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NAVY DEPARTMENT
THE DAVID W. TAYLOR MODEL BASIN
AERODYNAMICS LABORATORY
WASHINGTON 7, D.C.

WIND-TUNNEL INVESTIGATION OF AIR LOADS ON HUMAN BEINGS

by

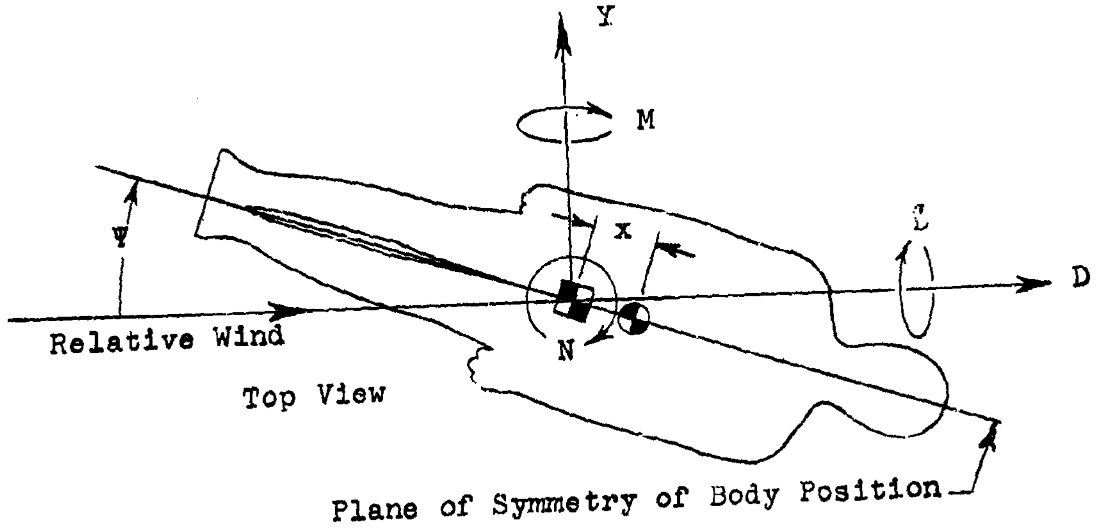
Thomas J. Schmitt

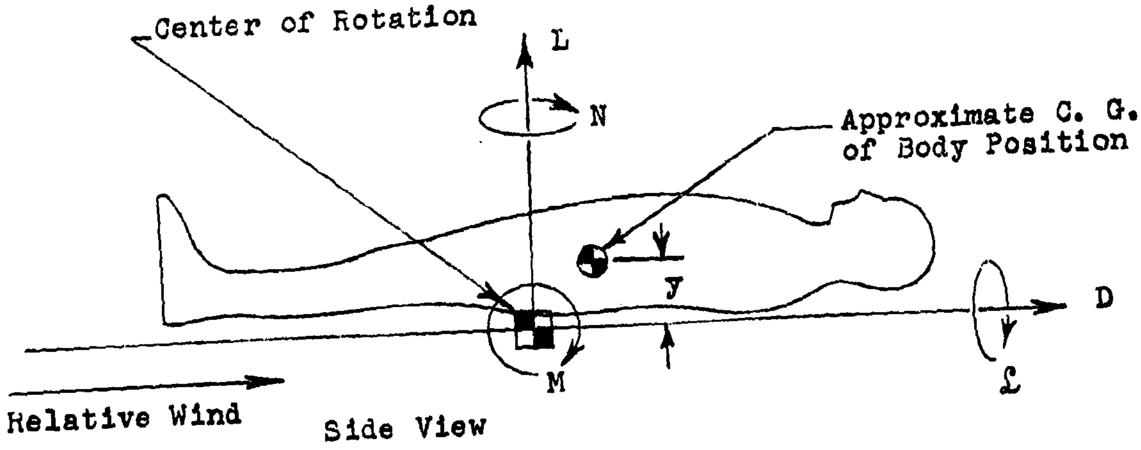
January 1954

Report 892
Aero 858

NOTATION

Positive Directions of Axes, Forces, Moments and Displacements Are Shown by Arrows





Axis	Force in pounds	Force Coefficient	Moment in pound-feet	Moment Coefficient
D	D (drag)	$C_D = {}^{DS}/qvH$	$\mathcal{L}$ (rolling)	$C_\ell = {}^{\mathcal{L}S}/qvH\ell$
Y	Y (side)	$C_Y = {}^{YS}/qvH$	M (pitching)	$C_m = {}^{MS}/qvH\ell$
L	L (lift)	$C_L = {}^{LS}/qvH$	N (yawing)	$C_n = {}^{NS}/qvH\ell$

General Symbols

S	surface area of subject in square feet
v	volume of subject in cubic feet
H	height of subject in feet
ℓ	characteristic length of body in feet (arbitrarily one foot)
q	dynamic pressure ($\rho V^2/2$) in pounds per square foot
V	airspeed in feet per second
R	Reynolds number ($\rho V\ell/\mu$)
ρ	mass density of air in slugs per cubic foot
μ	absolute coefficient of viscosity of air in pound-second per square foot
x	horizontal distance in feet between moment center and C. G. (measured parallel to body plane of symmetry)
y	vertical distance in feet between moment center and C. G.

Angular Setting

Ψ	angle of yaw in degrees (angle between relative wind vector and plane of symmetry of the body position)

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AERODYNAMICS LABORATORY
DAVID TAYLOR MODEL BASIN
UNITED STATES NAVY
WASHINGTON, D.C.

WIND-TUNNEL INVESTIGATION OF AIR LOADS ON HUMAN BEINGS

by

Thomas J. Schmitt

SUMMARY

An investigation was conducted in the Taylor Model Basin 8- by 10-foot subsonic, atmospheric Wind Tunnel 2 to determine the drag coefficient of man. Tests were made at several yaw angles with subjects of various sizes in five body positions: standing, sitting, supine, and two squat positions. Data were obtained for the subjects in both the clothed and nude conditions.

A parameter was formulated from the available physical characteristics of the subjects tested and all coefficients were based on this. Drag coefficients were obtained which should be reliable in predicting drag forces on men of average stature under a variety of conditions. Lift, side force, and moments were also obtained which indicate relative trends of motion for each position.

INTRODUCTION

Previously the Civil Aeronautics Administration ran a series of tests with several subjects in various positions subjected to momentary air blasts. Dr. Barry G. King of the Medical Division, CAA, proposed a wind-tunnel investigation of air loads on human beings to supplement these tests (Reference 1). The intent of the CAA is to correlate the basic drag data provided by the wind-tunnel study with the air-blast results. The data obtained should have widespread application in the prediction of the body behavior in free fall, parachute descent, ejection-seat escape, and in explosive decompression. The Office of Naval Research requested the Bureau of Aeronautics to authorize the Aerodynamics Laboratory of TMB to conduct a wind-tunnel investigation of air loads on human beings. "The immediate aim of this wind tunnel study would be to (a) determine the drag coefficient of man and (b) to evaluate the decompression technique as a means of determining man's tolerance to disorientation forces" (Reference 2).

Accordingly, the Aerodynamics Laboratory was authorized by the Bureau of Aeronautics to conduct the investigation in one of its 8- by 10-foot wind tunnels (Reference 3). The study was made during the period from 7 July 1952 to 30 July 1952, and advance copies of net force and moment data were forwarded to the CAA. This report presents the results of the test in coefficient form and completes the investigation.

SUBJECTS

Sixteen male subjects were utilized in this investigation, all of whom were provided by Dr. King of the CAA. The physical characteristics of all subjects are listed in Table 1. The age, weight, height, and surface area of each person were provided by the CAA. The volumes were determined at the Aerodynamics Laboratory by immersing the subjects in a drum of water and measuring their volumetric displacements.

It is believed that the range of subject sizes tested, sufficiently brackets the physical characteristics of an average male adult. However, no very large or small subjects were included in the tests. This should be considered in any application of the data presented.

Since the consideration of other body characteristics such as shape, bone structure, etc. is beyond the scope of this report, no discussion of the effect of such factors on drag is presented.

APPARATUS

The CAA provided individual supports for testing the subjects in the five body positions: standing, sitting, supine, and two squat positions. The supports were constructed of sheet steel, padded with foam rubber and leather, and fitted with leather straps for holding the subjects in place. They were adjustable and flexible to some extent to accommodate a variety of subject sizes. The supports for the five body positions with subjects in place are shown in Figures 1a through 1e.

Each of the five supports was fitted with a flange by which it was bolted to a standard steel I-beam mounted vertically in the tunnel on a rotatable milling head. Adjustable shields were provided to cover the I-beam from the floor of the tunnel up to the base of the subject. The I-beam support and the shields were fabricated at the Model Basin.

A hand-held normally-open microswitch was connected to a pilot light and utilized by the subjects for signaling if they wished the tunnel stopped because of any discomfort. It was the practice during a test run for the subject to hold the switch closed. If he should faint, the light would go out when he released the switch.

TESTS

All tests were made in the TMB 8- by 10-foot, closed-throat, atmospheric Wind Tunnel 2. The five body positions: standing, sitting, supine, Squat 1, and Squat 2, are illustrated in outline form through the plane of symmetry at $\Psi = 0°$ in Figure 1.

Tests were made on most of the sixteen subjects at dynamic pressures of 1.0, 9.0, and 26.0 pounds per square foot. Several subjects were also tested at a dynamic pressure of 37.0. In addition limited Reynolds-number tests were made with two subjects at 43.0, 50.0, 58.0, and 66.0 pounds per square foot. The approximate corresponding airspeeds and Reynolds numbers for the above dynamic pressures are listed in Table 2.

All the subjects were tested in two clothing conditions. One consisted of the subject attired in shirt and trousers and the other was nude (hereafter referred to as clothed and nude respectively). The subjects wore swim trunks for the nude tests. For both clothing conditions the subjects wore goggles, taped on to protect their eyes, and shoes.

Table 3 summarizes the body positions, dynamic pressures, and clothing conditions of all subjects tested.

RESULTS

The subjects of this investigation have been divided into two groups, each containing eight men. This report contains the six-component force and moment data presented in non-dimensional coefficient form for Subjects 1 through 8, who were selected as representative of the entire group for determination of the basic drag coefficient of the human body. Results for Subjects 9 through 16 were omitted since the data were incomplete and would not be of significant value to the report. Drag coefficients as a function of Ψ are presented in Figures 2 and 3; effects of clothing on the drag coefficient are presented in Figure 4; the variation of drag coefficient with Reynolds number is illustrated in Figure 5; and the remaining force and moment coefficients are plotted in Figures 6 through 10.

The data are referred to the system of axes shown in the notation; the moment center coincides with the top-center of the I-beam support, which was the center of rotation. The coefficients, defined in the notation, have been based on a parameter which is elaborated in the discussion.

No tare or interference corrections were applied to the data. The support strut was shielded for all body positions to eliminate this source of tare. No feasible method was devised for determining the tare effect of the body support or the interference of the shield. However, since the supports were relatively small and fitted the subjects closely in most cases, their effects were probably of small magnitude.

An appendix is included which gives the derivation of equations for transferring the moments to an average body center-of-gravity for each of the five positions. Figure 11 illustrates how the average centers-of-gravity were obtained. The individual centers-of-gravity were furnished by the CAA.

