat and Restraint Harness Rationale

After consultations with the Acceleration Section, it was considered advisable to design the supine seat with the same angles as those introduced into a human seat. Accordingly, the following design details were to be provided: (1) the back angle is to be 0-5 degrees above the horizontal, (2) the angle between the back and upper thigh, 90 degrees, and (3) that between the lower thigh and calf 0-1 degree above the horizontal (Fig. 6). For purposes of strength and lightness of weight, the seat frame could be constructed of thin-wall aluminum tubing. Titanium would be even lighter.

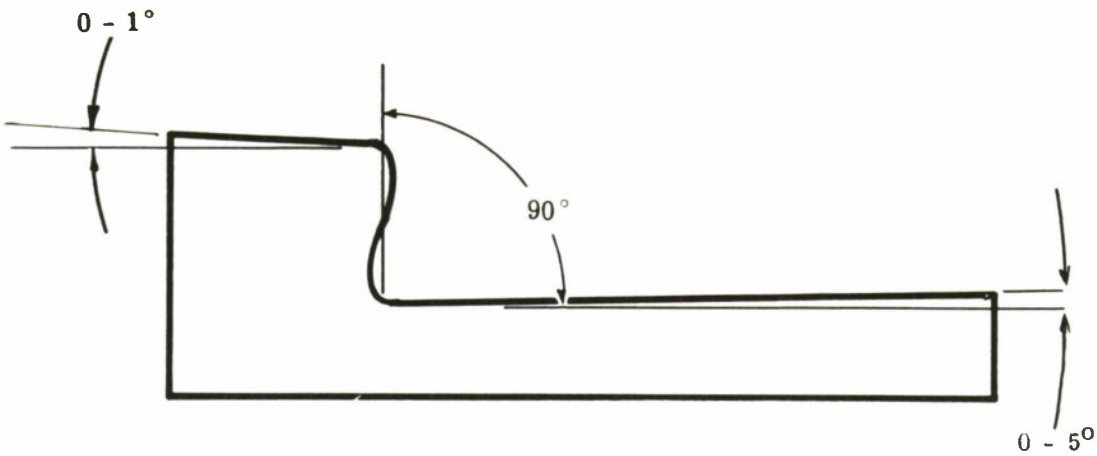

FIGURE 6 - MACAQUE SUPINE SEAT ANGLE LIMITATIONS

The net seat is to be taut and is to be made of the Raschel knit nylon mesh used for the squirrel monkey seat and restraint harness. To eliminate the problem of the seat protruding into the sacro-iliac region, two design factors have been introduced. First, in place of an absolute 90° angle, the seat frame at this point in to be curved away from the body (Fig. 7). Second, a dowel is situated about one inch from this curve. The net fits into this curvature and is held taut by nylon cord stretched between the netting and the dowel. The net is attached to the seat by small hooks fixed to the seat frame at one-half inch intervals.

A restraint harness or suit of Raschel knit nylon mesh for full-torso and legs is to be integrated with the seat. This harness will restrain the monkey from the neck to just above the ankles. A quick access zipper, opening from the foot end, will permit ready positioning of the subject. Through this arrangement, he cannot inadvertently open the suit. A one-inch adjustability of the harness is provided for by lacing. To permit waste eleimination there is a hole in the buttocks region of the netting.

