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AUTHORITY

AFMC-STINFO, per DTIC Form 55, 23 Jan 2006

ARMY AIR FORCES
MATERIEL COMMAND
ENGINEERING DIVISION
MEMORANDUM REPORT ON FER:gbk:49

Date June 5, 1943

SUBJECT: Articulated Plastic Manikin Standards.

LABORATORY Aero Medical

SERIAL No. EMG-49-695-25

Contract No.
Expenditure Order No. 695-?
Purchase Order No.

A. Purpose:

1. To report the construction of three plastic manikins designed for use in size studies in aircraft design and related subjects.

B. Factual Data:

1. Two thousand nine hundred and sixty-one Aviation Cadets were studied anthropometrically and reported in Materiel Command Memorandum Report No. EXP-M-49-695-40, dated October 5, 1942, subject: "Anthropometric Data on Army Air Forces Flying Personnel." The data obtained were analyzed on the basis of total stature range, shown in Exhibit A, which was divided into equal thirds. From these three equal divisions in stature, the corresponding populations were taken and the total set of data or each sub-series was averaged. These three sets of averages were then utilized in establishing the dimensions required for three arbitrary manikin standards, termed Type A, Type B, and Type C. Type A represents an average of the entire series. Type B represents an average of the dimensions obtained in the sub-series falling into the short third of the stature range. Type C represents an average of the dimensions obtained in the sub-series falling in the long third. The values of the dimensions are listed in Exhibit B. The pictographic demonstrations of these various measurements are shown in Exhibit C. A scale drawing of each of the three sizes, in various views, is given in Exhibit D.

2. Actual percentages of the total series falling into the size group are: Type B, 17.3 per cent; Type C, 9.4 per cent; and Type A, representing the 100 per cent distribution. The lack of balance between Type B and Type C is due to the fact that selection has occurred which cuts off the lower limit of the size distribution somewhat above the actual lower limit of general size ranges so that the entire distribution curve has its mode moved somewhat toward the lower limit. This lack of balance has only statistical interest - no practical importance, since the original classification was based upon equal thirds of the range. The total range obtained was 156 to 198 centimeters; Type B falls in a range 156-169 centimeters; and Type C falls in a range 184-198 centimeters.

No. of Pages - 26

3. From the three sets of data described above, specifications were established for construction of three-dimensional manikins made of plastic and articulated in such a manner that they might attain most positions encounterable in movements of the human body.

4. Mr. G. W. Borkland, 515 South Laflin Street, Chicago, Illinois, was contracted to sculpt three basic reference statues from which the plastic manikins could be designed.

5. The General Plastics Corporation, 515 South Laflin Street, Chicago, Illinois, was contracted to construct the manikins. A photograph of the Type A manikin is shown in Exhibit E. The manikins B and C follow this same construction.

6. Inasmuch as the plastic manikins cannot attain full movement exhibited by the human body, certain correction factors must be utilized in actual performance of the manikins. Type A must have the total span corrected by the addition of 2 1/16 inches to obtain the calculated value. The anterior arm reach must be corrected by the addition of 2 1/2 inches for the attainment of the calculated value. Type B must have the total span corrected by the addition of 2 inches to obtain the calculated value. The anterior arm reach must be corrected by the addition of 2 7/8 inches. Type C must have the total span corrected by the addition of 2 11/16 inches for the attainment of the calculated value. The anterior arm reach must be corrected by the addition of 3 5/8 inches.

C. Conclusions:

1. The Aviation Cadet series referred to in paragraph B1 above has been analyzed on the basis of stature range to produce three basic size standards, producing three sets of data representing:

a. An average of the entire population - stature range 156-198 cm. (61.5 inches to 78 inches).

b. An average of the short 1/3 of the stature range (17.3 per cent of the population) - stature range 156-169 cm. (61.5 inches to 66.5 inches).

c. An average of the long third of the stature range - 184-198 cm. (72.5 inches to 78 inches).

2. Three articulated plastic manikins have been constructed on the basis of the three sets of specifications derived in paragraph C1 for the purpose of serving as basic size references in any

way required by aircraft and aircraft accessory designers and manufacturers, as well as any further needs brought out on clothing and other related subjects. Designs of cockpits, turrets, catwalks, etc., may be studied with benefit of these manikins, as well as size of clothing, parachute harnesses, etc.

F. G. Hall, Maj. A.C

Approved by A. P. GAGGE, Major, A.C.
Chief, Biophysics Branch

Concurrence:
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Distribution:

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Approved by F. O. CARROLL, Brig. Gen., USA
Chief, Engineering Division

Exhibit 1.

FREQUENCY DISTRIBUTION CHART
STATURE IN 2961 A.A.F CADETS.

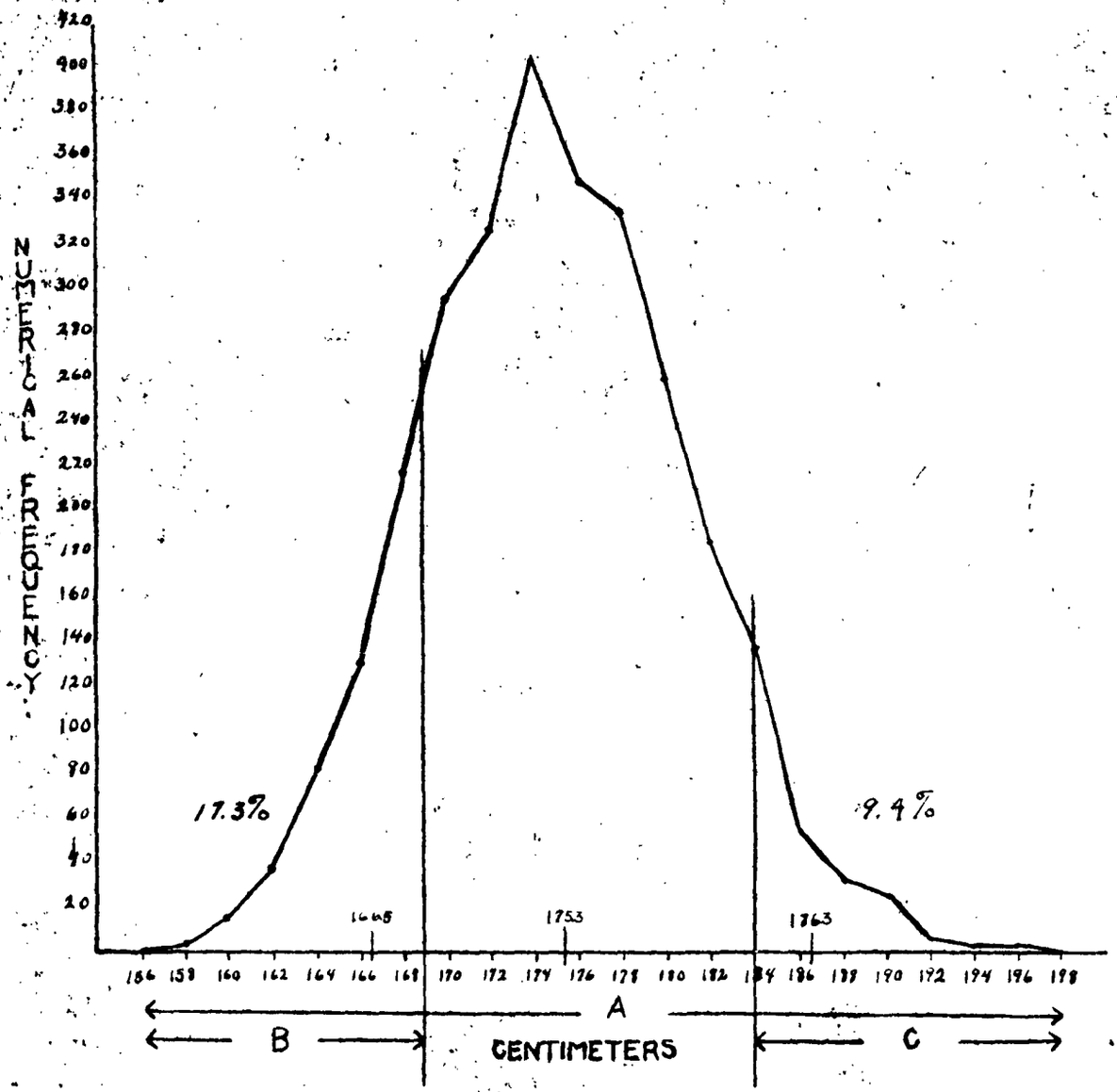


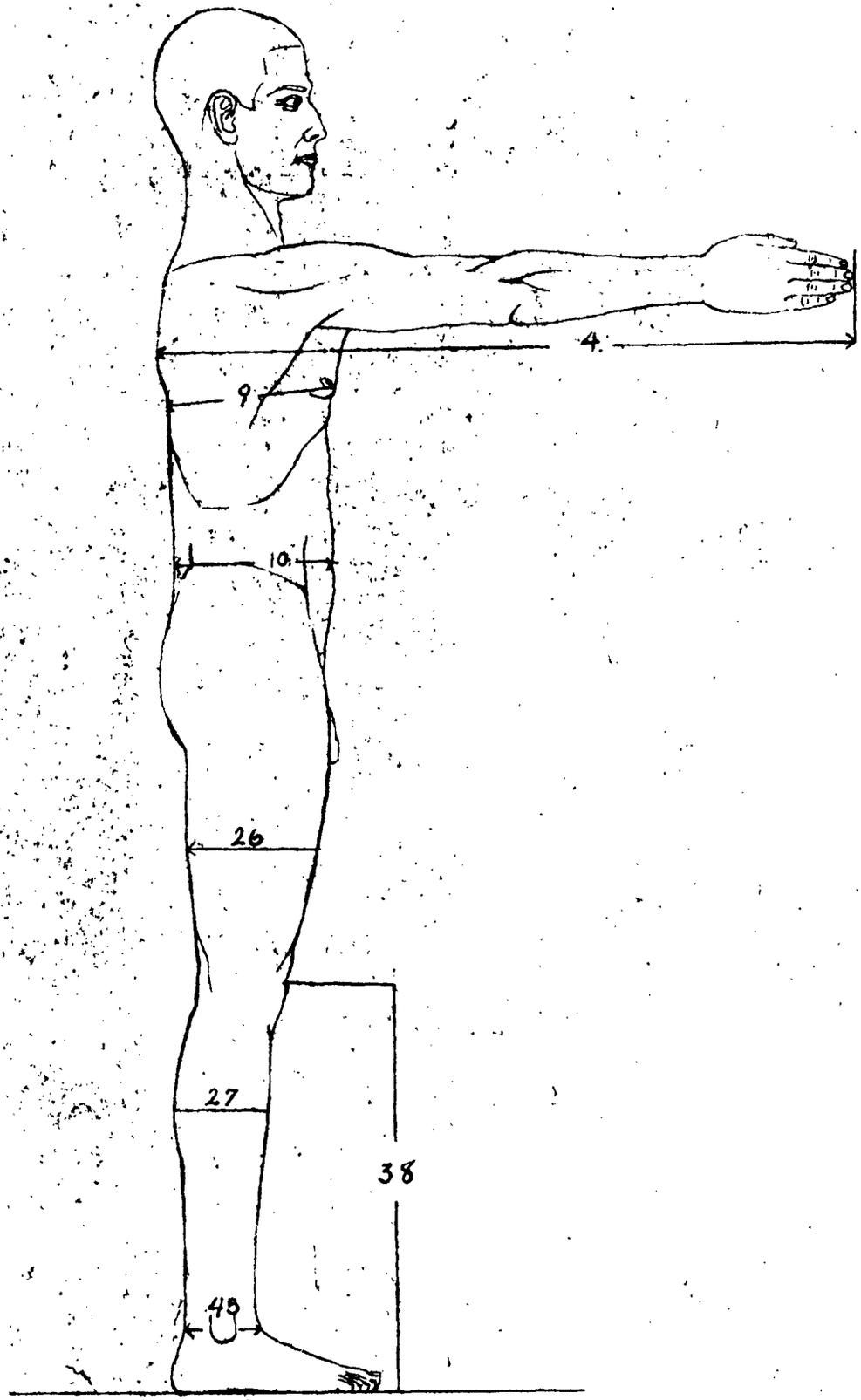
Exhibit B.