DISCUSSION

Previous studies concerning drag of the human body, as summarized in Reference 4, were limited by the extent and type of information available. Primarily this information consisted of the free-fall velocity of a parachutist, from which a drag coefficient based on an estimated frontal area was determined. To avoid limiting the usefulness and scope of this report, a drag coefficient was obtained which varies with orientation in yaw for each of the five positions tested. This was accomplished by determining a basic parameter utilizing the physical characteristics of the subjects tested rather than an estimated frontal area. This procedure resulted in drag coefficients of reasonable accuracy for the human body orientated in a great variety of positions with respect to the relative wind. These coefficients should simplify drag studies of an average male if his physical characteristics are known as employed in the basic parameter.

DETERMINATION OF THE BASIC PARAMETER -- The following physical characteristics of all subjects tested were known:

W	weight in pounds
H	height in feet
v	volume in cubic feet
S	surface area in square feet

Five trial parameters, namely, $v^{2/3}$, v/H, 170 v/HW, and vH/S, were formulated utilizing the above characteristics. The purpose of the constant 170 (an arbitrary value representing average weight) was to obtain drag coefficients nearer unity for the parameters involving weight.

Trial computations of drag coefficient were made with the five parameters, resulting in the selection of vH/S as the one which rendered the least variation in C_D among the eight subjects. Obviously, the above parameters do not account for such differences in subjects as relative proportion of body members, looseness of skin, bone structure, etc. A consideration of the afore-mentioned factors in the determination of the drag coefficient is beyond the scope of the present discussion.

DRAG COEFFICIENT -- With the selection of vH/S as the basic parameter, the drag coefficients of Subjects 1 through 8 were computed and are presented in Figure 2 for the five body positions and two clothing conditions tested. The data are faired in a manner to present an envelope of the values of C_D obtained at each yaw angle. This method permits a visual inspection of the variation in individual drag coefficients.

The arithmetic means of the drag coefficients are presented in Figure 3. The half-values of the range indicated by the envelopes in Figure 2 divided by mean C_D for each yaw angle is approximately 0.09.

A significant fact is worth mentioning in connection with the average values presented in Figure 3. Upon referring to Figure 1 and the notation it will be apparent that the same body profiles are presented to the wind stream for the standing and supine positions at $\Psi = 90°$. Figure 3 indicates excellent agreement between the drag coefficients for the two body positions in both clothing conditions. This comparison seems to substantiate the statement in the results that the shield interference is of small magnitude.

Effect of Clothing -- Figure 4 presents the average incremental drag coefficient due to clothing for Subjects 1 through 8. For the purpose of increasing the usefulness of these data, it also gives the clothing effects as a percentage of the drag coefficient for clothed subjects. All values for these clothing effects were computed from the average drag-coefficient differences as shown in Figure 3. Fair agreement of the clothing contribution was obtained between the standing and supine positions at $\Psi = 90°$. Clothing caused a 20 percent increase in C_D for the standing position and a 17 percent increase for the supine position.

Reynolds Number Effect -- Tests were run at various dynamic pressures with Subjects 1 and 2 in the supine and Squat 1 positions respectively at $\Psi = 0°$ and $180°$. The resulting drag-coefficient values were plotted versus Reynolds number and are presented in Figure 5. All Reynolds numbers were based on an arbitrary characteristic length of one foot.

Only a slight drag-coefficient increase is evident above a Reynolds number of 0.5×10^6 for the two subjects at both yaw angles. There is a relatively sharp rise in C_D at Reynolds numbers below 0.5×10^6. This variation might be explained by the fact that only one test point, an airspeed of approximately 17.8 knots, was available below the Reynolds number of 0.5×10^6. At this low speed little displacement of the subjects' skin and clothing was evident. As the airspeed was increased, the subjects became more streamlined due to the smoothing of the clothing and skin. However, as the airspeed was increased to still higher values the clothing and skin began to flutter with increasing frequency. This would seem to explain the slight rise in C_D above a Reynolds number of 0.5×10^6 as due to an apparent increase in surface roughness.

SIDE-FORCE AND LIFT-FORCE COEFFICIENTS -- The side- and lift-force coefficients of Subjects 1 through 8 are presented in Figures 6 and 7 respectively. These data points were faired similarly to the drag data to give an envelope of the maximum and minimum values obtained at each value of Ψ. Because of the spread in coefficient values at each value of Ψ, these data seem to be of interest only as an indication of the trends exhibited by the human body. It is probable that their spread is due to the slightly different position each subject assumed in the supports. Also the subjects twisted varying amounts in the support as they were yawed during a dynamic run.

Generally the side-force coefficient is small compared to the drag coefficient at each angle of yaw with the exception of the standing position (Figure 6). The lift coefficients are practically negligible for all positions with the exception of the sitting position (Figure 7). For this position the lift coefficient varies from a relatively low negative value at $\Psi = 0°$ to a positive value at $\Psi = 180°$.

MOMENT COEFFICIENTS -- The pitching -, yawing -, and rolling - moment coefficients of Subjects 1 through 8 are presented in Figures 8, 9, and 10 respectively. These data were faired similarly to the force data. Relatively large variations also are present in the moment coefficients. This variation most likely is due to the shift of the subjects' body in the support. The wind force tended to change the subjects' position relative to the moment center as compared to his wind-off location. This effectively changed the static moments which introduced an uncorrectable variation in the final data for the various subjects. The moment coefficients should be useful in qualitative predictions of the motions of the body when subjected to a wind force.

Aerodynamics Laboratory
David Taylor Model Basin
Washington, D. C.
January 1954

APPENDIX

DETERMINATION OF EQUATIONS FOR TRANSFERRING THE MOMENTS FROM THE CENTER OF ROTATION OF THE SUPPORT SYSTEM TO THE AVERAGE CENTER OF GRAVITY OF EACH BODY POSITION

The moment arms, as defined in the notation, are listed below for the five body positions at 0° yaw. Each of these was taken from an average graphical location. This was determined by the center of a circle circumscribing the centers of gravity of four subjects of varying physique mounted in the supports (Figure 11).

Body Position	x in feet	y in feet
Standing	-0.03	0.74
Sitting	1.03	0.53
Supine	0.17	0.40
Squat 1	-0.14	0.98
Squat 2	0.13	0.29

General moment-transfer equations as derived from the physical layout of the supports are as follows:

$$M_{CG} = M_{CR} + (x\cos\Psi)\ L - yD$$

$$N_{CG} = N_{CR} + (x\sin\Psi)\ D + (x\cos\Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - yY - (x\sin\Psi)\ L$$

The subscripts CG and CR refer to the center of gravity and the center of rotation for each body position.

The specific moment-transfer equations for each body position are presented below.

APPENDIX (CONTINUED)

Standing Position

$$M_{CG} = M_{CR} - (0.03 \cos \Psi)\ L - 0.74\ D$$

$$N_{CG} = N_{CR} - (0.03 \sin \Psi)\ D - (0.03 \cos \Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - 0.74\ Y + (0.03 \sin \Psi)\ L$$

Sitting Position

$$M_{CG} = M_{CR} + (1.03 \cos \Psi)\ L - 0.53\ D$$

$$N_{CG} = N_{CR} + (1.03 \sin \Psi)\ D + (0.17 \cos \Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - 0.40\ Y - (0.17 \sin \Psi)\ L$$

Supine Position

$$M_{CG} = M_{CR} + (0.17 \cos \Psi)\ L - 0.40\ D$$

$$N_{CG} = N_{CR} + (0.17 \sin \Psi)\ D + (0.17 \cos \Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - 0.40\ Y - (0.17 \sin \Psi)\ L$$

Squat Position 1

$$M_{CG} = M_{CR} - (0.14 \cos \Psi)\ L - 0.98\ D$$

$$N_{CG} = N_{CR} - (0.14 \sin \Psi)\ D - (0.14 \cos \Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - 0.98\ Y + (0.14 \sin \Psi)\ L$$

Squat Position 2

$$M_{CG} = M_{CR} + (0.13 \cos \Psi)\ L - 0.29\ D$$

$$N_{CG} = N_{CR} + (0.13 \sin \Psi)\ D + (0.13 \cos \Psi)\ Y$$

$$\mathcal{L}_{CG} = \mathcal{L}_{CR} - 0.29\ Y - (0.13 \sin \Psi)\ L$$

The preceding moment-transfer equations may be employed to transfer the moment coefficients by merely substituting the appropriate coefficients in place of the net values indicated.

REFERENCES

1. CAA ltr dated 19 Feb 1952.

2. ONR ltr ONR:441:EKK:gjs NR 118-074, serial 7833, dated 12 March 1952.

3. BuAer ltr Aer-DE-31 NA onr 10451, serial 38782, dated 21 March 1952.

4. Hoerner, Sighard F.: Aerodynamic Drag. Midland Park, N. J., 1951.

TABLE 1

Physical Characteristics of Human Subjects

Subject	Age	Weight in pounds	Height in feet	Vol. in ft.^{3}	Surface Area in ft.^{2}
1	47	185	6.00	3.022	22.17
2	38	155	5.67	2.458	19.69
3	24	196	5.96	3.027	22.70
4	38	154	6.17	2.285	20.98
5	16	160	5.92	2.559	20.66
6	36	165	5.33	2.571	19.37
7	24	160	5.67	2.496	20.01
8	37	165	5.75	2.771	20.44
9	31	155	5.83	2.571	20.12
10	32	156	5.42	2.480	19.05
11	43	160	5.67	2.582	20.01
12	33	142	5.38	2.255	18.29
13	22	158	5.83	2.422	20.34
14	20	165	5.75	2.541	20.44
15	25	169	5.46	2.636	20.23
16	27	145	5.75	2.199	19.37

TABLE 2

Summary of Test Dynamic Pressures With Approximate Corresponding Airspeeds and Reynolds Numbers

q in lb/sq ft	V		$R \times 10^{-6}$
	in ft/sec	in knots	
1.0	30.1	17.8	0.17
9.0	90.2	53.4	0.51
26.0	153	90.8	0.87
37.0	183	108	1.04
43.0	195	116	1.14
50.0	212	126	1.21
58.0	227	134	1.32
66.0	243	144	1.39

The above Reynolds numbers are based on an arbitrary characteristic length (ℓ) of one foot.