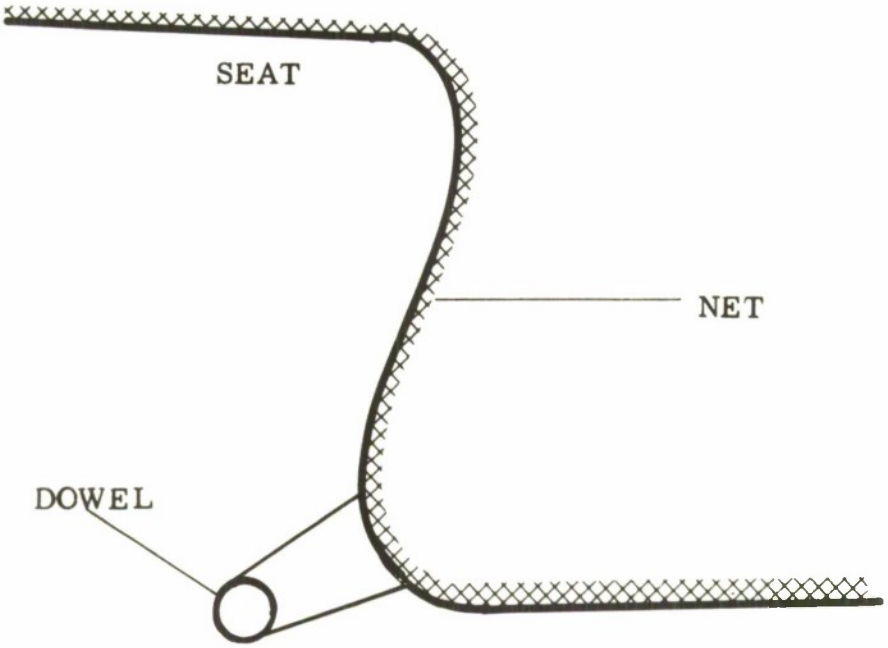

FIGURE 7 - SACRO-ILIAC REGION OF MACAQUE SUPINE SEAT

D. Design of Additional Equipment

For testing, the seat is to be completely inclosed in a lightweight, opaque box like inclosure. This is necessary to prevent or minimize disorientation and motion sickness. A small Plexiglas observation window can be installed in the box. In order to insure clean lines on the seat for ease of handling, all other required items will be attached to the surrounding inclosure or will be installed after the animal on the seat is slid into the box, head first. The testing devices, the light panel, telegraph key actuator and feeder box are located directly above the animal's face and upper torso. This permits immediate reaction to light signals and minimizes the space needed.

An arm rest panel padded with polyurethane foam will prevent undue injury to the animal's arms in the event these flail about. The inside of the inclosure also is lined with this foam to decrease the possibility of subject injury. As an added safety precaution, handles are situated on the arm rest panel, approximately at palm level of the inclined arms, providing the subject with objects to grasp during extreme vibrations. By being curved around the monkey's body, the panel serves as an additional restraint. The arm rest has fore-and-aft adjustability.

To minimize stasis and occlusion of blood in the subject's legs, a movable footrest is to be attached to the box after the seat is installed. This item will permit the monkey to flex his leg muscles under prolonged periods of stress.