Values and Distributions for Manikin Types.

	Type A			Type B			Ty	
	Average		Range	Average		Range	Average	
1. Weight	154.3 lbs.		110-210 lbs.	140.3 lbs.		110-180 lbs.	171.7 lbs.	
2. Stature	175.3 cm.	(69 in.)	156-198 cm.	166.5 cm.	(65 1/2 in.)	156-169 cm.	186.3 cm.	(73 1/
3. Total Span	181.3 cm.	(71 1/2 in.)	158-205 cm.	172.9 cm.	(68 in.)	158-192 cm.	191.5 cm.	(75 1/
4. Anterior Arm Reach	88.9 cm.	(35 in.)	75-103 cm.	85.0 cm.	(33 1/2 in.)	75-94 cm.	93.8 cm.	(36 7/
5. Span Akimbo	93.9 cm.	(37 in.)	81-108 cm.	89.5 cm.	(35 1/4 in.)	81-99 cm.	99.7 cm.	(36 in
6. Bi-acromial	39.3 cm.	(15 1/2 in.)	32-46 cm.	38.0 cm.	(15 in.)	32-43 cm.	40.6 cm.	(16 in
7. Bi-deltoid	45.3 cm.	(17 3/4 in.)	39-52 cm.	44.1 cm.	(17 1/2 in.)	39-49 cm.	46.5 cm.	(18 1/
8. Chest Breadth	28.3 cm.	(11 1/4 in.)	22-34 cm.	27.5 cm.	(10 5/8 in.)	23-33 cm.	29.2 cm.	(11 1/
9. Chest Depth	20.3 cm.	(8 in.)	16-28 cm.	19.8 cm.	(7 5/8 in.)	16-24 cm.	20.9 cm.	(8 1/4
10. Abdominal Depth	20.4 cm.	(8 in.)	16-27 cm.	19.8 cm.	(7 5/8 in.)	16-25 cm.	21.0 cm.	(8 1/4
11. Bi-iliac	28.4 cm.	(11 1/4 in.)	23-34 cm.	27.3 cm.	(10 3/4 in.)	23-30 cm.	29.8 cm.	(11 3/
12. Head Circumference	56.4 cm.	(22 1/4 in.)	51-62 cm.	55.8 cm.	(22 in.)	53-61 cm.	57.0 cm.	(22 3/
13. Chest Circumference	90.7 cm.	(36 1/4 in.)	78-110 cm.	88.6 cm.	(34 7/8 in.)	78-102 cm.	93.2 cm.	(36 5/
14. Upper Arm Circumference	29.1 cm.	(11 1/2 in.)	25-34 cm.	28.4 cm.	(11 1/4 in.)		29.9 cm.	(11 3/
15. Forearm Circumference	24.2 cm.	(9 1/2 in.)	22-28 cm.	23.7 cm.	(9 1/3 in.)		24.8 cm.	(9 3/4
16. Shoulder-Fingertip	75.8 cm.	(29 13/16 in.)		72.5 cm.	(28 1/2 in.)		79.0 cm.	(31 1/
17. Forearm-Fingertip	49.5 cm.	(19 1/2 in.)		47.3 cm.	(18 2/13 in.)		52.1 cm.	(20 2/
18. Hand Length	19.3	(7 5/8 in.)	16-22 cm.	18.5 cm.	(7 1/4 in.)	16-20 cm.	20.3 cm.	(8 in.
19. Hand Breadth	8.6 cm.	(3 3/8 in.)	7-10 cm.	8.4 cm.	(3 1/4 in.)	7-10 cm.	8.9 cm.	(3 1/2
20. Wrist Breadth	6.0 cm.	(2 3/8 in.)		5.8 cm.	(2 1/4 in.)		6.2 cm.	(2 1/2
21. Wrist Thickness	4.1 cm.	(1 5/8 in.)		4.0 cm.	(1 1/2 in.)		4.3 cm.	(1 3/1
22. Shoulder-Elbow	36.9 cm.	(14 1/2 in.)	31-43 cm.	35.0 cm.	(13 3/4 in.)	31-39 cm.	39.2 cm.	(15 1/
23. Elbow-Seat	23.0 cm.	(9 1/16 in.)		22.5 cm.	(8 7/8 in.)		23.6 cm.	(9 1/
24. Bi-epicondylar Elbows	42.0 cm.	(16 1/2 in.)	32-54 cm.	40.9 cm.	(16 1/8 in.)	32-51 cm.	43.2 cm.	(17 in
25. Bi-trochanteric	35.7 cm.	(14 in.)	30-47 cm.	34.4 cm.	(13 1/2 in.)	31-39 cm.	37.2 cm.	(14 2/
26. Thigh Circumference	52.3 cm.	(20 5/8 in.)	47-60 cm.	51.1 cm.	(20 1/8 in.)		53.8 cm.	(21 1/
27. Calf Circumference	35.5 cm.	(14 in.)	28-45 cm.	34.7 cm.	(13 5/8 in.)	28-42 cm.	36.5 cm.	(14 1/
28. Xiphoid Height	125.0 cm.	(49 3/16 in.)		118.7 cm.	(46 3/4 in.)		132.8 cm.	(52 5/
29. Lower Rib Height	112.0 cm.	(44 1/8 in.)		106.4 cm.	(41 7/8 in.)		119.0 cm.	(46 5/
30. Umbilicus Height	104.8 cm.	(41 3/16 in.)		99.6 cm.	(39 3/16 in.)		111.4 cm.	(43 7/
31. Iliac Crest Height	104.8 cm.	(41 3/16 in.)		99.6 cm.	(39 3/16 in.)		111.4 cm.	(43 7/
32. Pubic Height	89.1 cm.	(35 in.)		84.6 cm.	(33 3/8 in.)		94.6 cm.	(37 3/
33. Crotch Height	82.2 cm.	(32 3/8 in.)		78.1 cm.	(30 11/16 in.)		87.4 cm.	(34 3/
34. Sitting Height	92.1 cm.	(36 1/4 in.)	83-103 cm.	88.4 cm.	(34 7/8 in.)	83-94 cm.	96.4 cm.	(38 in
35. Trunk Height	59.9 cm.	(23 5/8 in.)	50-69 cm.	57.5 cm.	(22 5/8 in.)	50-62 cm.	62.8 cm.	(24 3/
36. Buttock-Knee	58.8 cm.	(23 3/8 in.)	49-70 cm.	56.6 cm.	(22 1/4 in.)	51-65 cm.	63.3 cm.	(24 7/
37. Patella Height - Sitting	55.3 cm.	(21 3/4 in.)	46-65 cm.	52.3 cm.	(20 5/8 in.)	46-57 cm.	59.2 cm.	(23 1/
38. Patella Height - Standing	51.7 cm.	(20 3/8 in.)		49.1 cm.	(19 3/8 in.)		55.0 cm.	(21 1/
39. Knee Breadth	19.2 cm.	(7 1/2 in.)	16-29 cm.	18.6 cm.	(7 1/3 in.)	16-22 cm.	19.9 cm.	(7 7/
40. Foot Length	26.8 cm.	(10 1/2 in.)	22-31 cm.	25.6 cm.	(10 1/16 in.)	22-29 cm.	28.1 cm.	(11 1/
41. Foot Breadth	9.8 cm.	(3 7/8 in.)	8-12 cm.	9.5 cm.	(3 3/4 in.)	8-11 cm.	10.2 cm.	(4 in
42. External Malleolus (Ankle) Height	7.5 cm.	(3 in.)		7.1 cm.	(2 13/16 in.)		8.0 cm.	(3 1/
43. Internal Malleolus (Ankle) Height	8.7 cm.	(3 3/8 in.)		8.3 cm.	(3 1/4 in.)		9.3 cm.	(3 5/
44. Ankle Breadth	7.6 cm.	(3 in.)		7.4 cm.	(3 in.)		7.9 cm.	(3 1/
45. Ankle Thickness	9.6 cm.	(3 13/16 in.)		9.3 cm.	(3 11/16 in.)		10.0 cm.	(3 15
46. Nasion-Menton	12.3 cm.	(4 7/8 in.)	10-15 cm.	12.0 cm.	(4 3/4 in.)	10-14 cm.	12.6 cm.	(5 in
47. Squatting Diagonal*	84.5 cm.	(33 1/4 in.)	71-102 cm.	81.8 cm.	(32 1/8 in.)	75-99 cm.	88.2 cm.	(34 3