TABLE 3

Summary of Nominal Dynamic Pressures for the Body Positions and Clothing Conditions of all Subjects Tested

Subject Number	Body Position									
	Standing		Sitting		Supine		Squat 1		Squat 2	
	Clothed	Nude	Clothed	Nude	Clothed	Nude	Clothed	Nude	Clothed	Nude
1	1,9,26	9,26,37	1,9,26	1,9,26	1,9,26	*9,26,37			1,9,26	1,9,26
2	1,9,26	9,26,37	1,9,26	9,26,37	1,9,26	9,26,37	1,9,26**	9,26,37	1,9,26	9,26,37
3	1,9,26	1,9,26	1,9,26	9,26,37	1,9,26	9,26,37	1,9,26	1,9,26	1,9,26	1,9,26
4	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	9,26,37	1,9,26	9,26,37
5	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
6	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
7	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
8	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
9	1,9,26	1,9,26					1,9,26	1,9,26		
10	1,9,26	1,9,26								
11	1,9,26	1,9,26								
12					1,9,26	1,9,26				
13			1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
14			1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26	1,9,26
15			1,9,26	1,9,26			1,9,26	1,9,26	1,9,26	1,9,26
16			1,9,26	1,9,26			1,9,26	1,9,26	1,9,26	1,9,26

* Subject 1 was also tested with dynamic pressures of 43, 50, 58, and 66 at $\Psi = 0°$ and 180°

** Subject 2 was also tested with dynamic pressures of 37, 43, 50, 58, and 66 at $\Psi = 0°$ and 180°

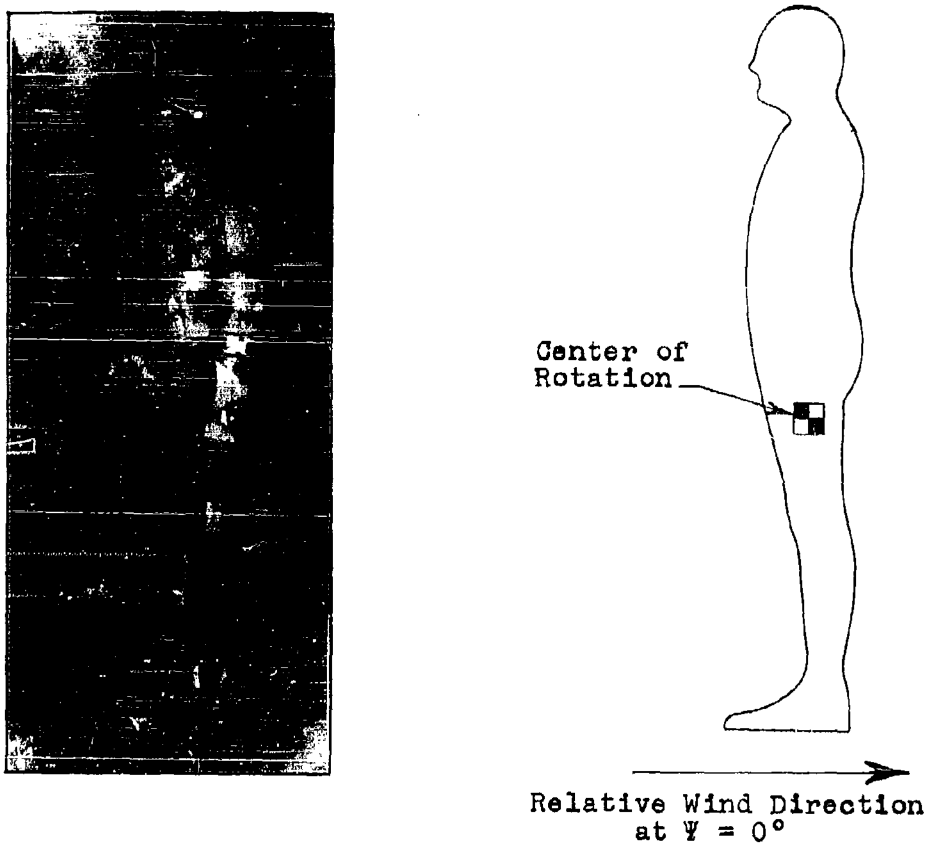

Figure 1 - Photographs of Various Subjects Mounted in The Wind Tunnel in The Five Body Positions and Orientation of Each Position With Respect to The Relative Wind

(a) Clothed Subject 11, Standing Position

$\Psi = 0°$, $q = 26.0$ lb/sq ft

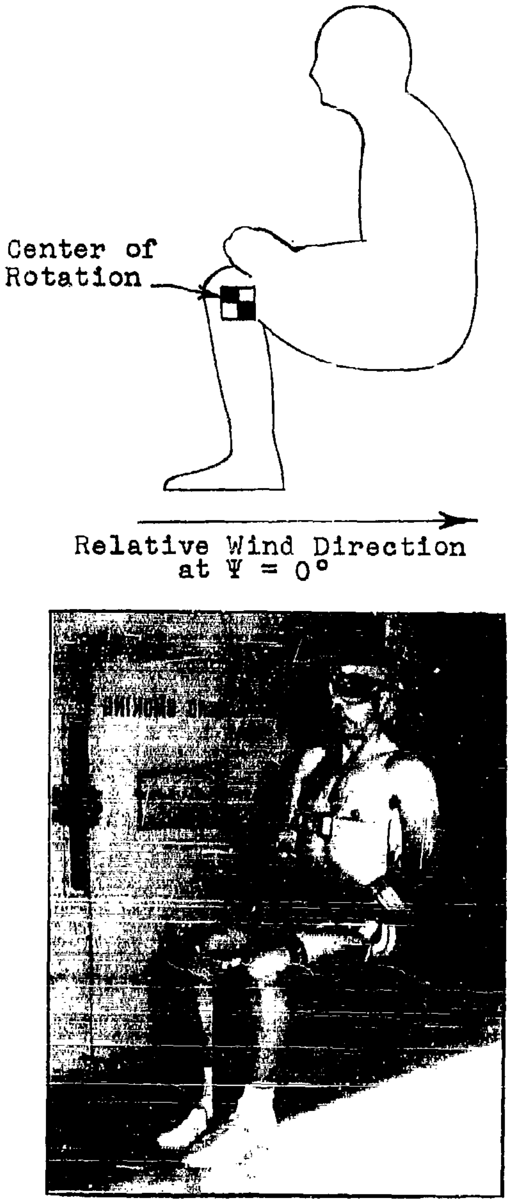

Figure 1 (Continued)

(b) Nude Subject 2, Sitting Position

$\Psi = 0°$, $q = 37.0$ lb/sq ft

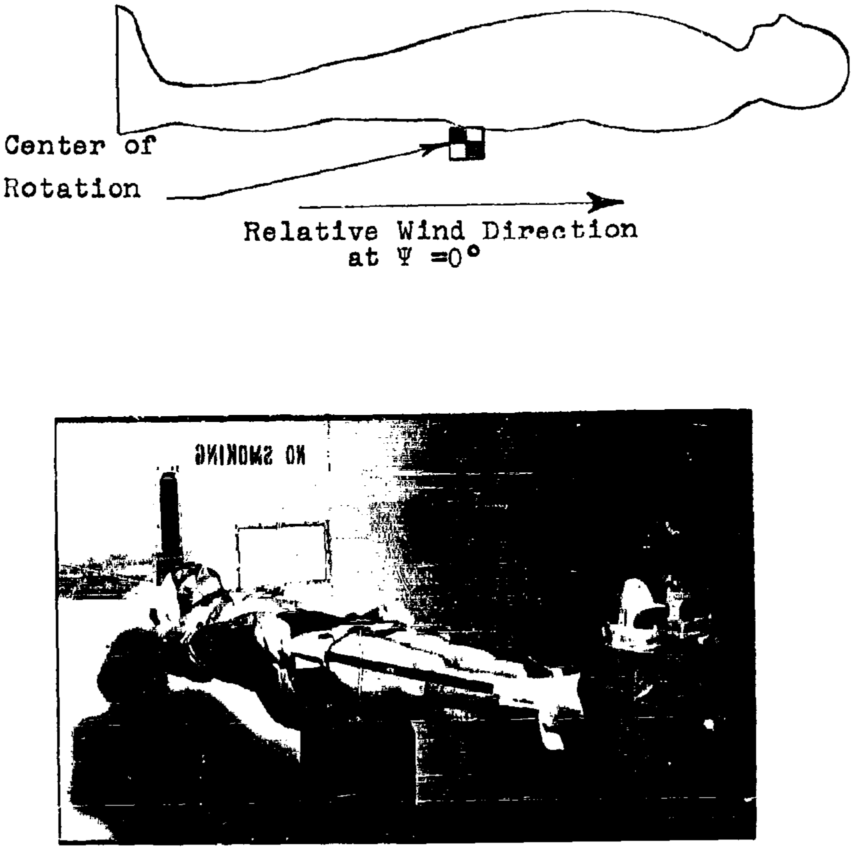

Figure 1 (Continued)

(c) Nude Subject 12, Supine Position

$\Psi = -90°$, $q = 26.0$ lb/sq ft

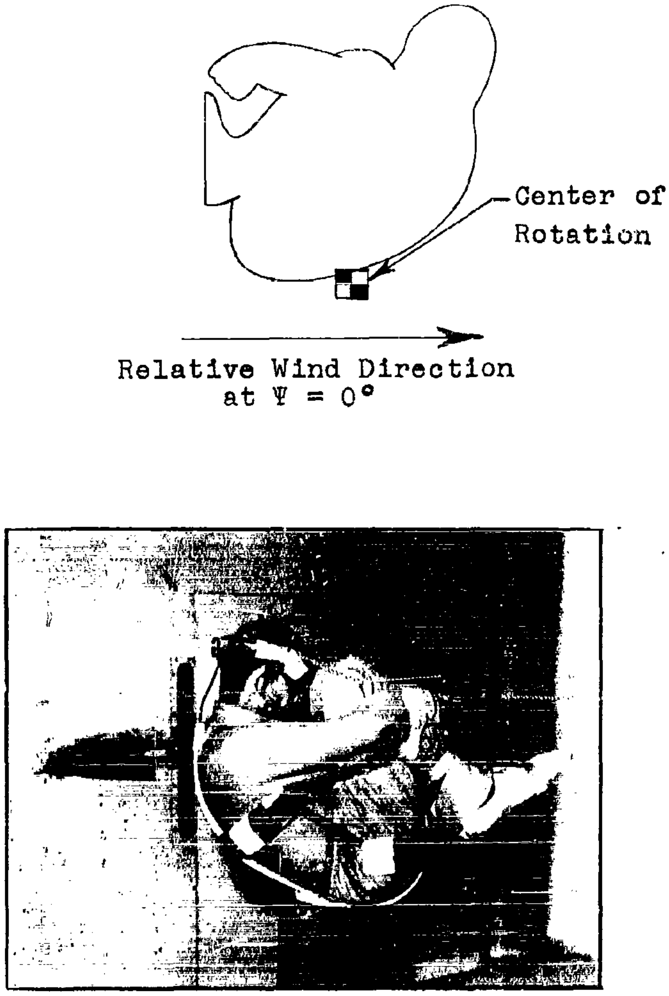

Figure 1 (Continued)