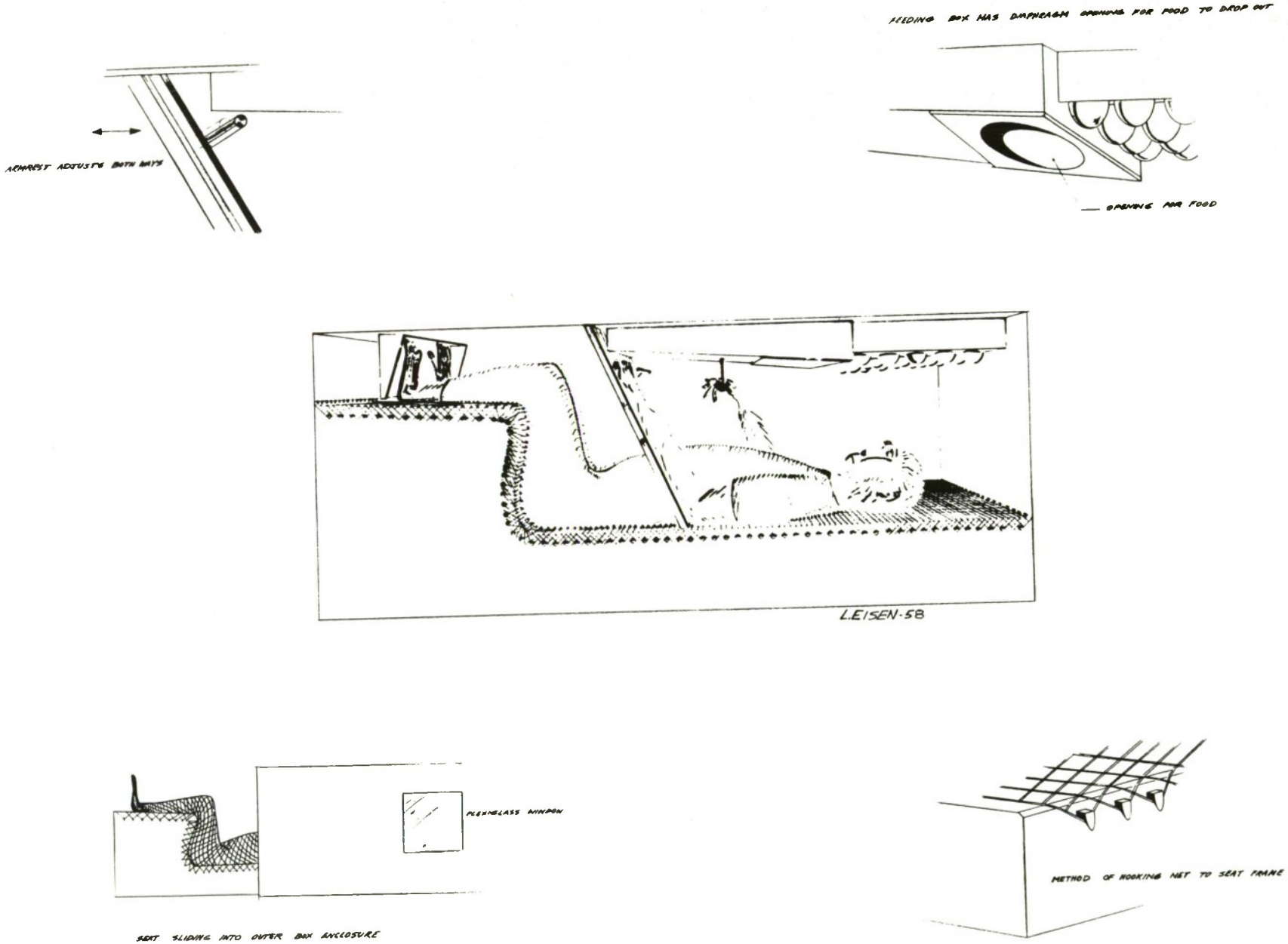

FIGURE 8 - RENDERING OF MACAQUE SUPINE SEAT – SHOWING DETAILS

A rendering of the completed seat and inclosure, with sketches of details, are included as Fig. 8.

E. Design Concepts

Adjustability is a major criterion, having been incorporated into the restraint harness, the arm rest panel and foot rest. Easy handling of the subject is another. In addition, the seat is made sufficiently long to accept somewhat larger Macaques than that measured. There is also extra room to permit a head restraint or helmet, if tests requiring these are conducted. Smallness in the size of the test subject should not be a problem.

It must be expected that after the initial fabrication of the seat and harness, some modifications will be required depending on the size of the monkeys selected, as well as the tests being run. The lack of body dimension data on Macaques, as well as their size variability, makes such modification necessary.

SECTION IV

INSTRUMENTS AND MEASURING PROBLEMS

Standard anthropometric instruments were used to measure the Macaque (Fig. 9). These were as follows:

One-forth inch steel, "Wyteface" tape for cirumferences

Sliding calipers for breadths and shorter lengths, i.e., hand, upper arm, etc.,

Anthropometer, upper section only, for major lengths.

The techniques used were modeled after those described in WADC Technical Report 52-321. * These techniques could serve only as guides because of the uniqueness of the problem. Few comparable measurements have been taken on monkeys and no standardized measuring techniques for primates have been established. This problem was compounded in the present instance by the fact that the Macaque was completely limp and his body in a basically unnatural position. On the other extreme stands the conscious monkey which offers another problem. The squirrel monkey was measured in such a state and was extremely active. It was therefore impossible to fix the instruments at physical landmarks, and the measurements had to approximate their location as nearly as possible while the subject was in constant motion.

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* Hertzberg, H.T.E., Daniels, G.S., and Churchill, E., Anthropometry of Flying Personnel - 1950, WADC Technical Report 52-321, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, September 1954.

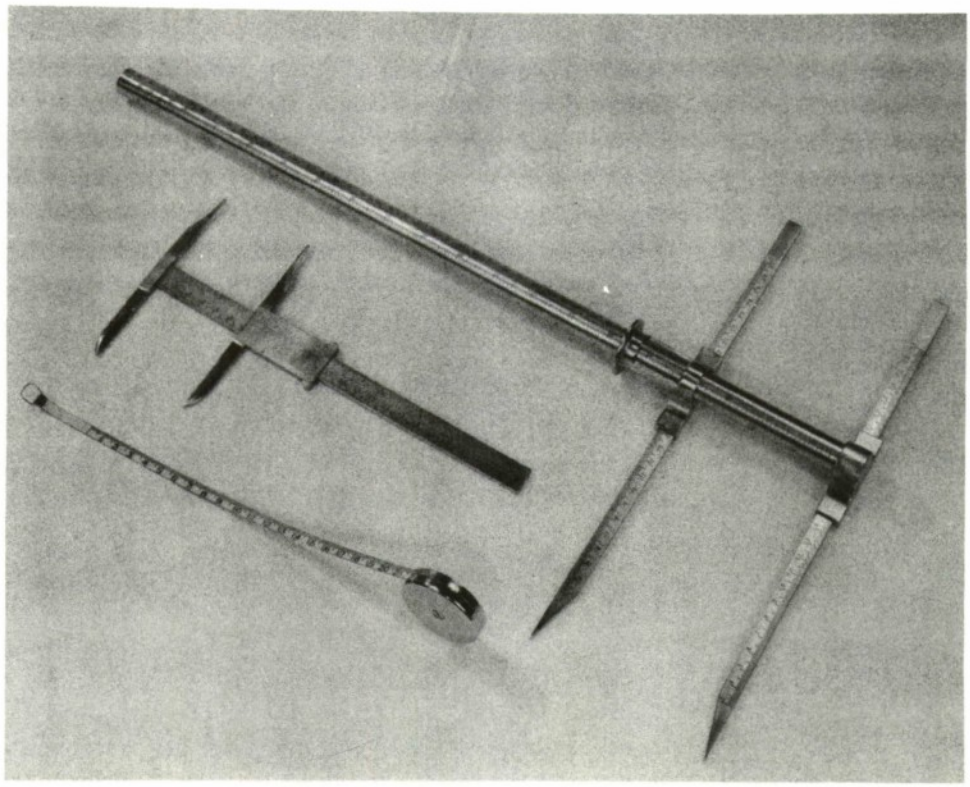


FIGURE 9 - ANTHROPOMETRIC INSTRUMENTS

Thus, in neither the conscious nor unconscious state is a standard measurement obtainable, only a close approximation. For this reason, it is not essential to use precision anthropometric instruments. Any good standard ruler and tape measure graduated in tenths or quarters of an inch would be suitable. Effort should be made to be accurate within 0.25 of an inch.