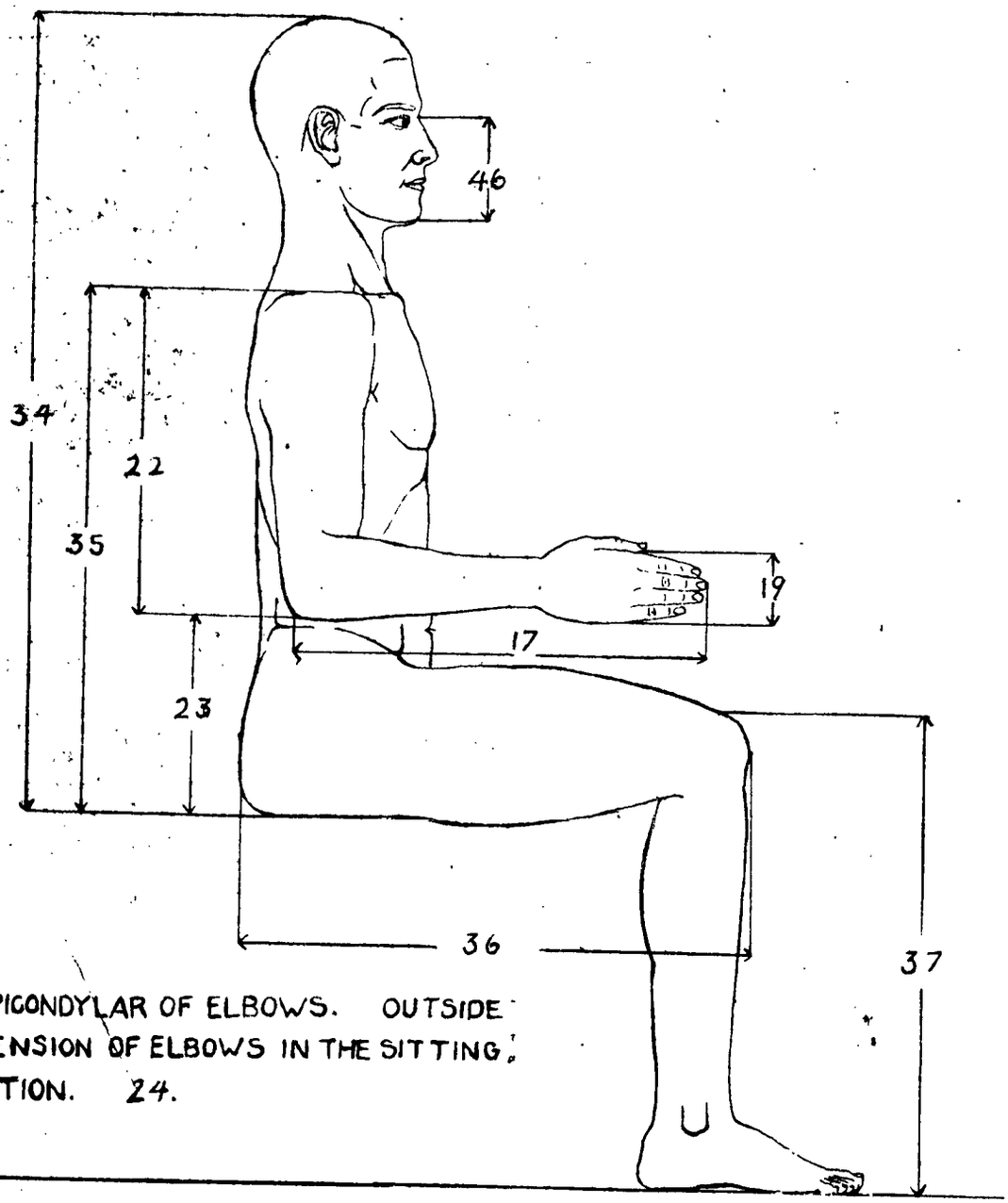
*The subject sits on a six-inch block, as near the edge as comfortable, with the heels drawn in at the base of the block. He leans forward at the hips and clasps his hands at the knees. The dimension extends from the maximum curvature of the back near the shoulders to the tip of the longest toe.

Exhibit C.



Locations of Measurements.

Exhibit C - Cont'd.



BI-EPICONDYLAR OF ELBOWS. OUTSIDE DIMENSION OF ELBOWS IN THE SITTING POSITION. 24.

Exhibit C - Cont'd.

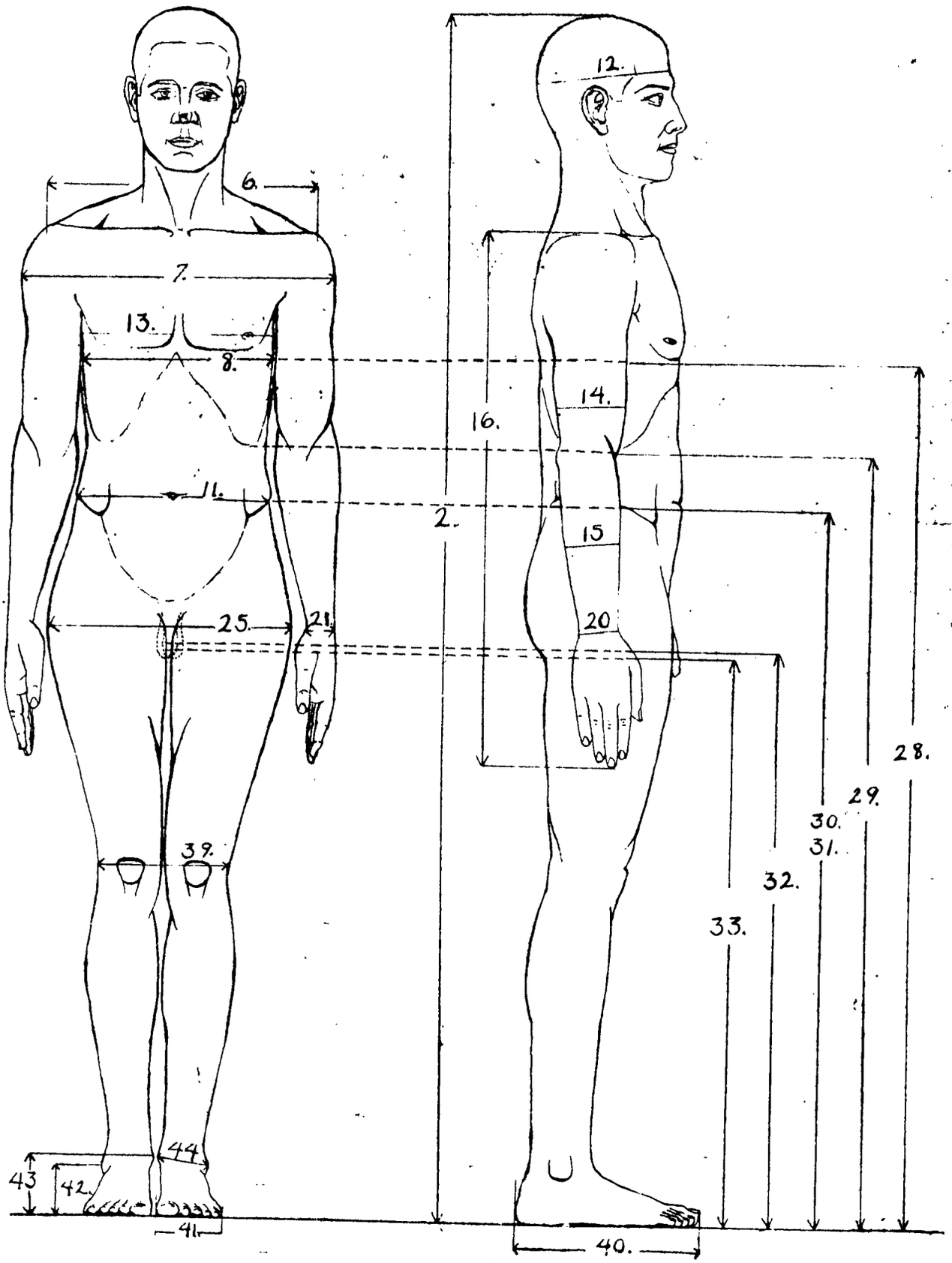
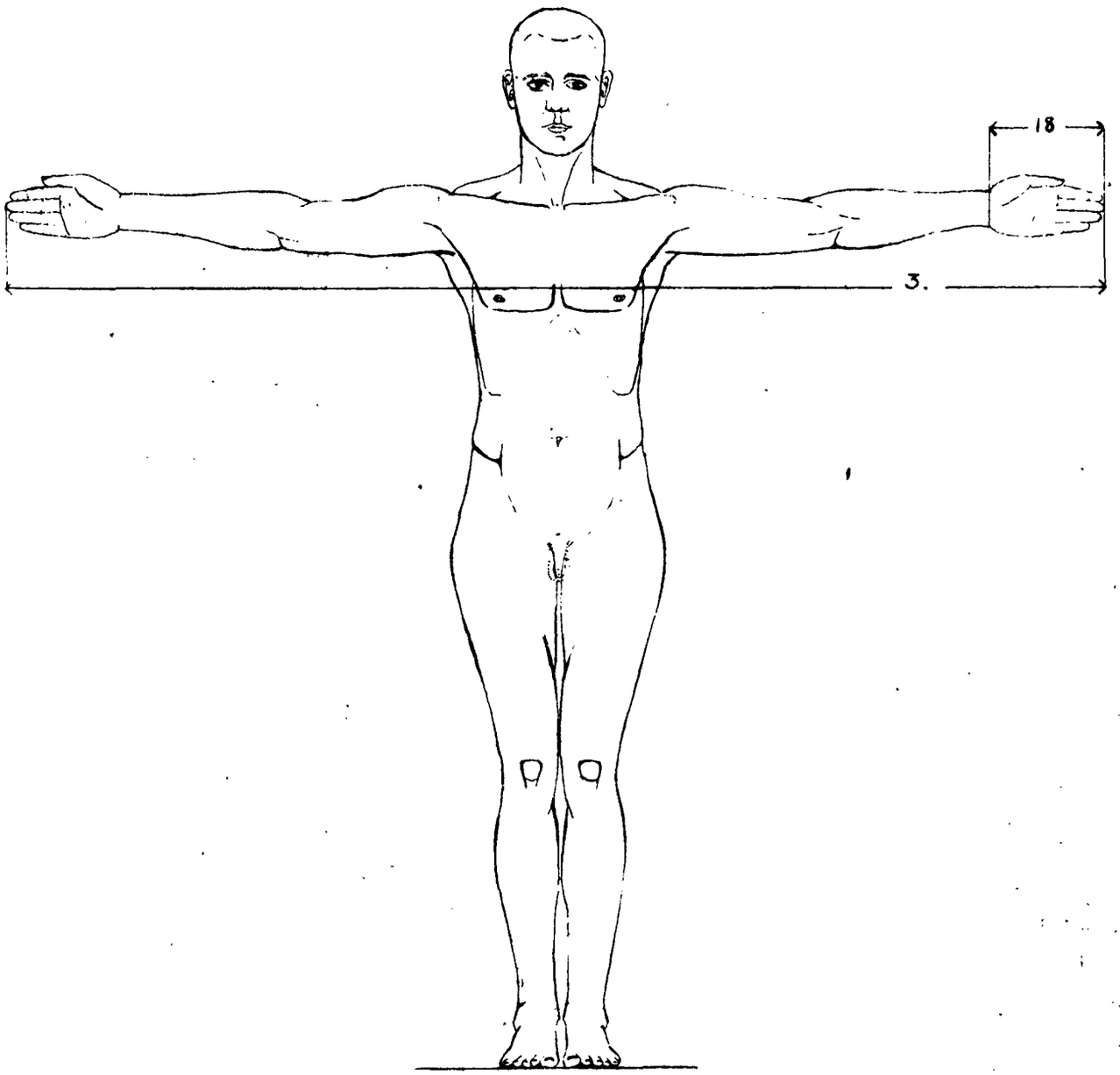