(d) Clothed Subject 2, Squat Position 1

$\Psi = -150°$, $q = 26.0$ lb/sq ft

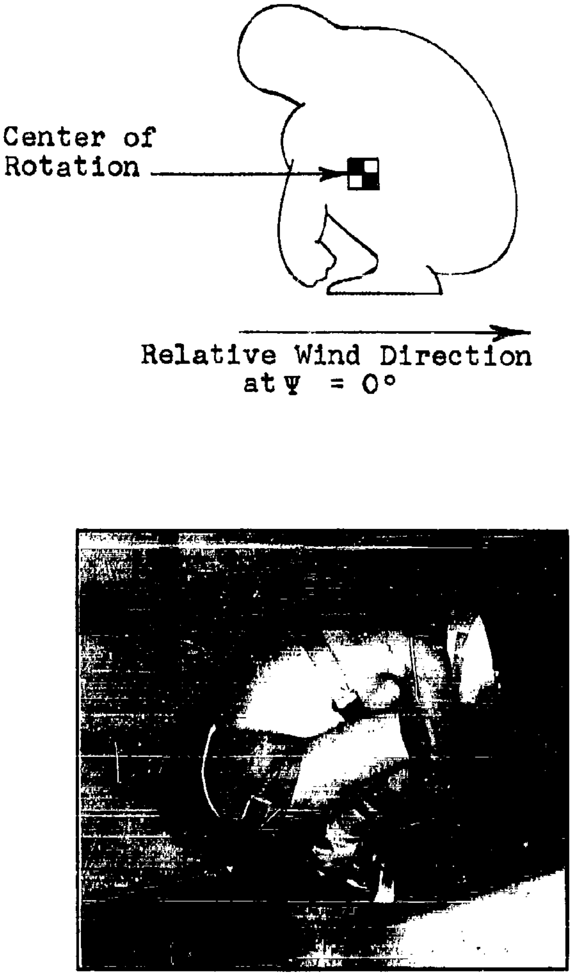

Figure 1 (Concluded)

(e) Nude Subject 3, Squat Position 2

$\Psi = -150°$, $q = 26.0$ lb/sq ft

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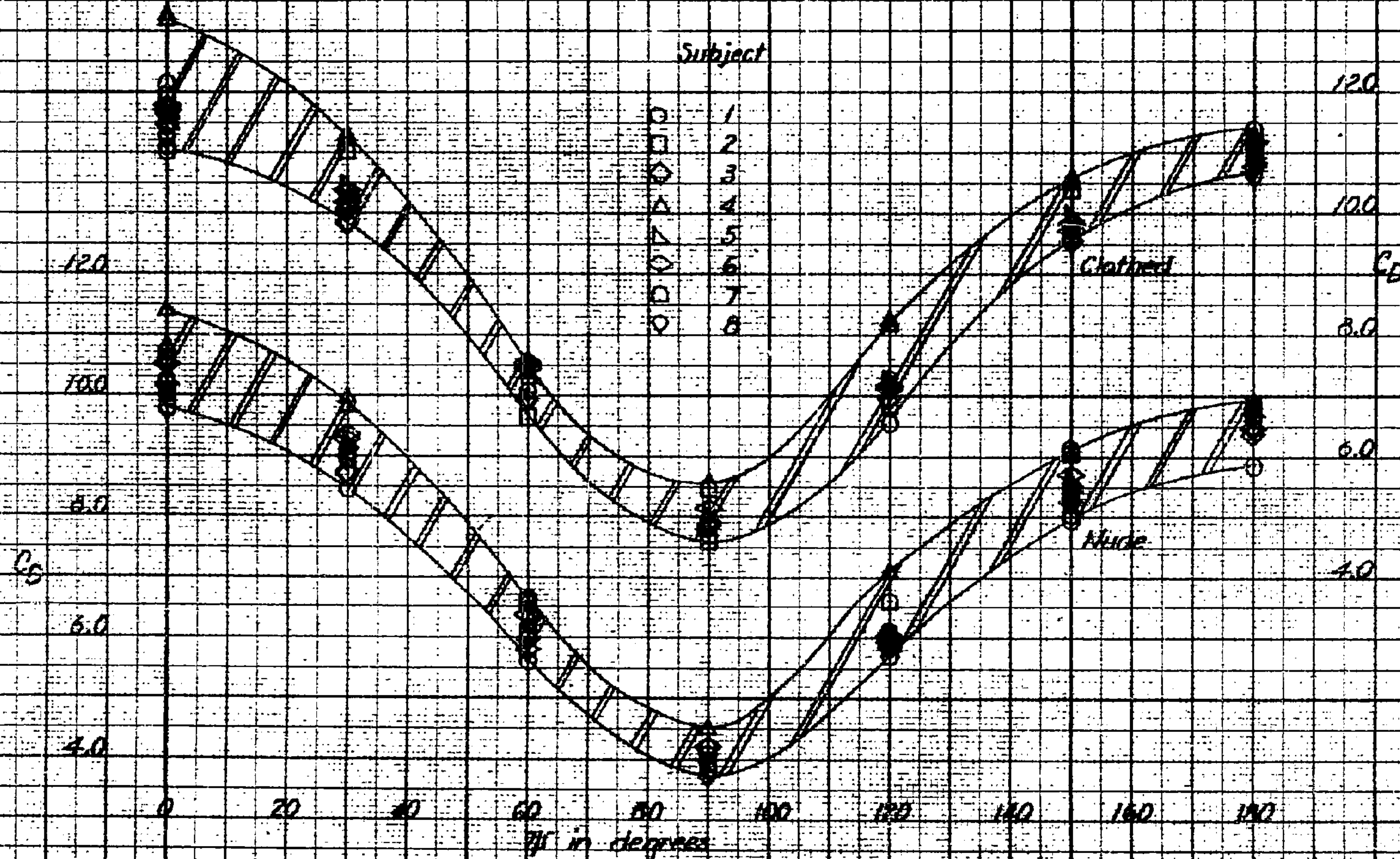

Figure 2—Drag Coefficient of Several Subjects at Various Angles of Yaw

(a) Standing Position, $q = 9.0$ lb/ft^2

PC 14 May '53

FIGURE 2a

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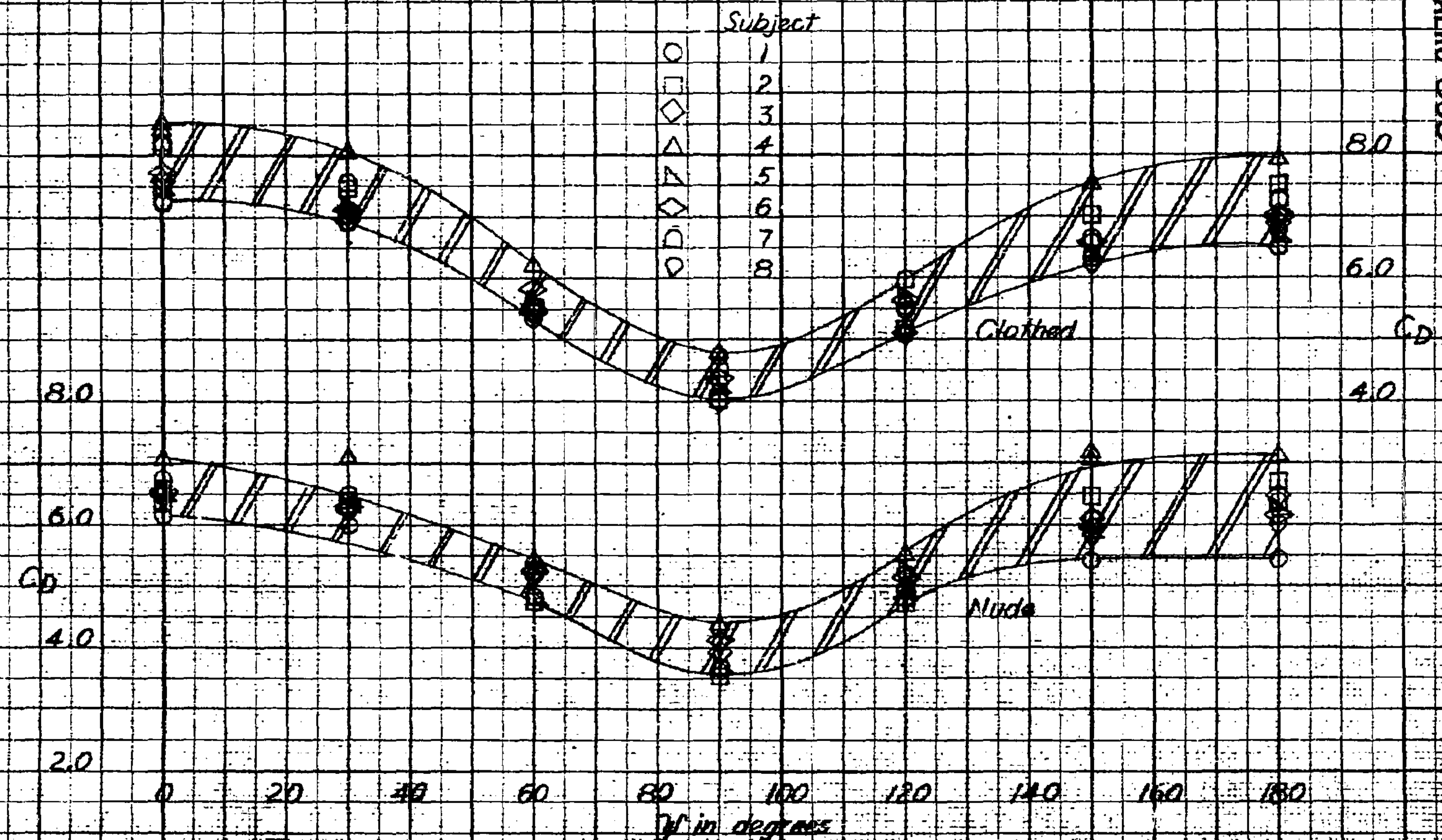

Figure 2 (Continued)