APPENDIX

MACACA CYNOMOLGUS NO. 1143

1. Weight 4lb 14oz

2. Height (length)
   a. Top of head to top of tail 12.85*
   b. Bottom of tail to stylion 9.00
   c. Tail Length 18.85

Heights (Sitting)

3.
3. Sitting Height 12.85
4. Acromial Height 11.1
5. Upper arm length 4.82
6. Popliteal Height 3.3
7. Knee Height 5.45

Depths (Sitting)

8. Total arm reach 11.23
9. Lower arm length 7.36
10. Buttock-knee length 5.68
11. Buttock-posterior calf length 4.46

Breadths (Sitting)

12. Bideltoid 4.25
13. Elbow-elbow 5.54
14. Hip-breadth 4.14

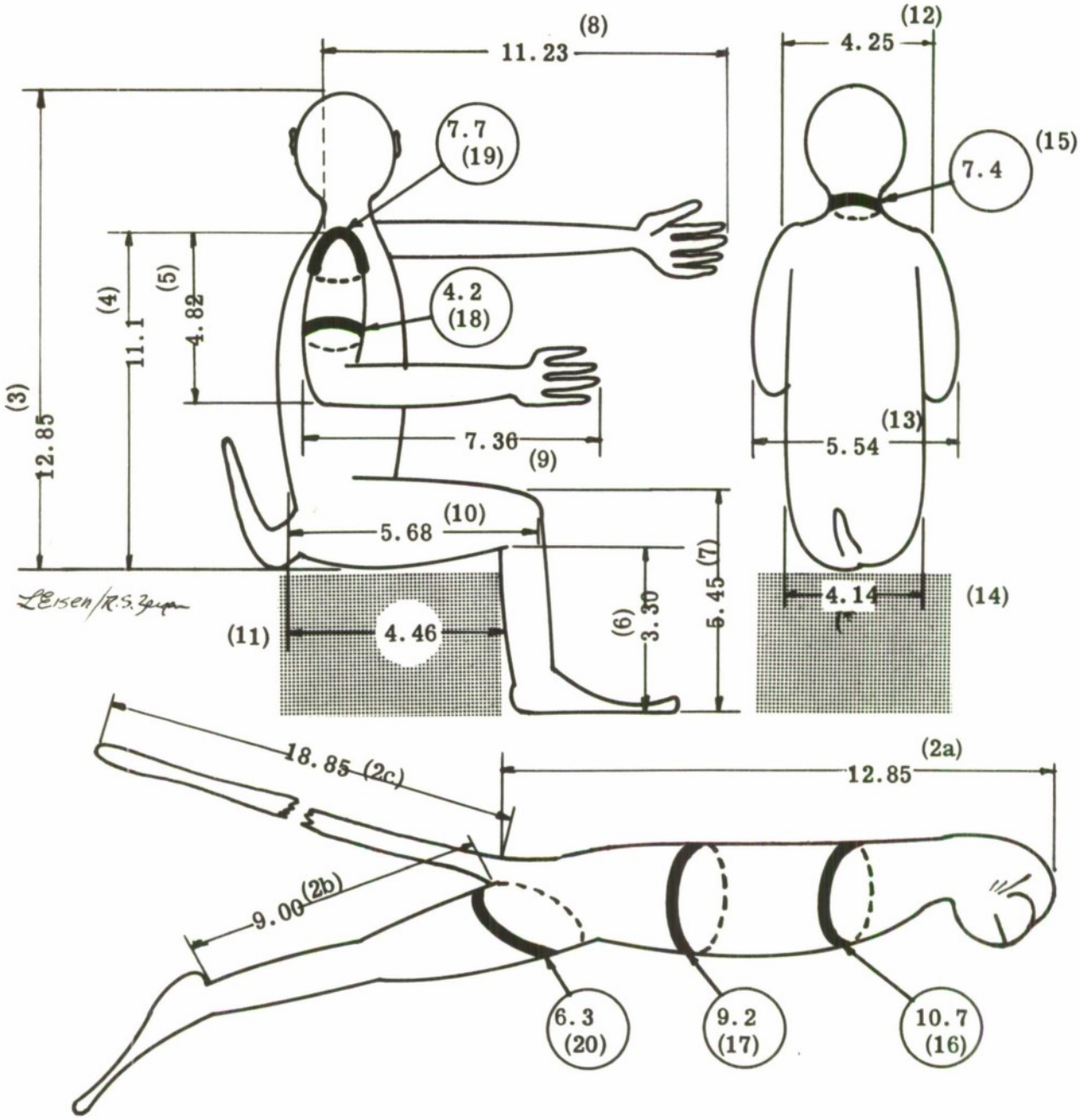
Circumferences

15. Neck 7.4
16. Chest 10.7
17. Waist 9.2
18. Biceps 4.2
19. Scye 7.7
20. Upper Thigh 6.3

See Fig. 10 for location of above points.