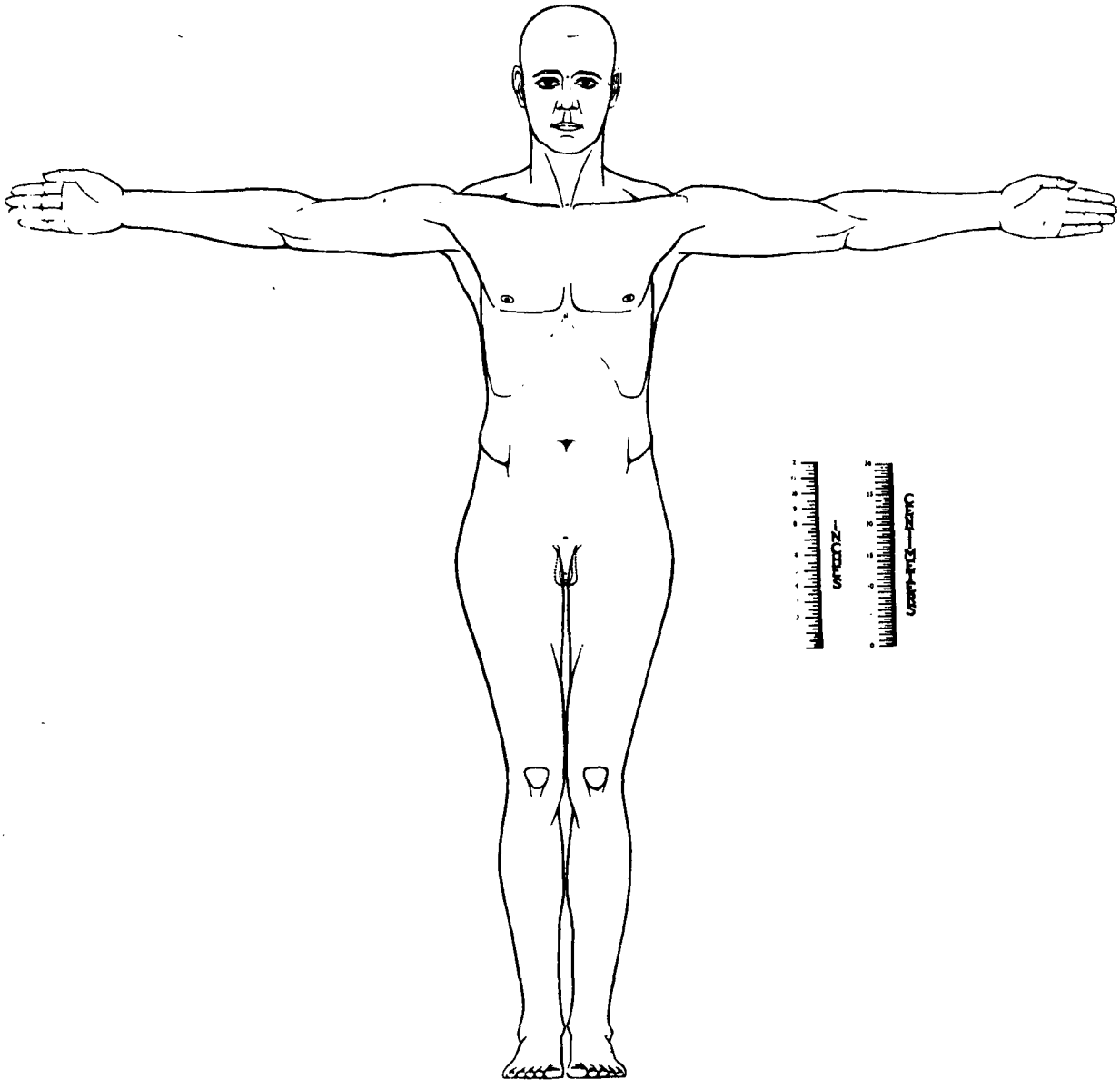
Exhibit 6 - Cont'd.



5. SPAN AKIMBO IS MEASURED TO THE TIPS OF THE ELBOWS WITH THE FOREARM IN TO THE CHEST

1148886

Exhibit D

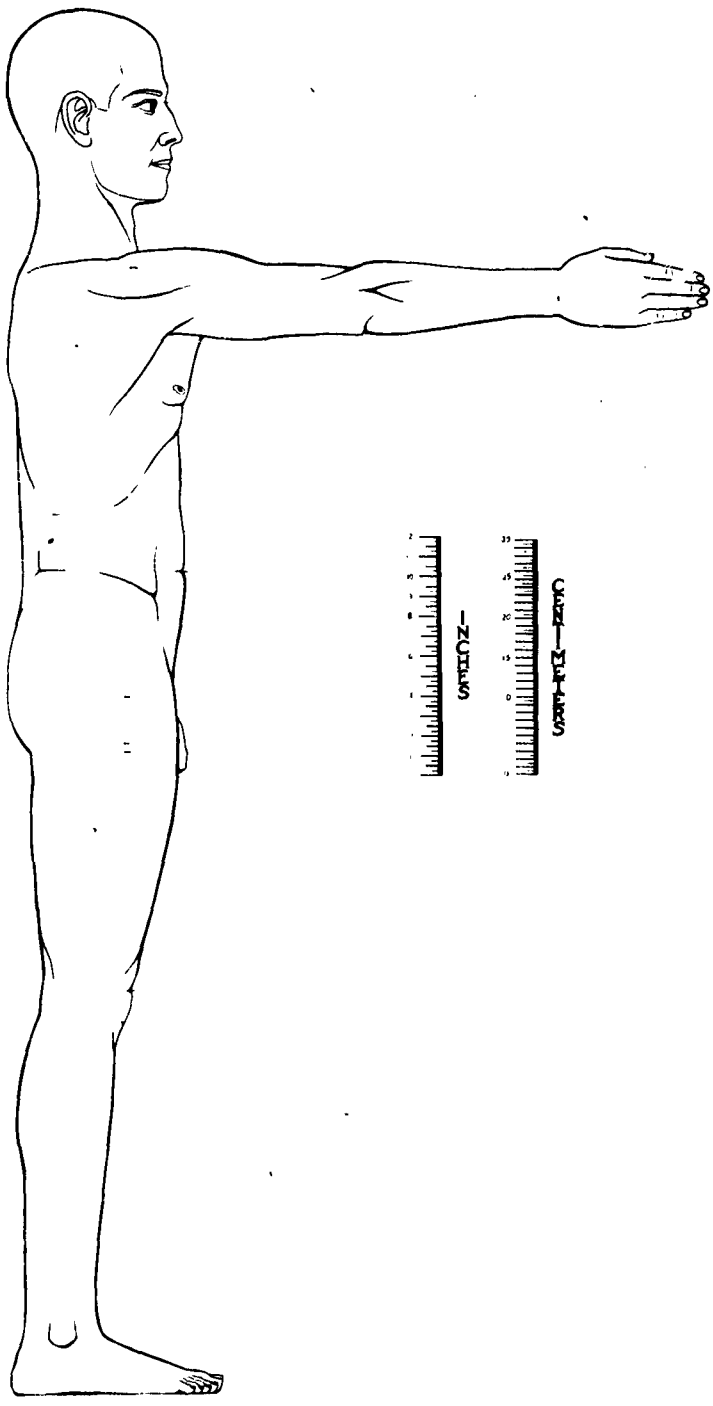


A.A.F. TYPE A.

Scale Reduction

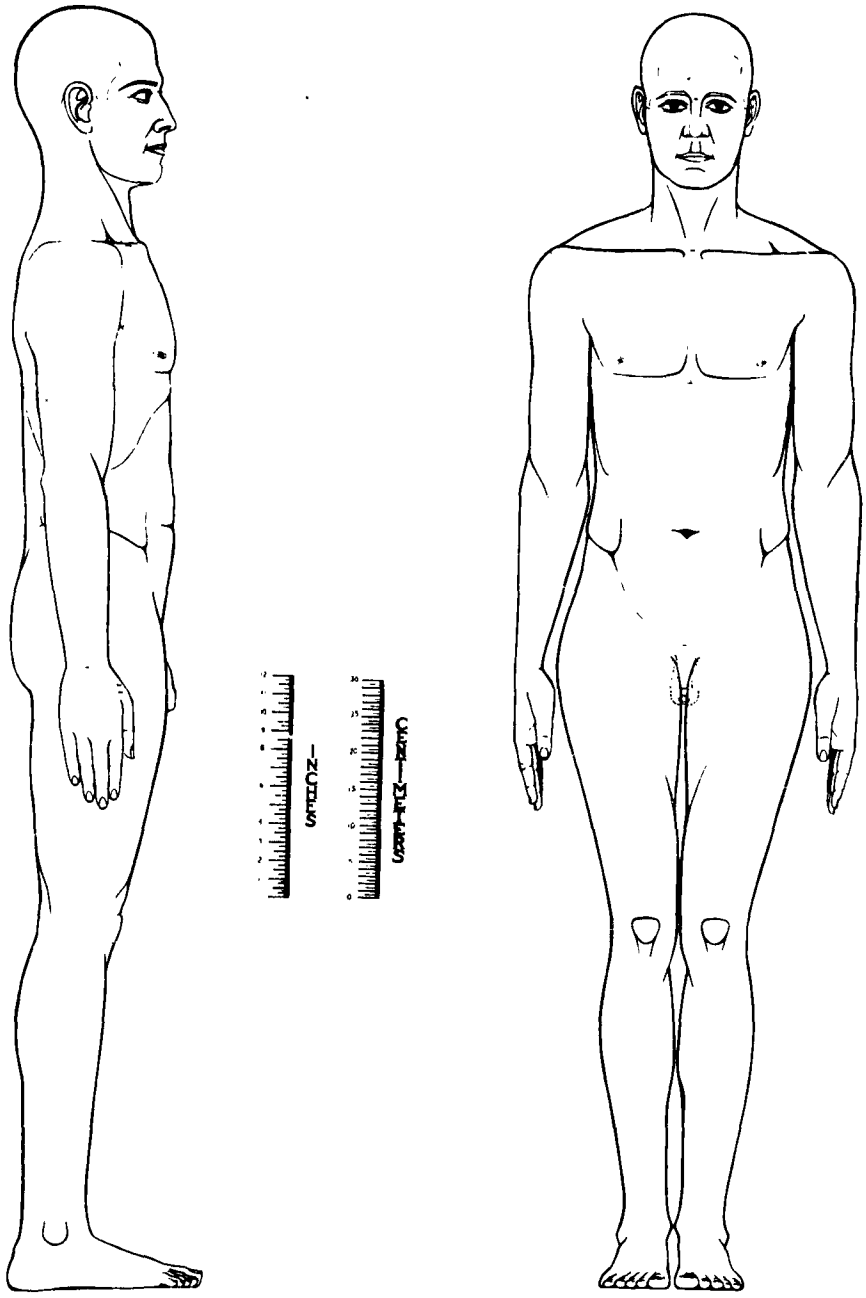
1148887

Exhibit D - Cont'd.