(b) Sitting Position, $q = 9.0$ lb/ft^2

FG 14 May 53

FIGURE 2b

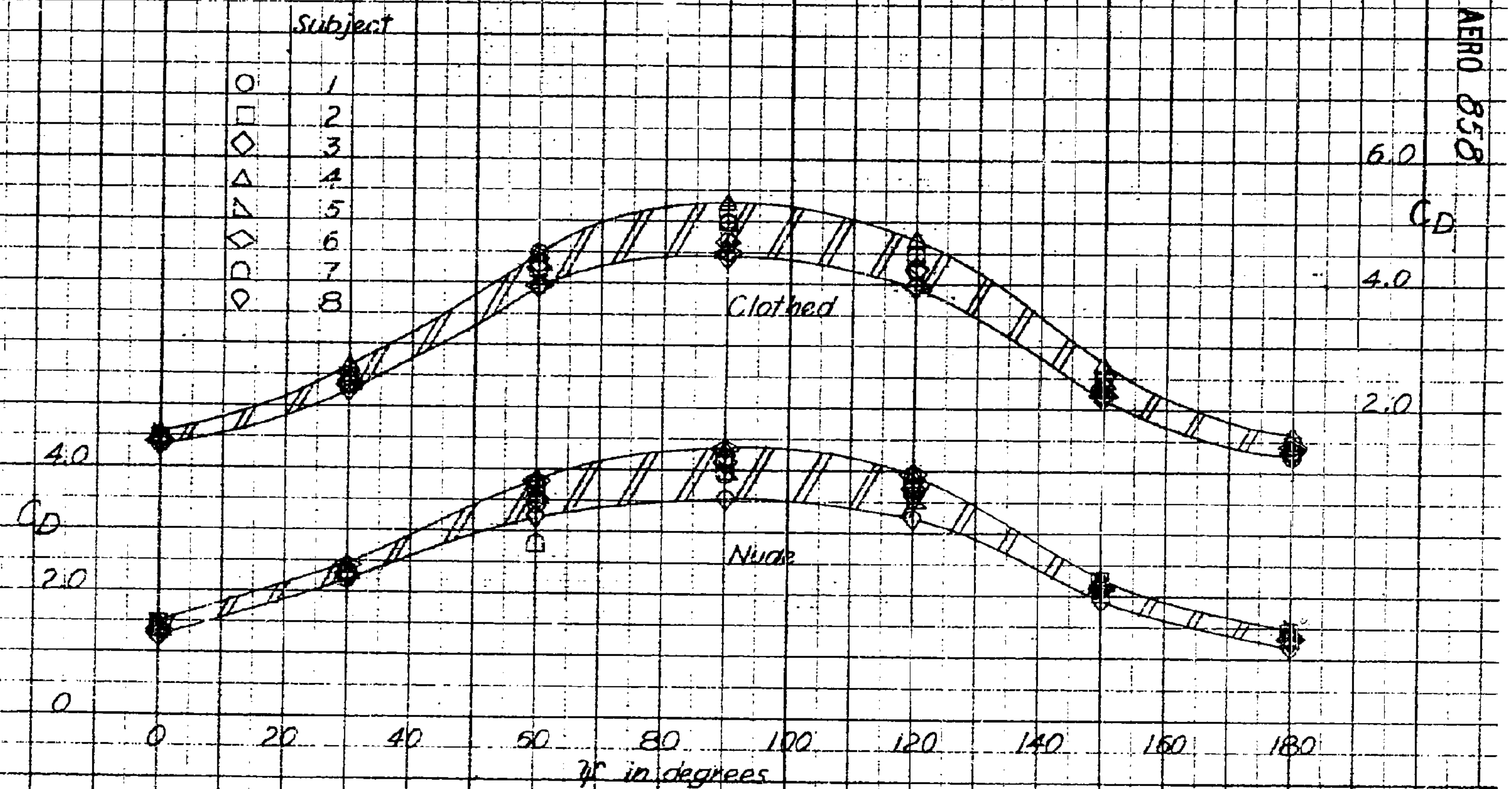

Figure 2 (Continued)

(c) Supine Position, $q = 9.0$ lb/ft^2

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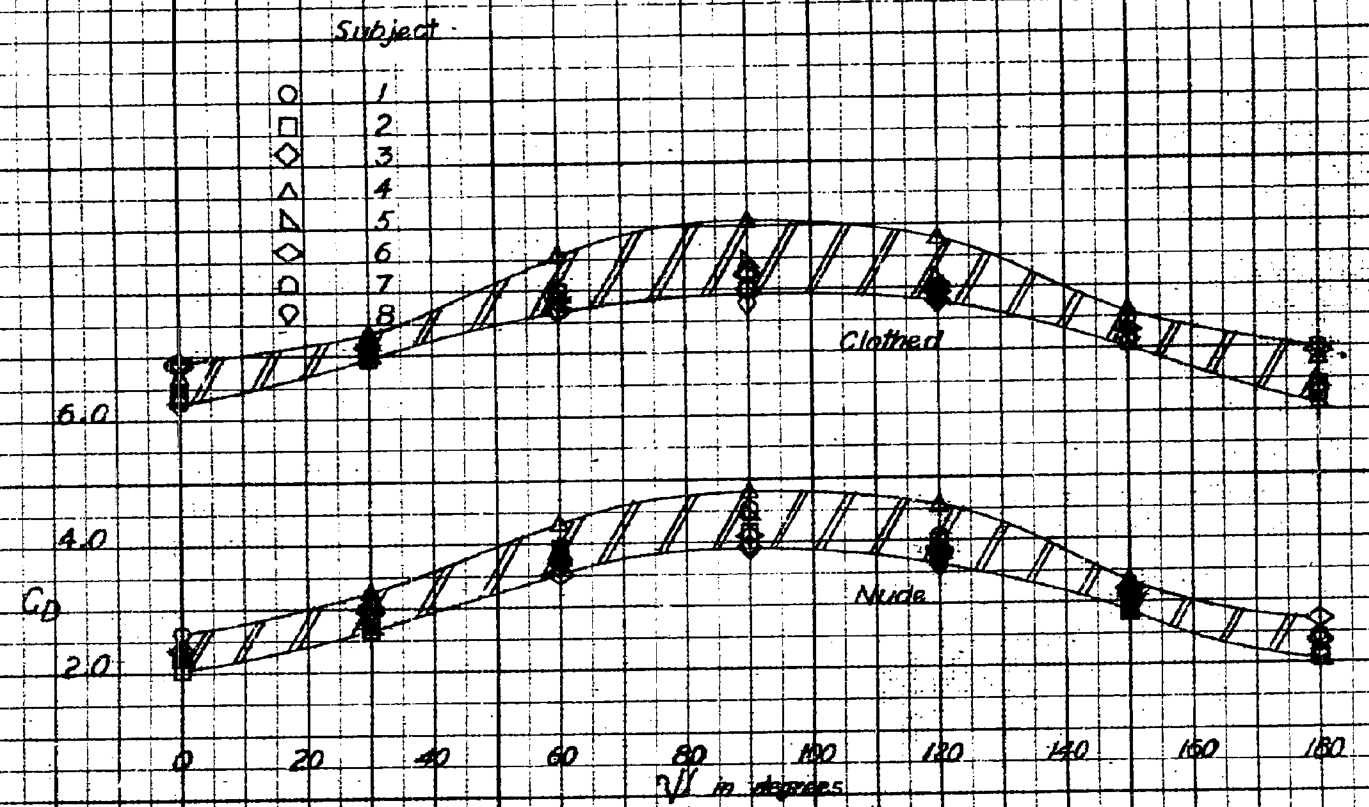

Figure 2 (Continued)

(d) Squat Position I, $q = 9.0$ lb/ft^2

PC 14 May '53

FIGURE 2d

AERO 858

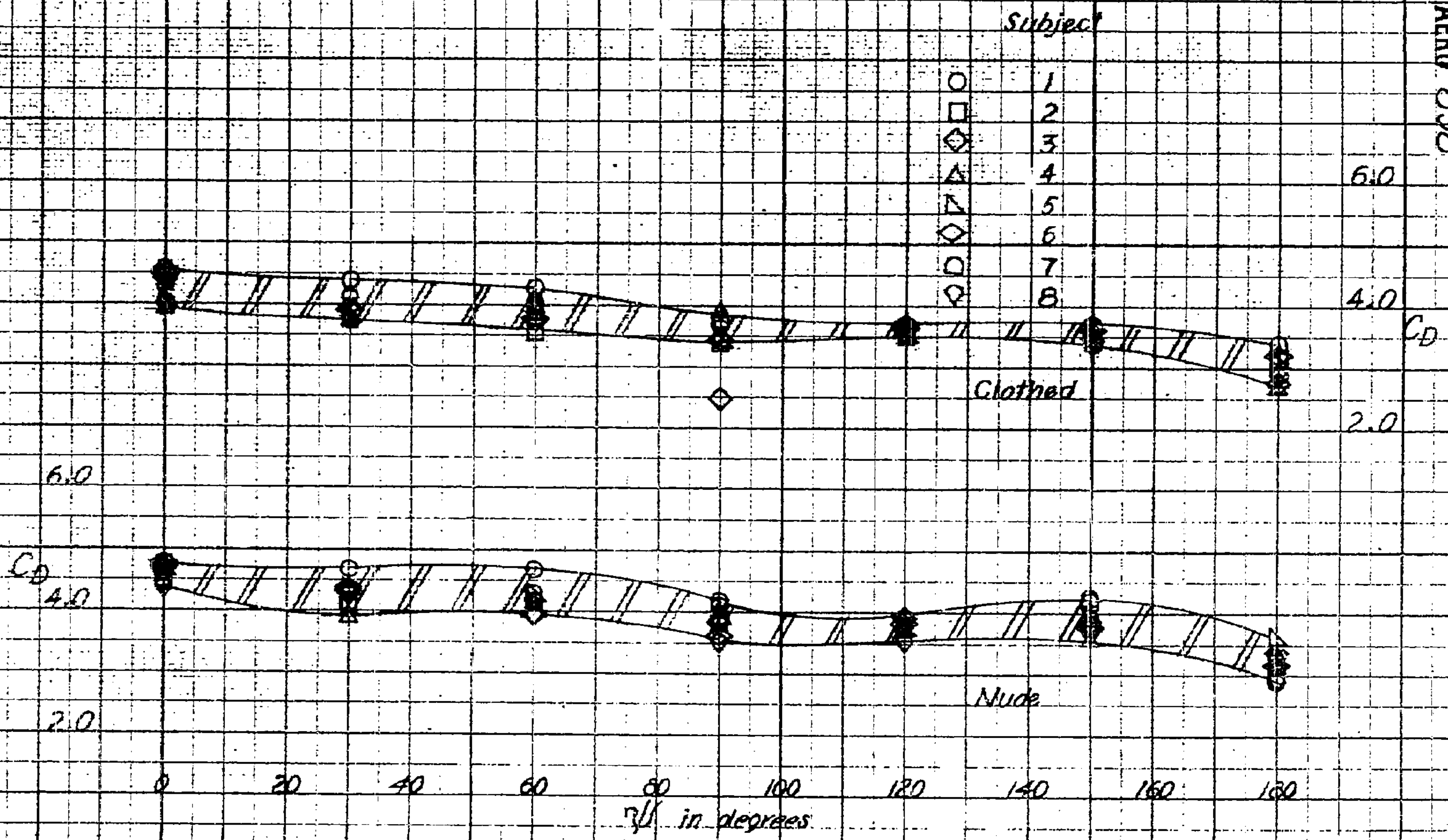

Figure 2 (Concluded)