* All measurements in inches

TABLE 1 - DESIGN MEASUREMENTS FOR SEAT AND HARNESS

MACACA CYNOMOLGUS #1143*



*ALL DIMENSIONS IN INCHES
Figures in Brackets refer to Table I.

WEIGHT 4 POUNDS 14 OUNCES

FIGURE 10 - BASIC DIMENSIONS

Based on a sketch made by F. P. Saul, Aug 58

MACACA CYNOMOLGUS NO. 1143

Arcs and breadths at the following points:

	ARC	BREADTH
1. Across nipples	7.25*	3.15
2. Widest part of chest	8.20	3.45
3. Narrowest part of stomach (just above crotch)	6.70	2.80
4. Top of upper thigh	6.85	3.50
5. Top of knee cap	4.10	2.60
6. 2.45 inches above top of ankle	3.95	3:10
7. Top of ankle	3.05	2.05

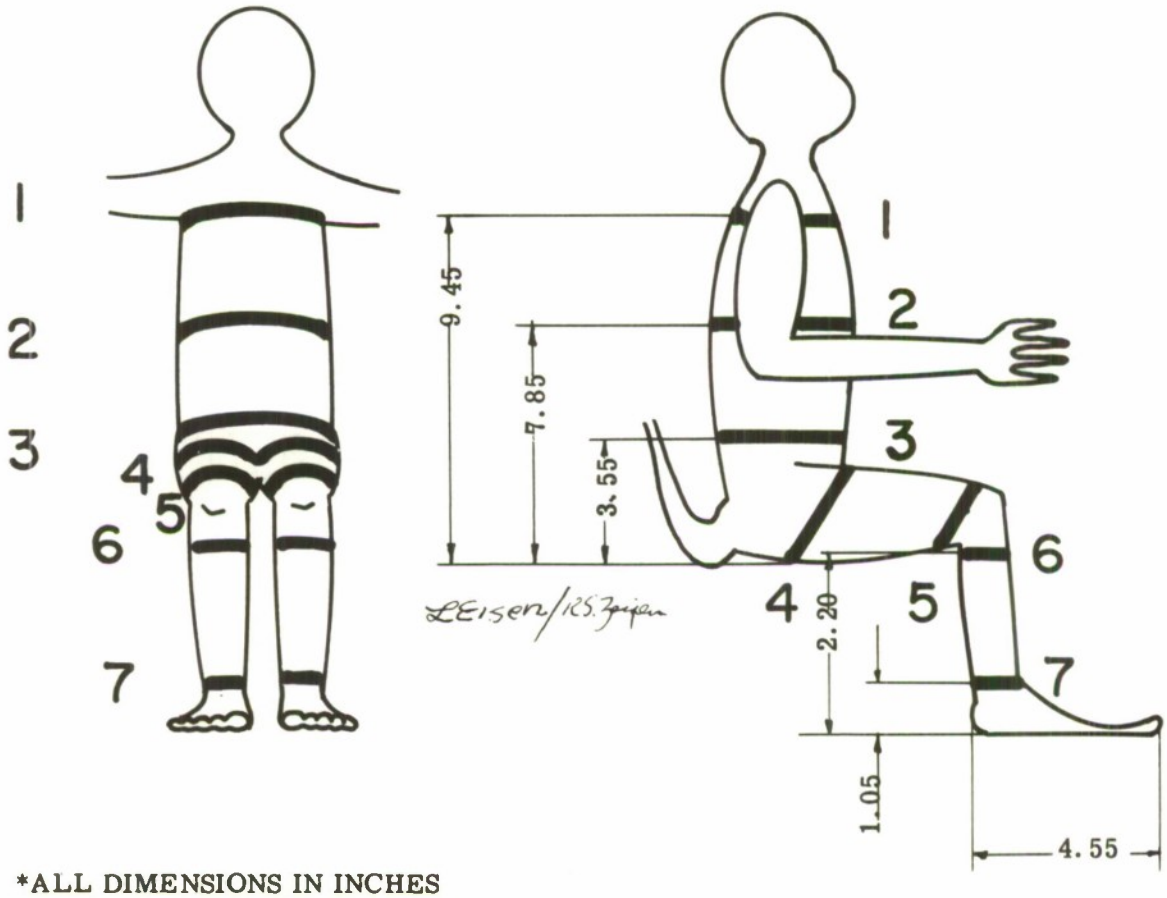
See Fig. 11 for location of above points and for palm location and foot length.