A.A.F. TYPE A.

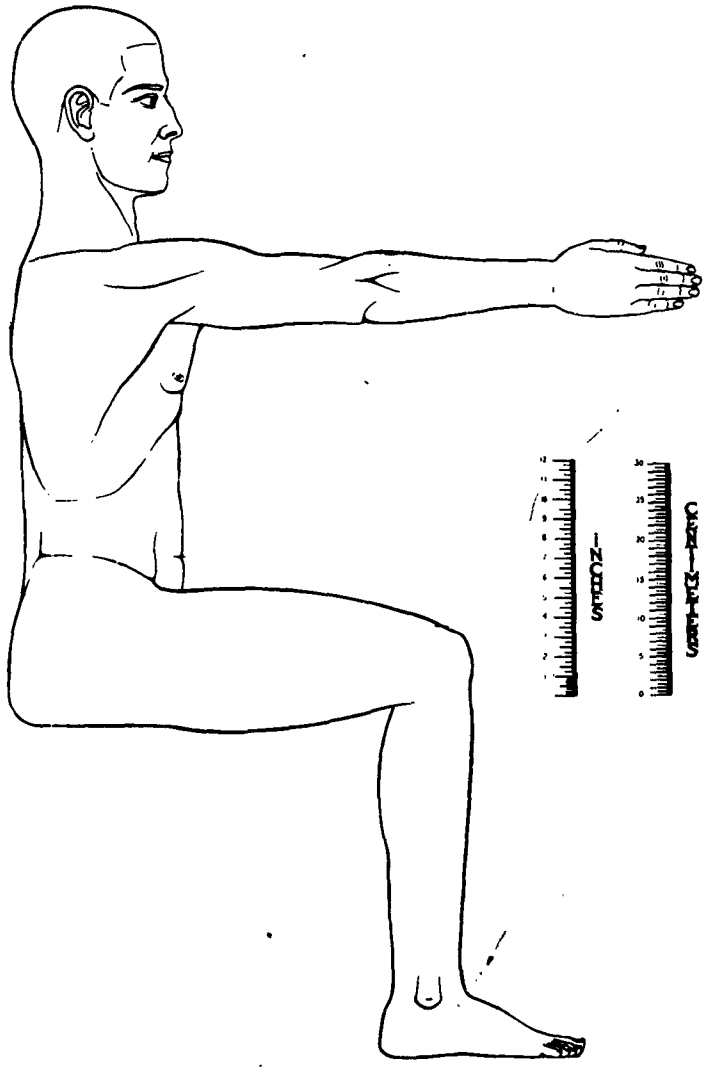
Exhibit D - Cont'd.



A.A.F. TYPE A.

1148809

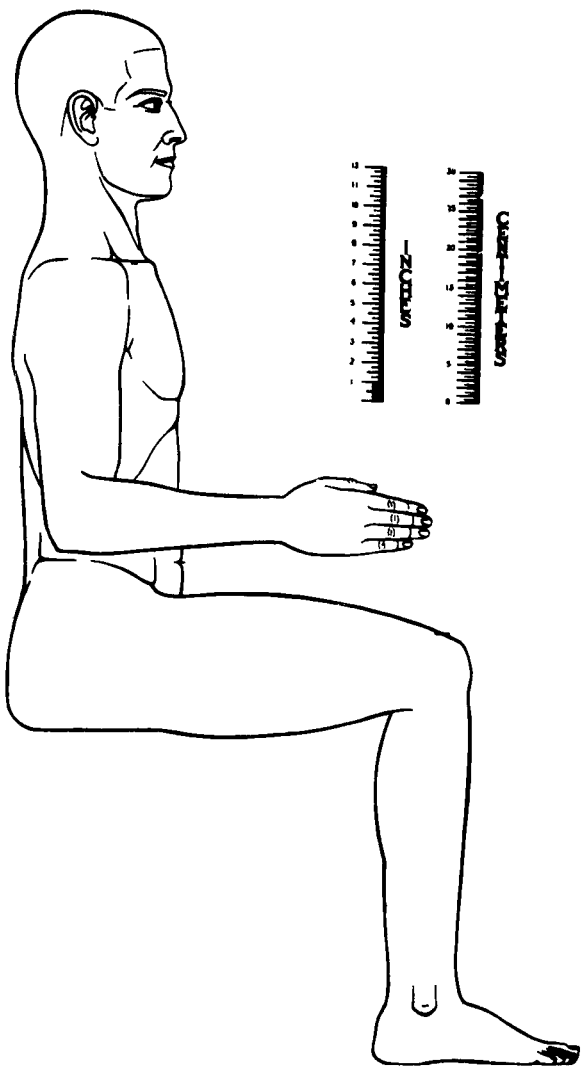
Exhibit D - Cont'd.



A.A.F. TYPE A.

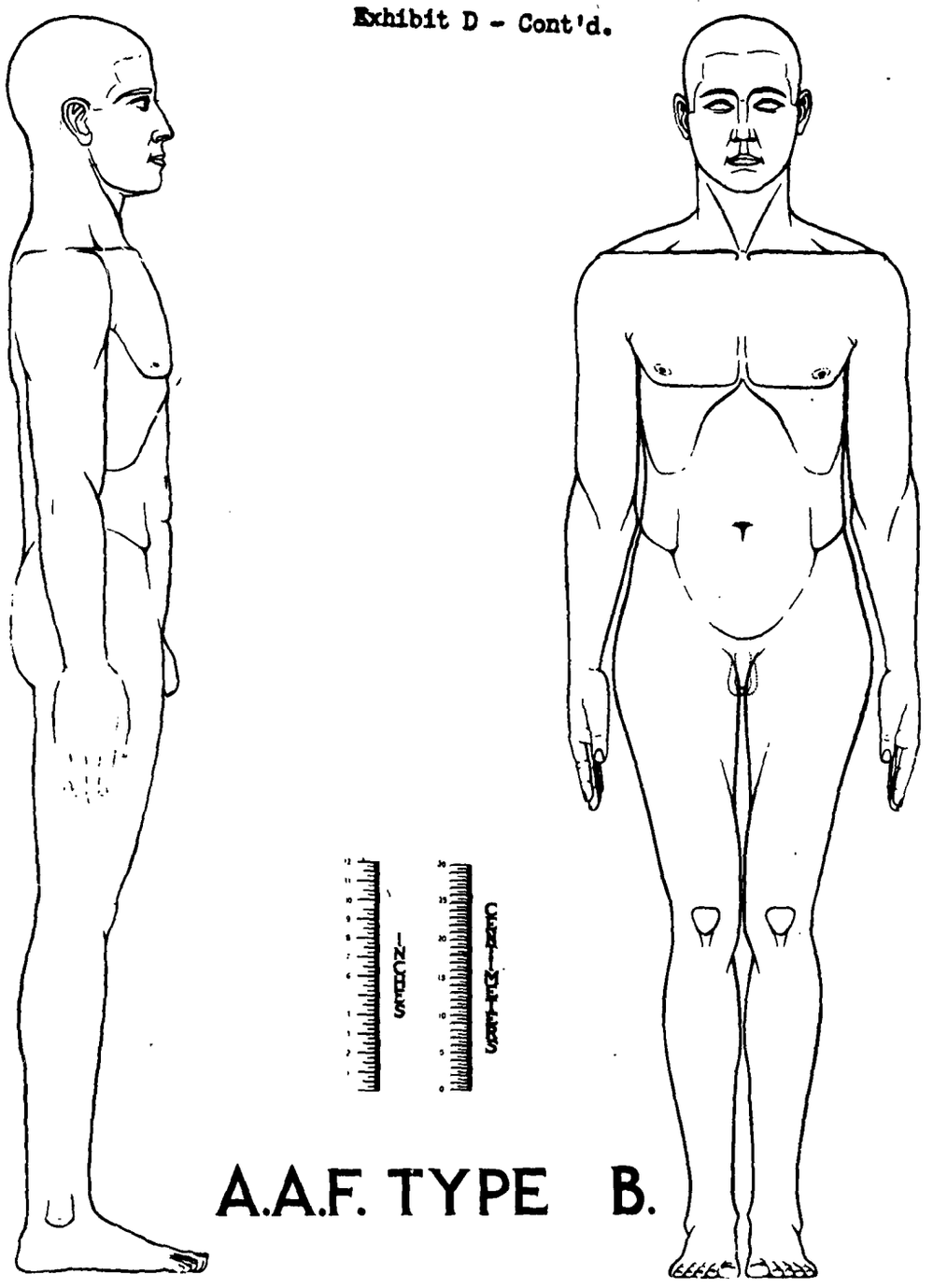
1148911

Exhibit D - Cont'd.



A.A.F. TYPE A.

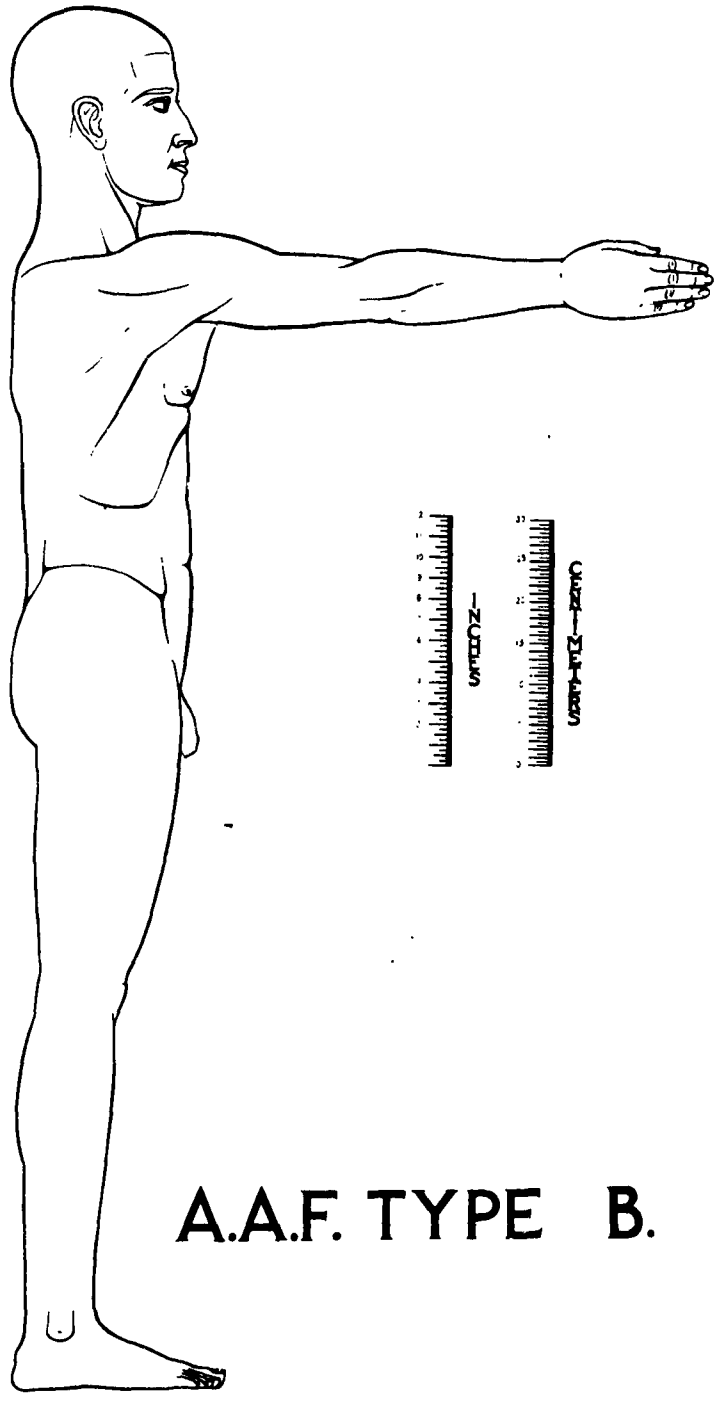
Exhibit D - Cont'd.