(e) Squat Position 2, $q = 9.0$ lb/ft^2

PC 14 May '53

FIGURE 2e

AERO 858

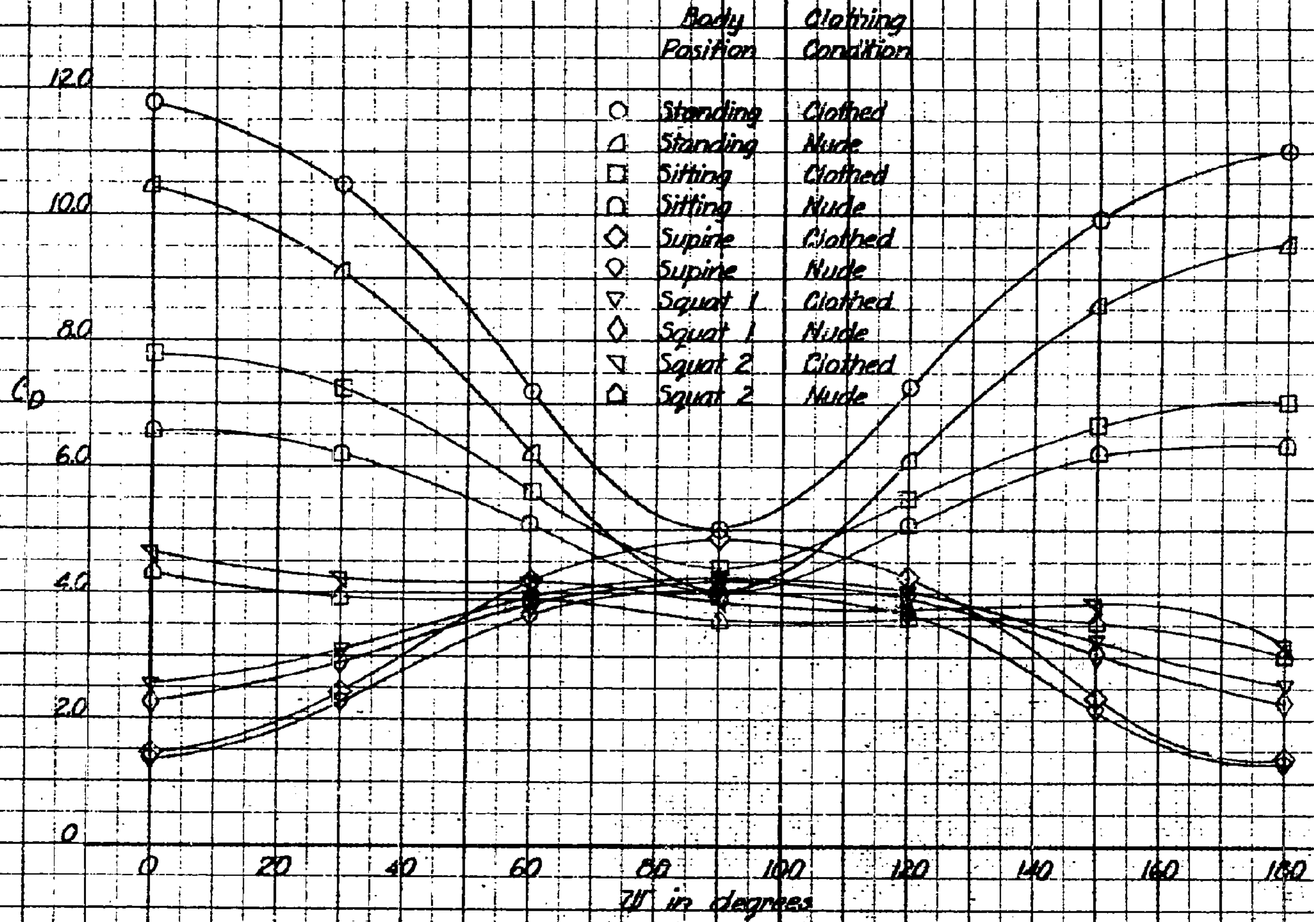

Figure 3—Average Drag Coefficient C_D of Subjects 1 Through 8

$q = 9.0\ \mathrm{lb/ft^2}$

TJS 9 Oct '53

FIGURE 3

AERO 858

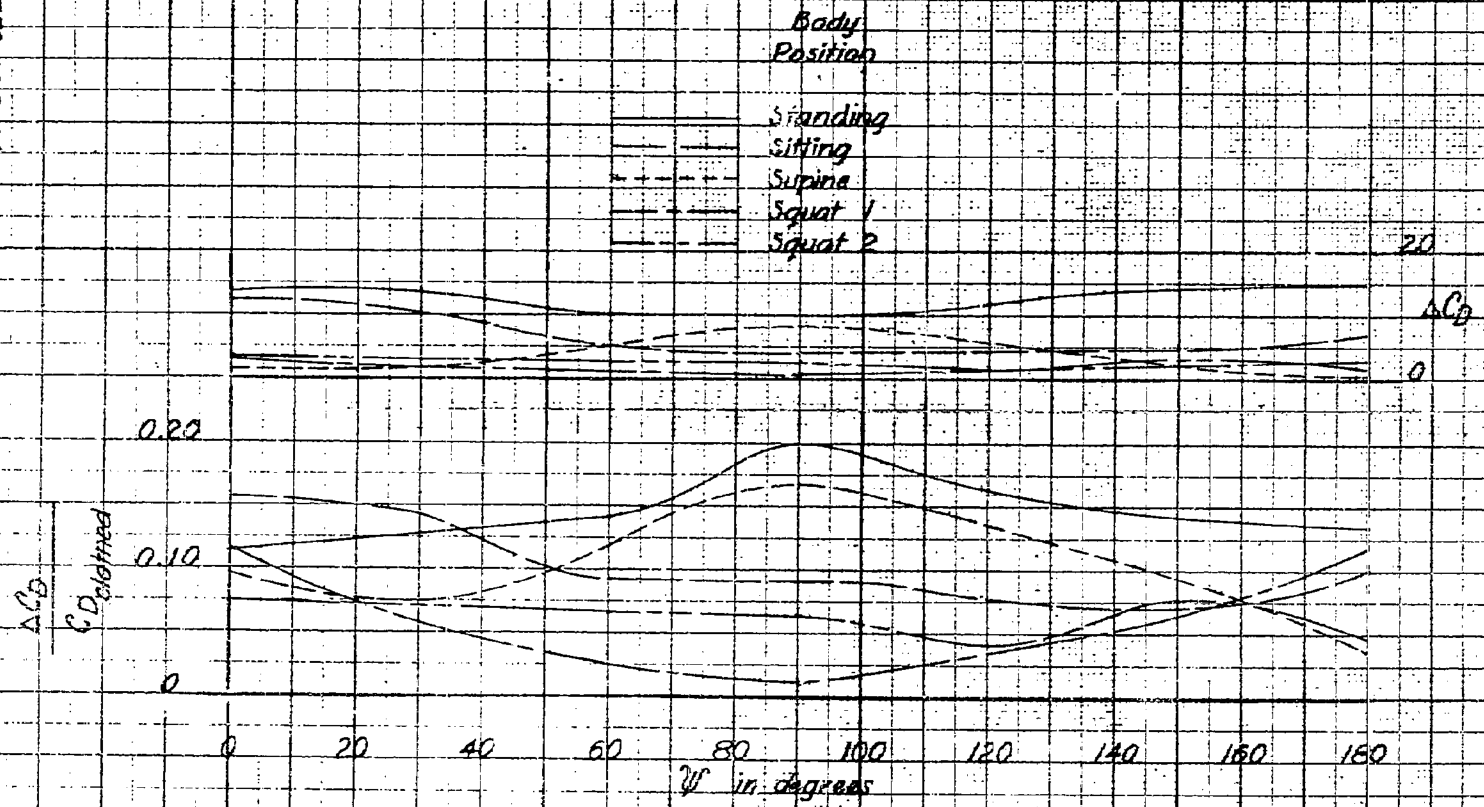

Figure 4 — Effect of Clothing on Drag Coefficient

$q = 9.0$ lb/ft^2

TJS 14 Oct '53

FIGURE 4

AERO 858

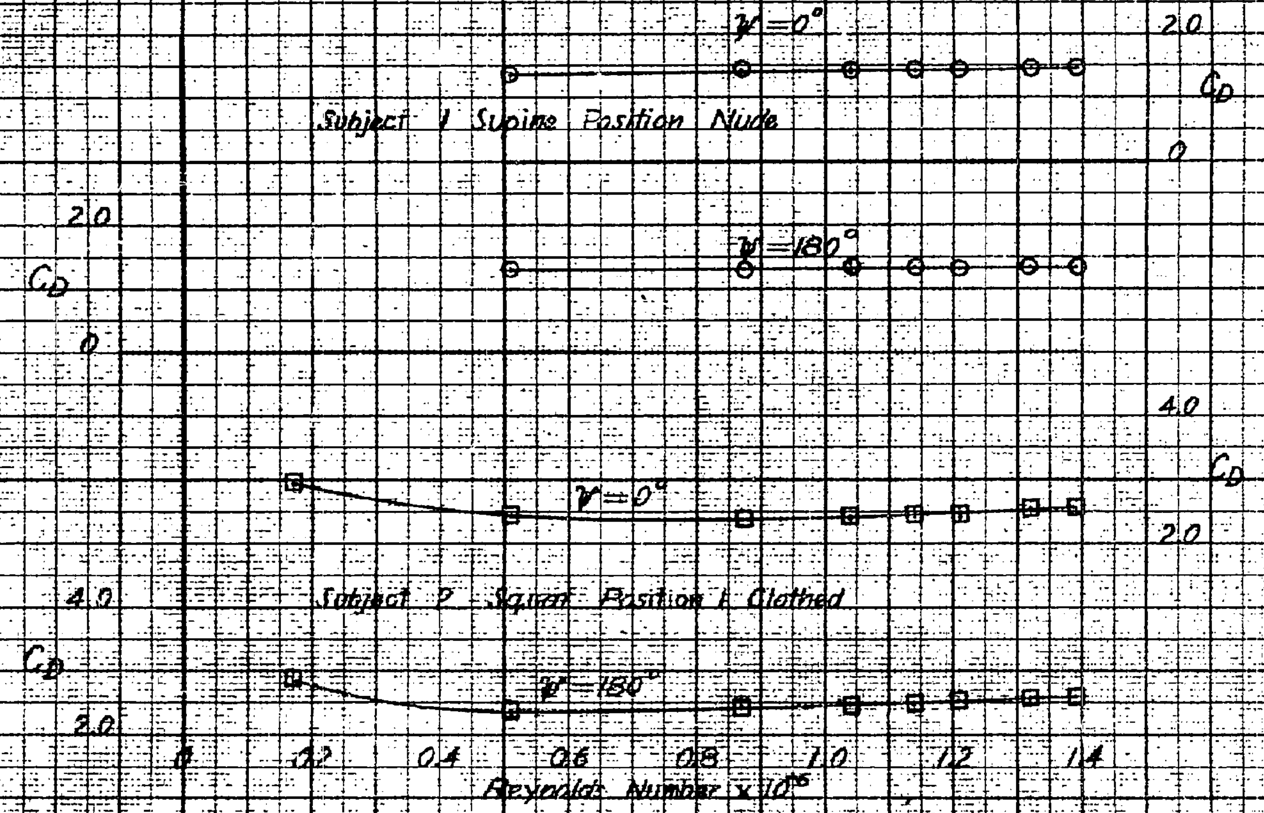