*All measurements in inches.

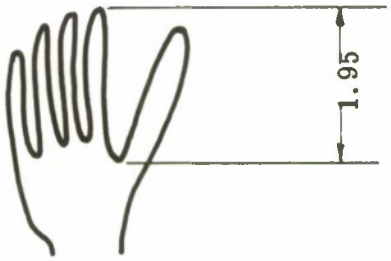
TABLE 2 - DESIGN MEASUREMENTS FOR HARNESS (ARCS)

MACACA CYNOMOLGUS #1143*

POINTS OF ARCS FOR NET SUIT



*ALL DIMENSIONS IN INCHES



HAND DIMENSION

FIGURE 11 - ARC MEASUREMENTS

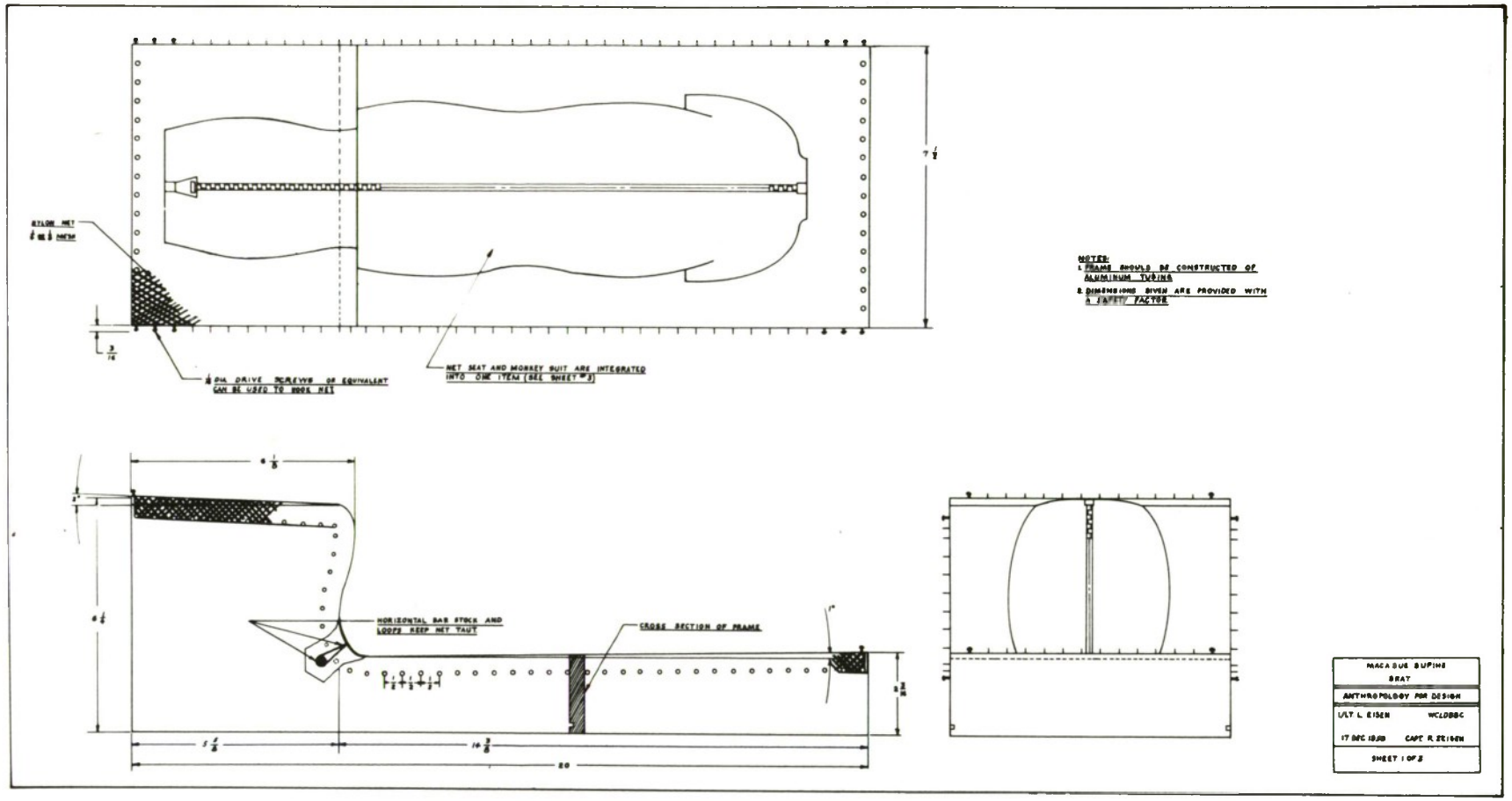

NOTES:
1. FRAME SHOULD BE CONSTRUCTED OF ALUMINUM TUBING
2. DIMENSIONS GIVEN ARE PROVIDED WITH A SAFETY FACTOR
NET SEAT AND MONKEY SUIT ARE INTEGRATED INTO ONE ITEM (SEE SHEET #3)
HORIZONTAL BAR STOCK AND LOOPS KEEP NET TAUT
CROSS SECTION OF FRAME
MACA BUG BUPINS
SEAT
ANTHROPOLOGY FOR DESIGN
L/LT L. EISEN
WCLOBBC
17 DEC 1959
CAPT R. ZEIGEN
SHEET 1 OF 3