A.A.F. TYPE B.

1148192

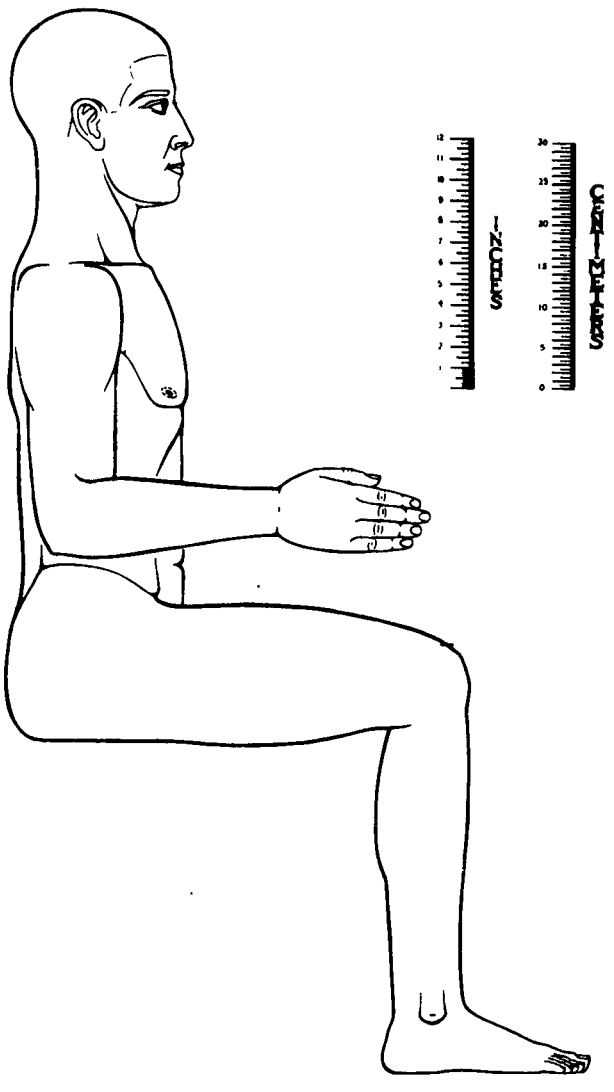
Exhibit D - Cont'd.



A.A.F. TYPE B.

114893

Exhibit D - Cont'd.



A.A.F. TYPE B.

1148124

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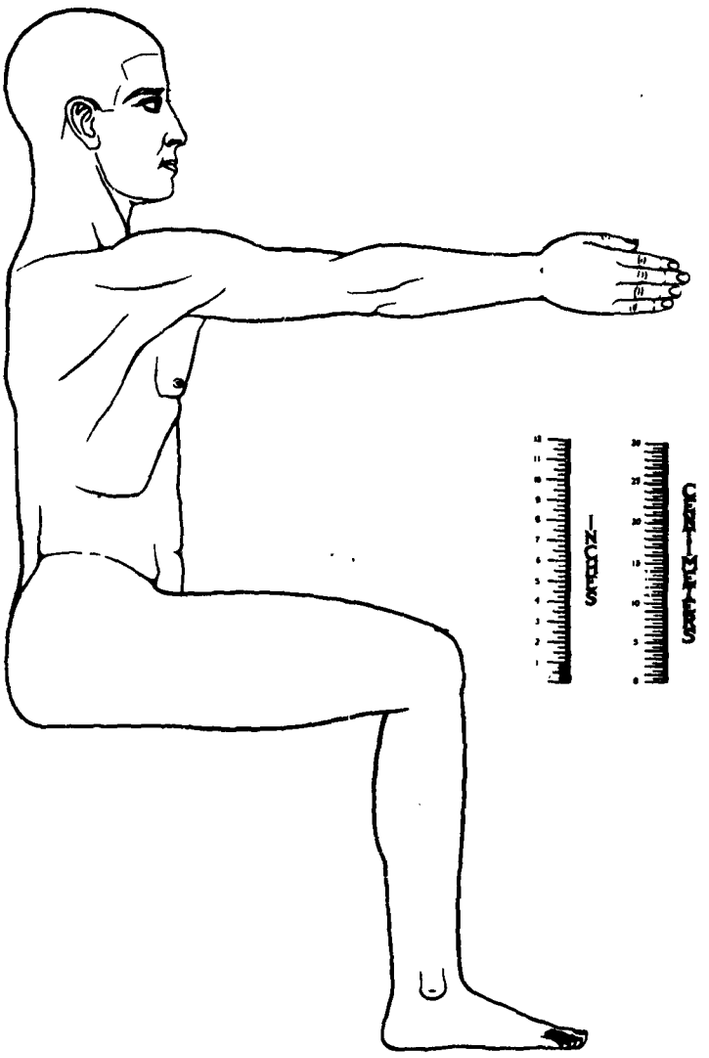
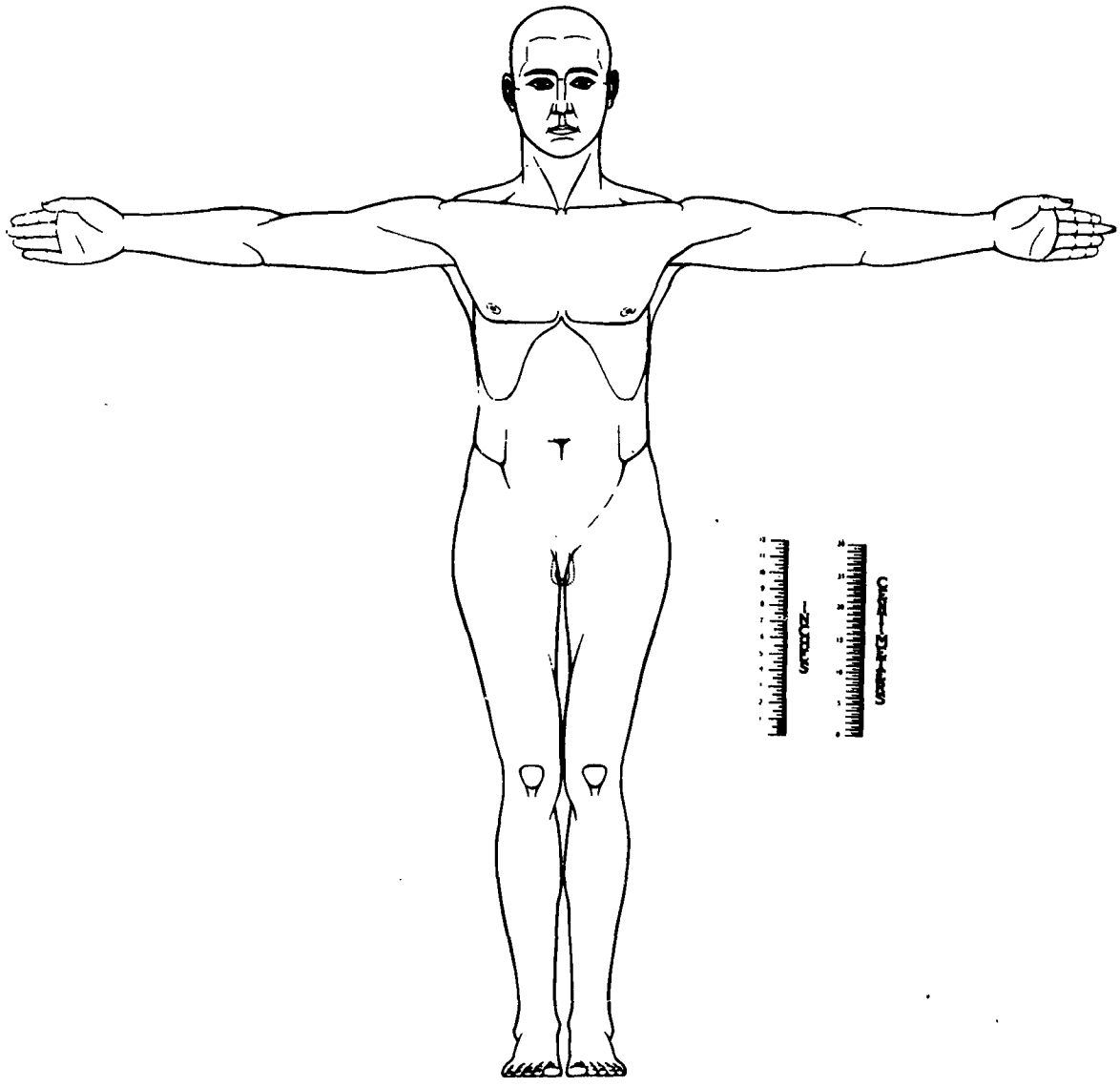


A.A.F. TYPE B.