Figure 5 Effect of Reynolds Number on the Drag Coefficient

TJS 14 Oct '53

FIGURE 5

AERO 858

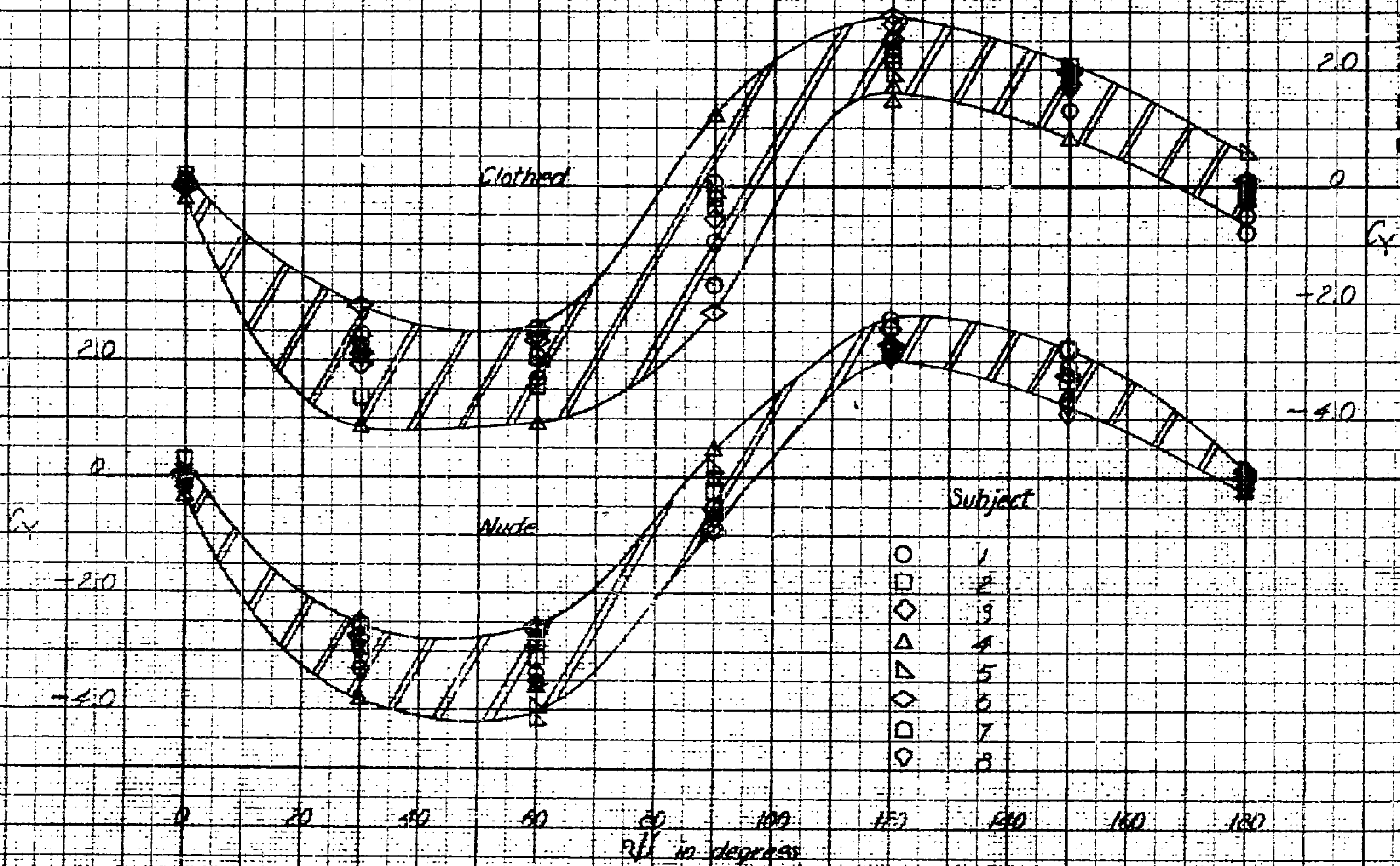

Figure 6 – Side Force Coefficient of Subjects 1 through 8

(a) Standing Position, q = 9.0 lb/ft²

PC 14 May '53

FIGURE 6a

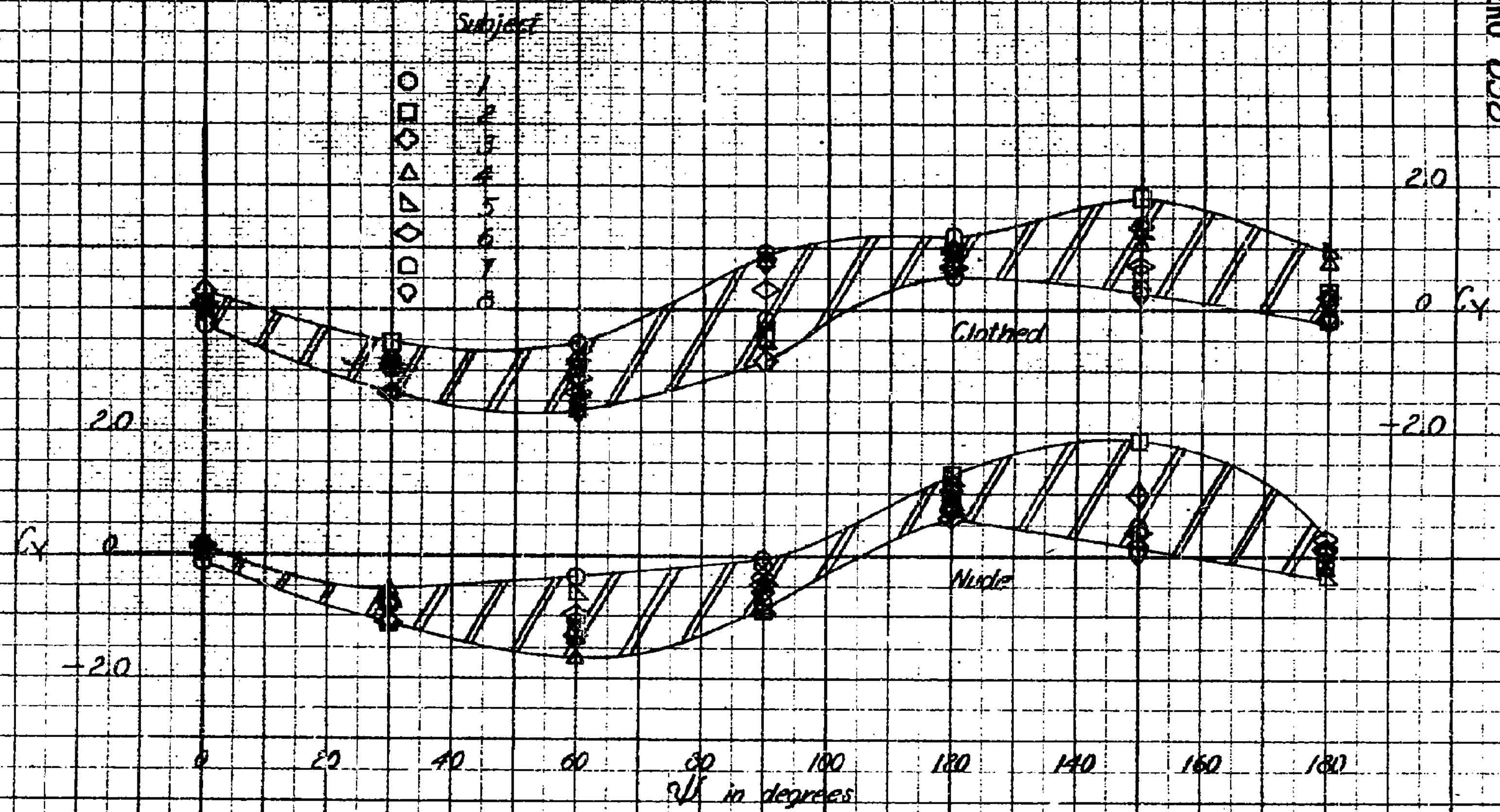

Figure 6 (Continued)

(b) Sitting Position, q = 9.0 lb/ft²

PC 15 May '53

AERO 858

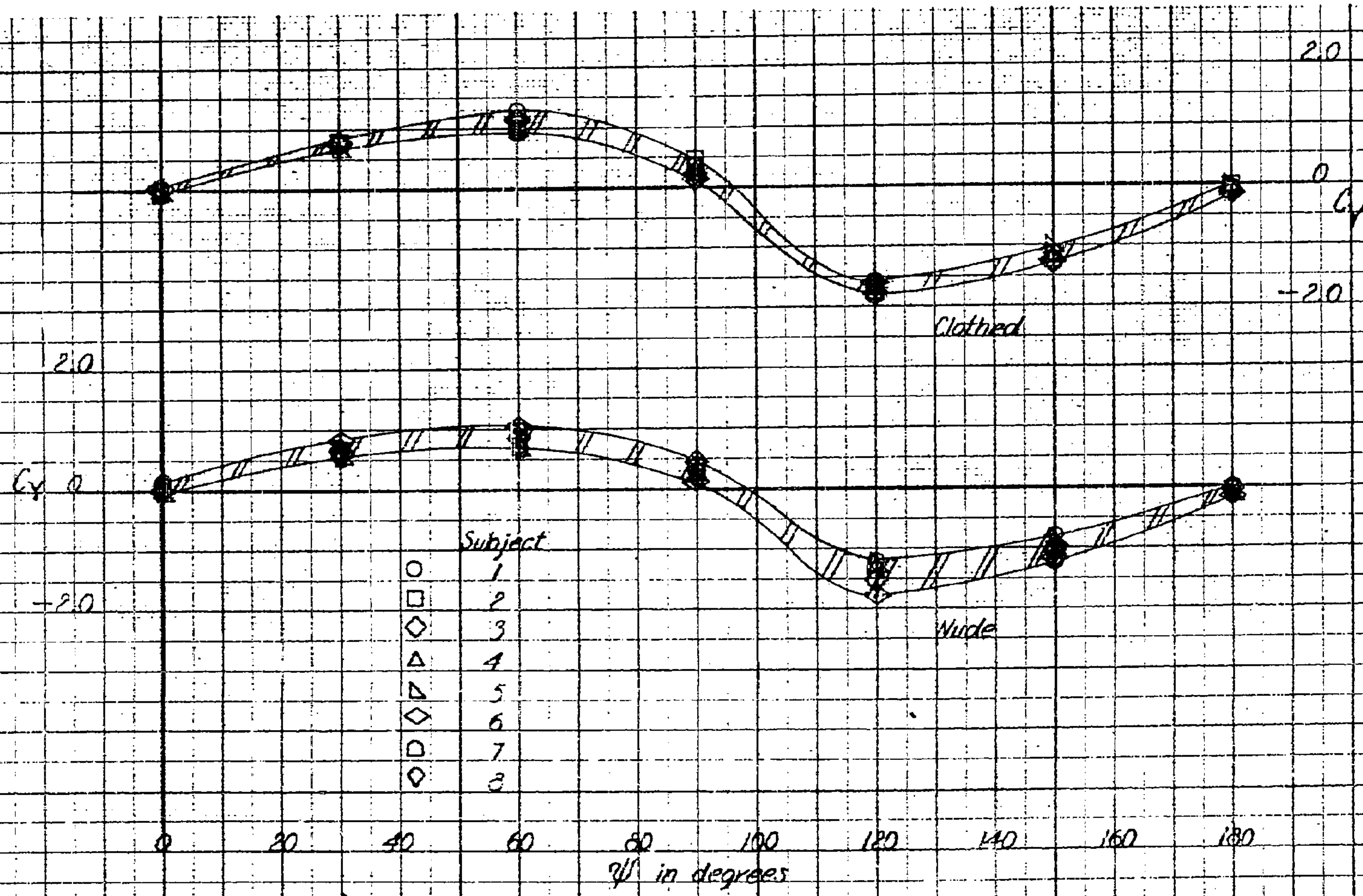

Figure 6 (Continued)