FIGURE 12

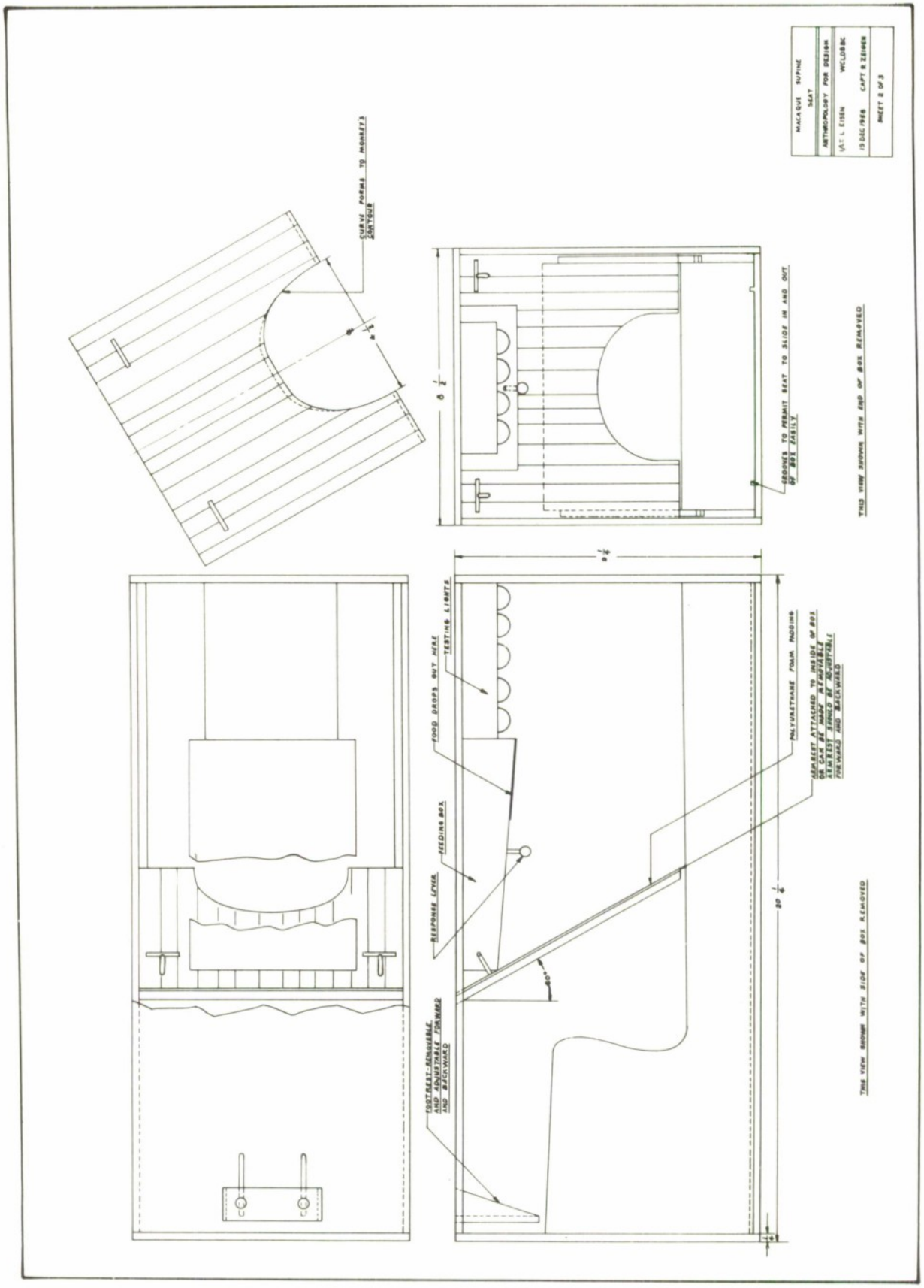
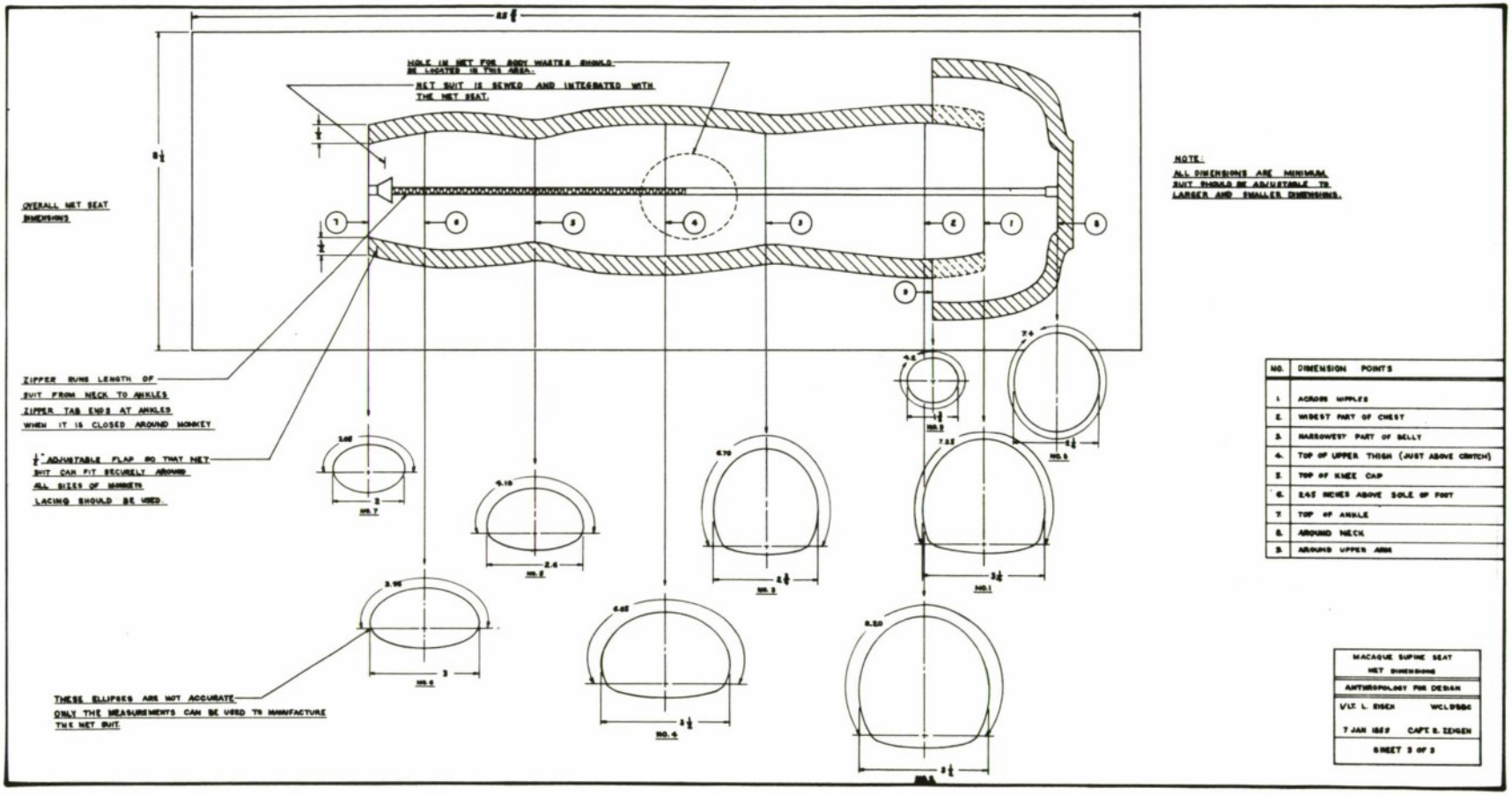