114895

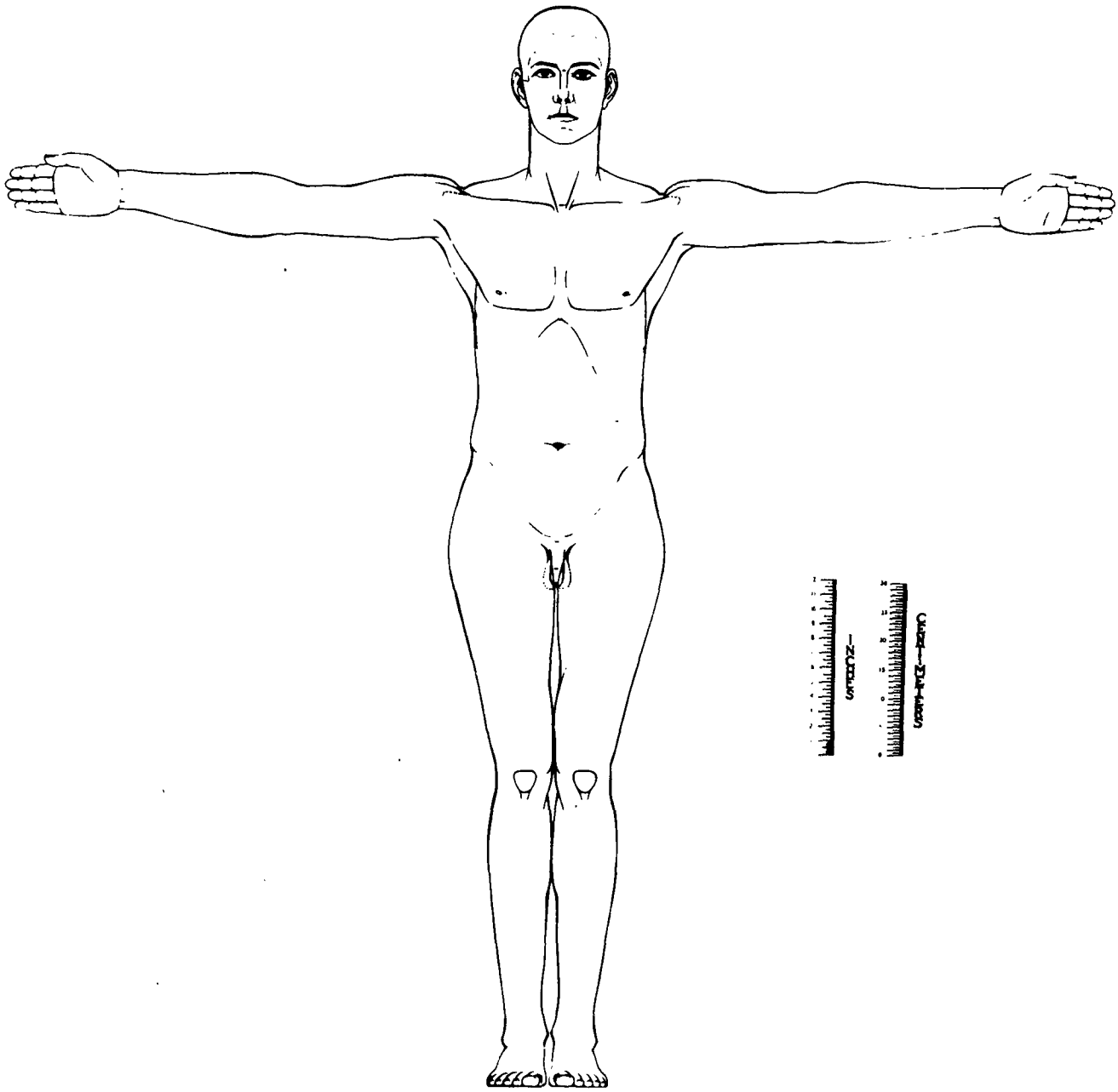
Exhibit D - Cont'd.



A.A.F. TYPE B.

1148 96

Exhibit D - Cont'd.



A.A.F. TYPE C.

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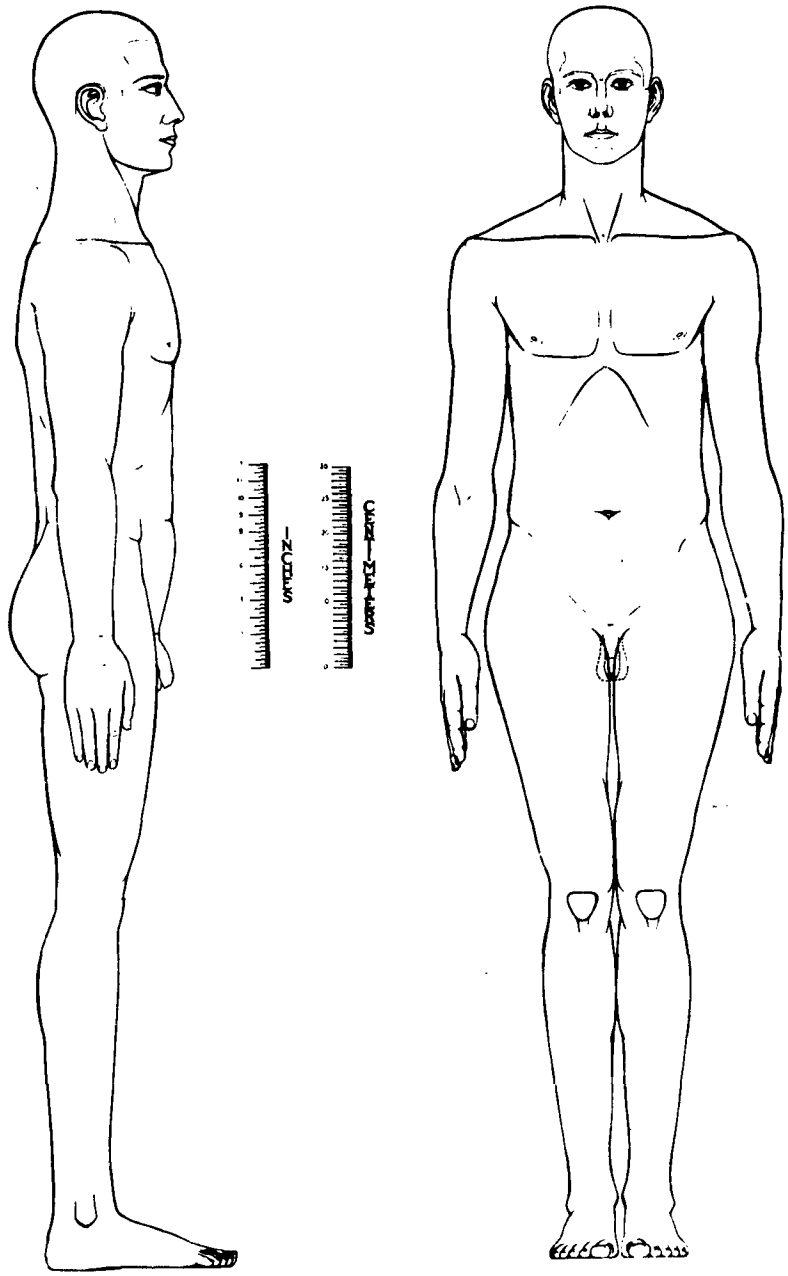

A.A.F. TYPE C.

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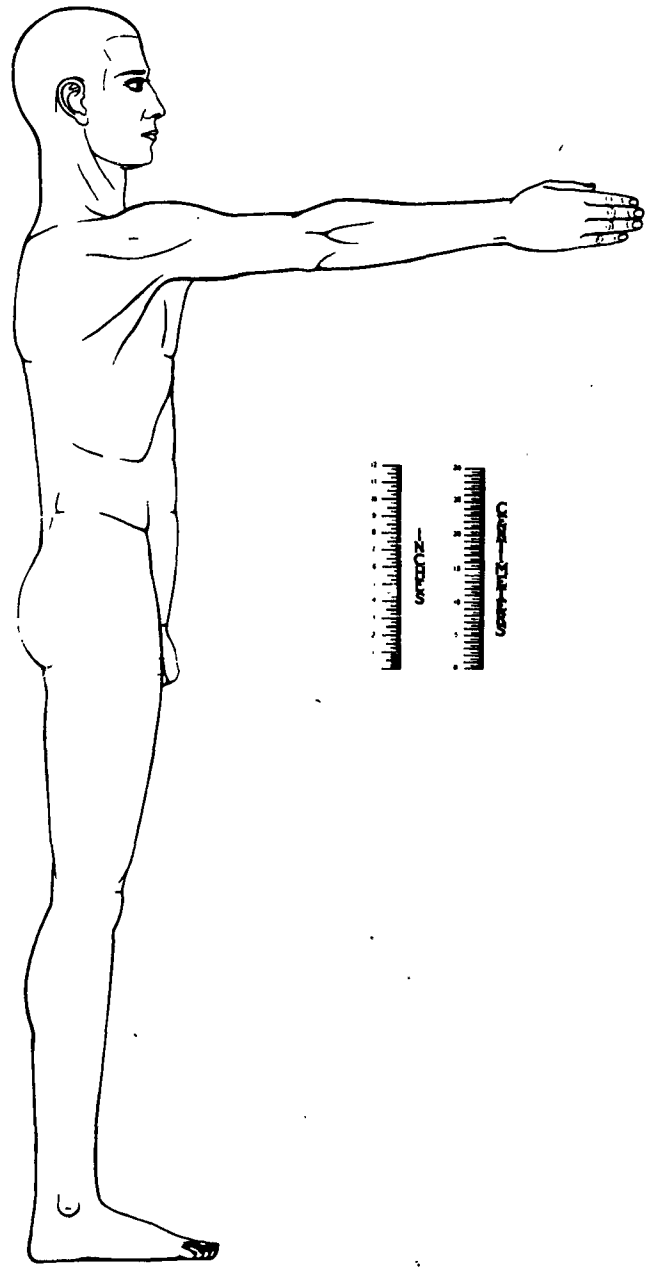
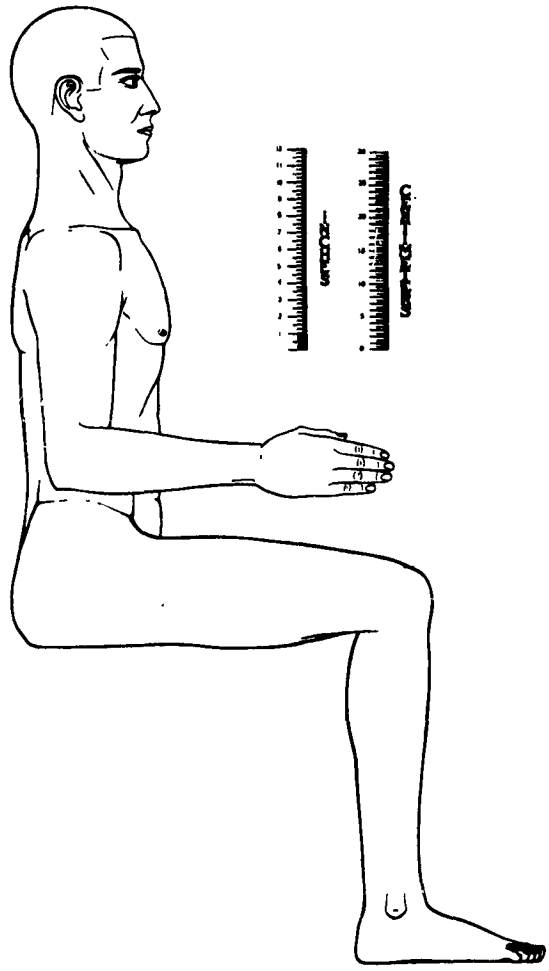


A.A.F. TYPE C.

1148 99

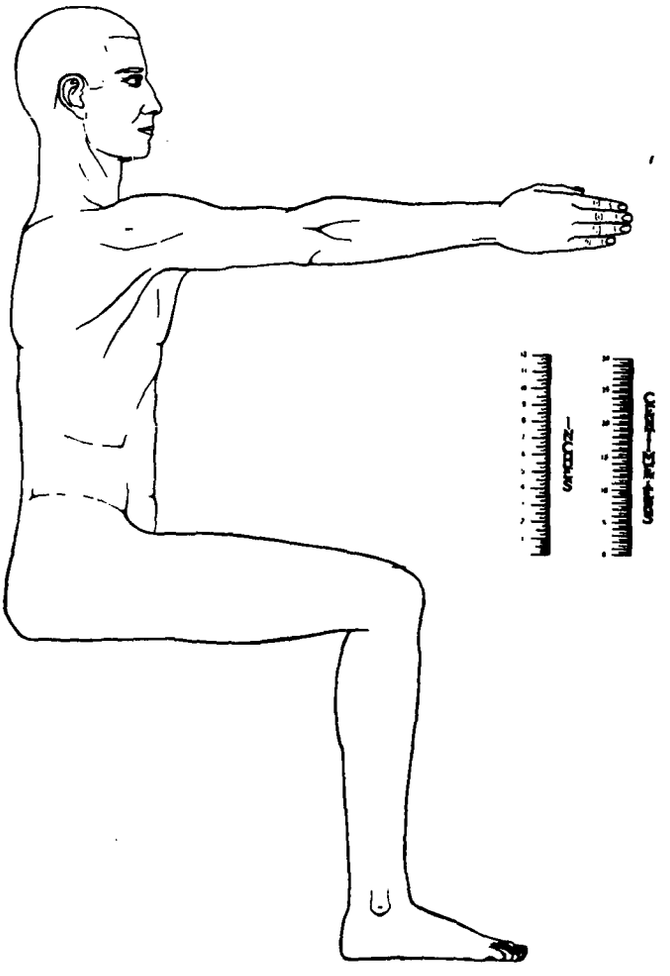
Exhibit D - Cont'd.



A.A.F. TYPE C.

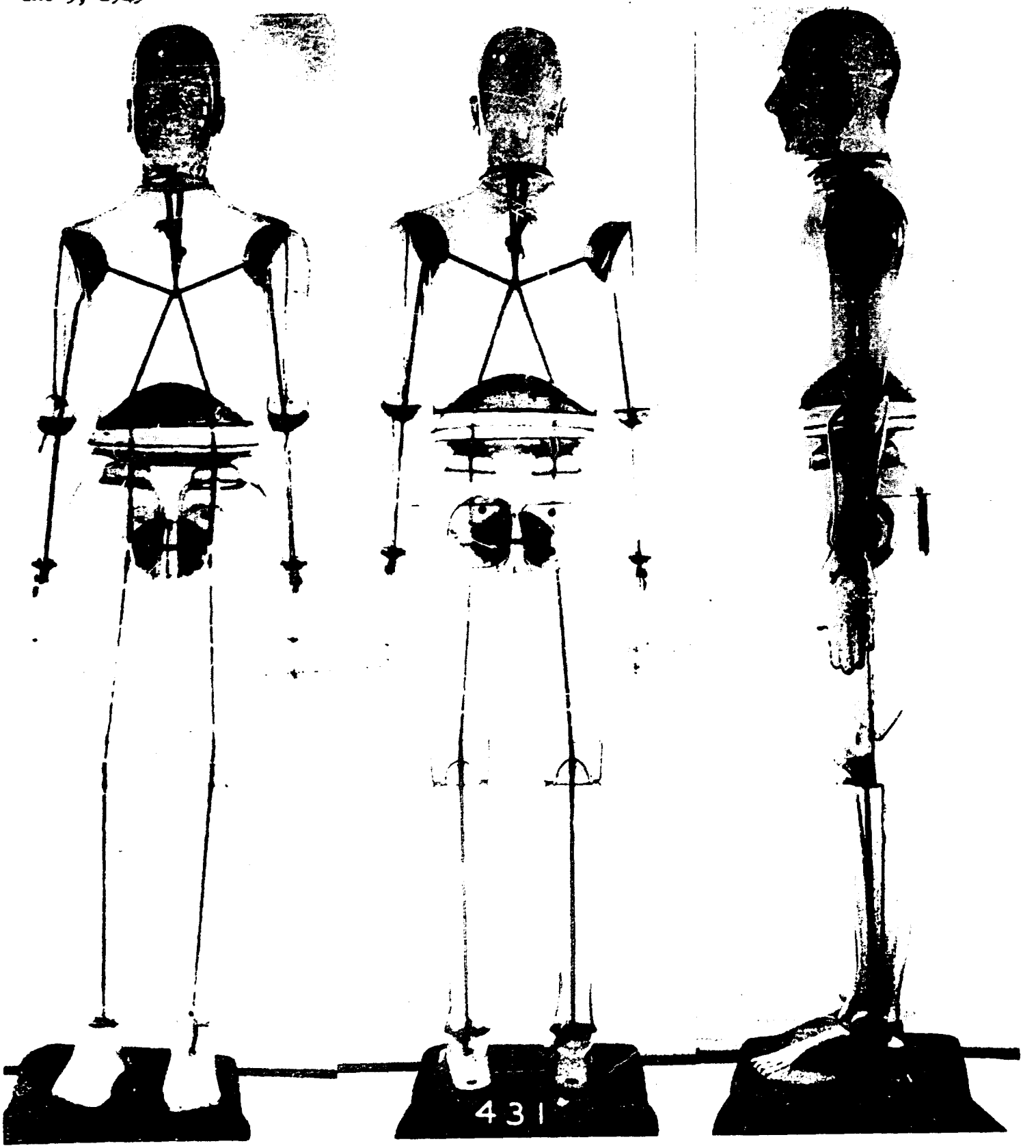
1142010

Exhibit D - Cont'd.



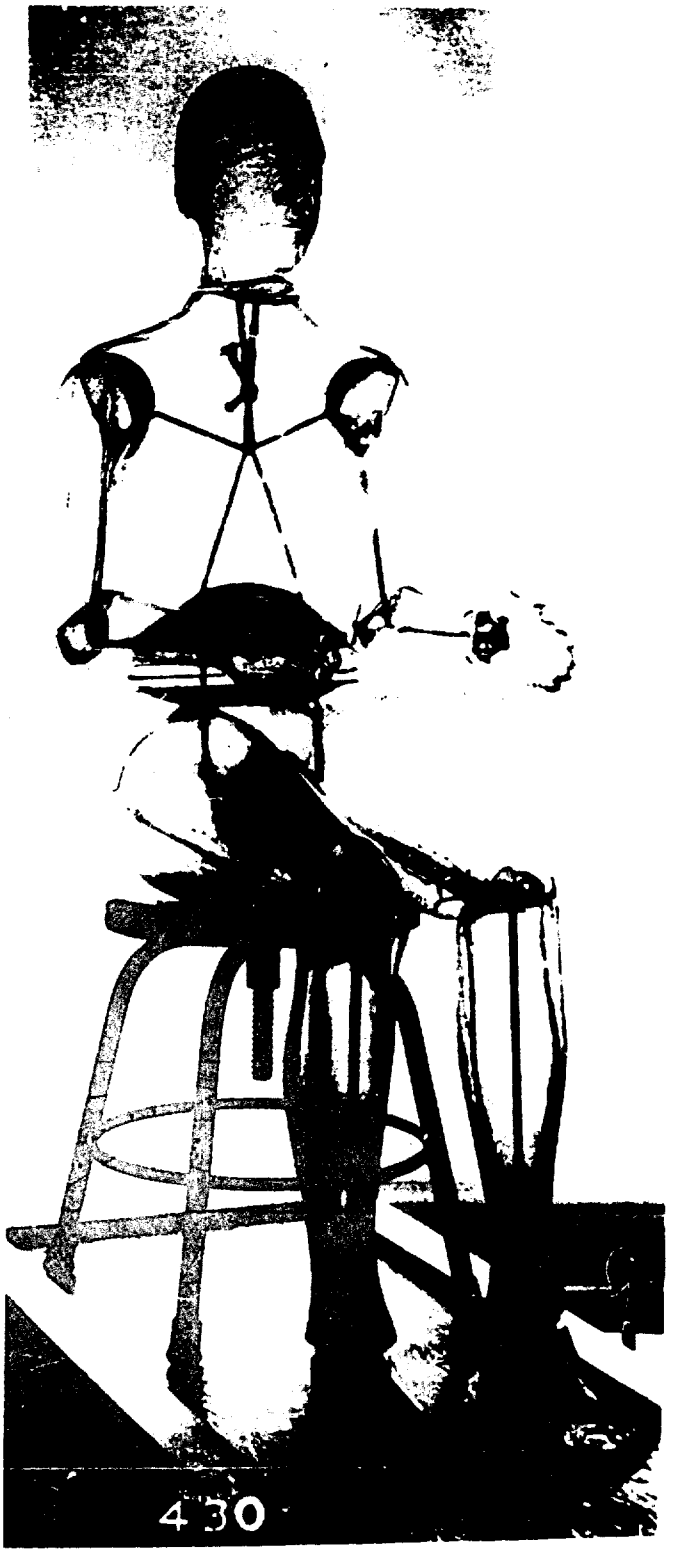
A.A.F. TYPE C.

Exhibit E.



Standing and Sitting Views, Manikan A.A.F. Type A - Standing Views.

Exhibit E - Cont'd.



Sitting View.

(UNPUBLISHED CARD)

UNCLASSIFIED ASTIA (1)

ATI 114 072

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AIR MATERIEL COMMAND, ENGINEERING DIV., DAYTON, O.
(SERIAL NO. ENG-49-695-28)

ARTICULATED PLASTIC MANIKIN STANDARDS - MEMORANDUM REPORT

RANDALL, FRANCIS E. 5 JUNE 43 26PP PHOTOS, DIAGRS, GRAPH

AMC, WRIGHT-PATTERSON AIR FORCE BASE, DAYTON, O.

ANTHROPOMETRY
PERSONNEL, FLYING

ARTS AND SCIENCES, MISCELLANEOUS (65) 32
ANTHROPOLOGY (2)

AD-B808 545

UNCLASSIFIED

129800