MACAQUE SUPINE SEAT
ANTHROPOLOGY FOR DESIGN
CAPT R ZEIMER
SHEET 2 OF 3
CURVE FORMS TO MONKEY'S CONTOUR
GROOVES TO PERMIT SEAT TO SLIDE IN AND OUT OF BOX EASILY
THIS VIEW SHOWS WITH END OF BOX REMOVED
FOOD DROPS OUT HERE
TESTING LIGHTS
FEEDING BOX
RESPONSE LEVER
FOOT REST-REMOVABLE AND ADJUSTABLE FORWARD AND BACKWARD
POLYURETHANE FOAM PADDING
ARMREST ATTACHED TO INSIDE OF BOX OR CAN BE MADE REMOVABLE TO ALLOW ADJUSTABLE FORWARD AND BACKWARD
THIS VIEW SHOWN WITH SIDE OF BOX REMOVED

FIGURE 13



NO.	DIMENSION POINTS
1.	ACROSS NIPPLES
2.	WIDEST PART OF CHEST
3.	NARROWEST PART OF BELLY
4.	TOP OF UPPER THIGH (JUST ABOVE CRITCH)
5.	TOP OF KNEE CAP
6.	2.45 INCHES ABOVE SOLE OF FOOT
7.	TOP OF ANKLE
8.	AROUND NECK
9.	AROUND UPPER ARM

FIGURE 14