(c) Supine Position, $q - 9.0$ lb/ft^2

DATE 15 May '53

FIGURE 6c

AERO 858

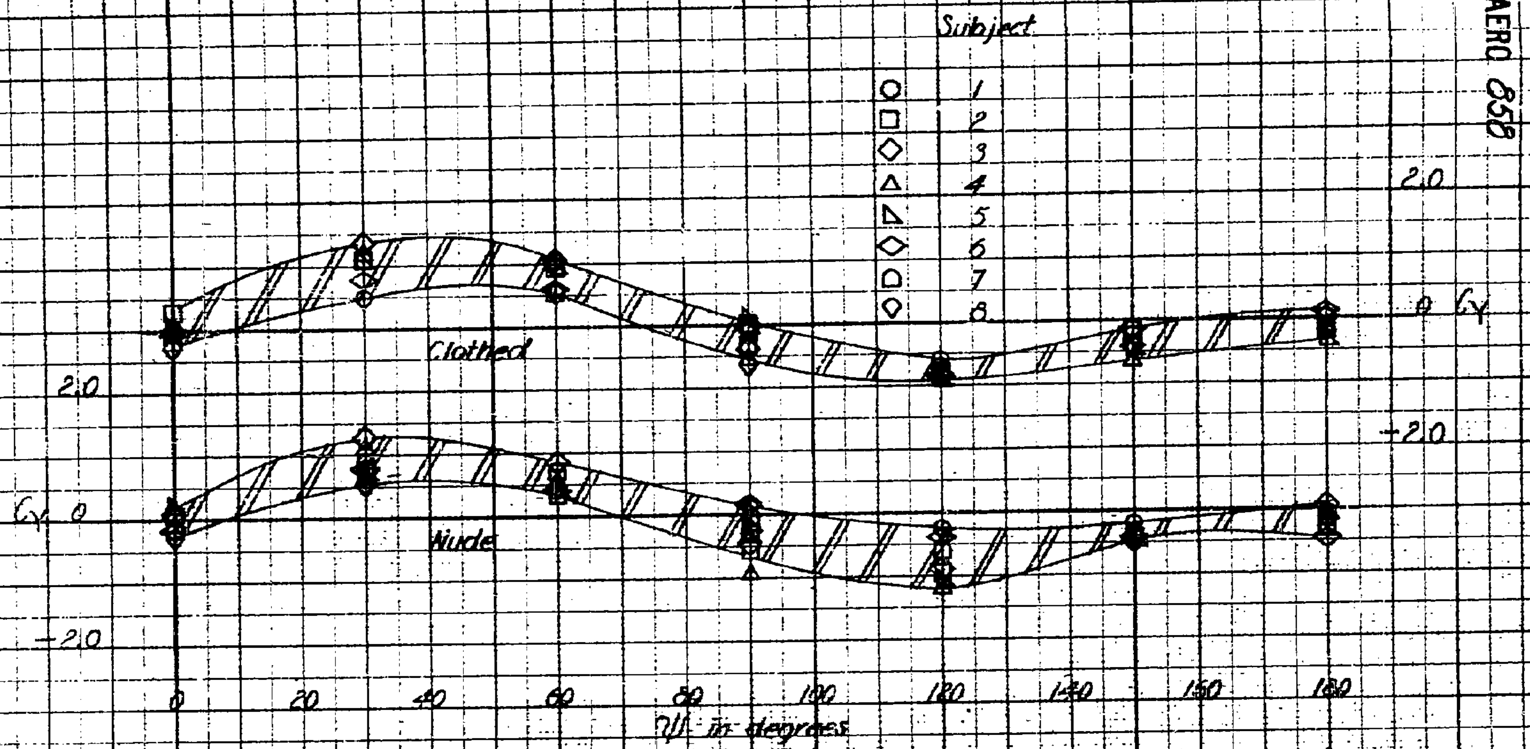

Figure 6 (Continued)

(d) Squat Position I, $q = 9.0$ lb/ft^2

PC 15 May '53

FIGURE 6d

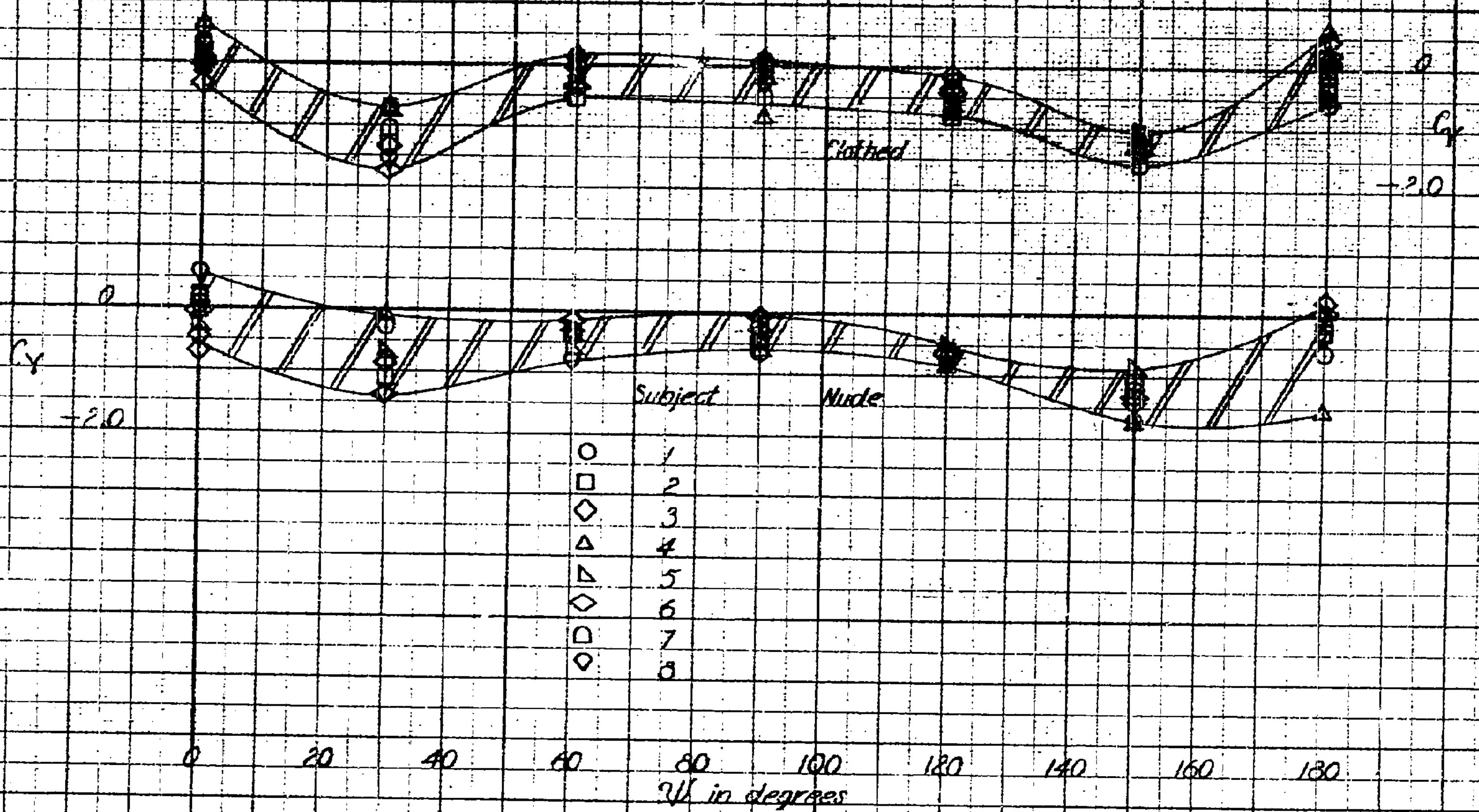

Figure 6 (Concluded)

(e) Squat Position 2, $q = 9.0\ \mathrm{lb/ft^2}$

PC 14 May 53

AERO 858

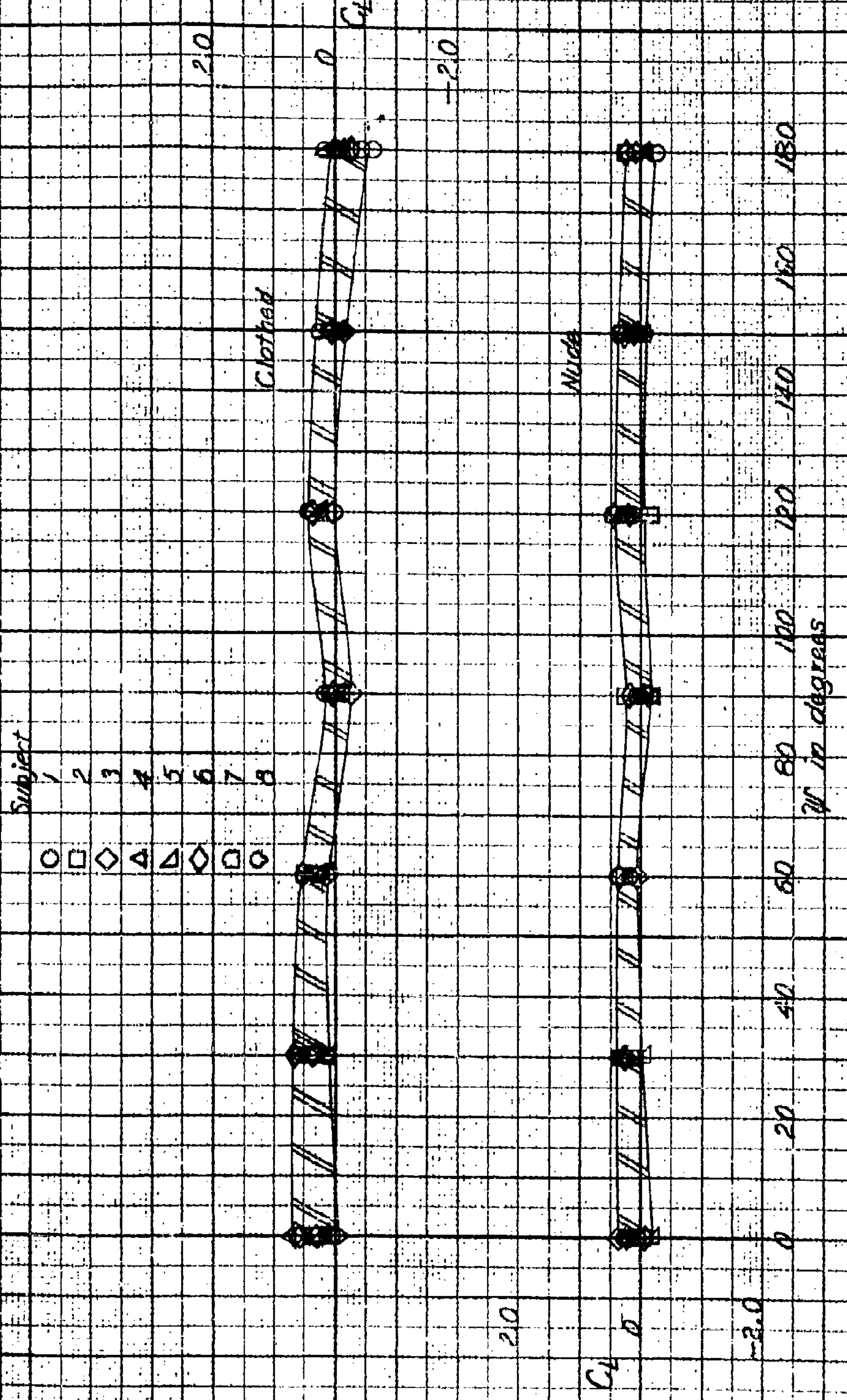

Figure 7 – Lift Coefficient of Subjects 1 through 8

(a) Standing Position, $q = 9.0$ lb/ft^2

BK 23 July '53

FIGURE 7a

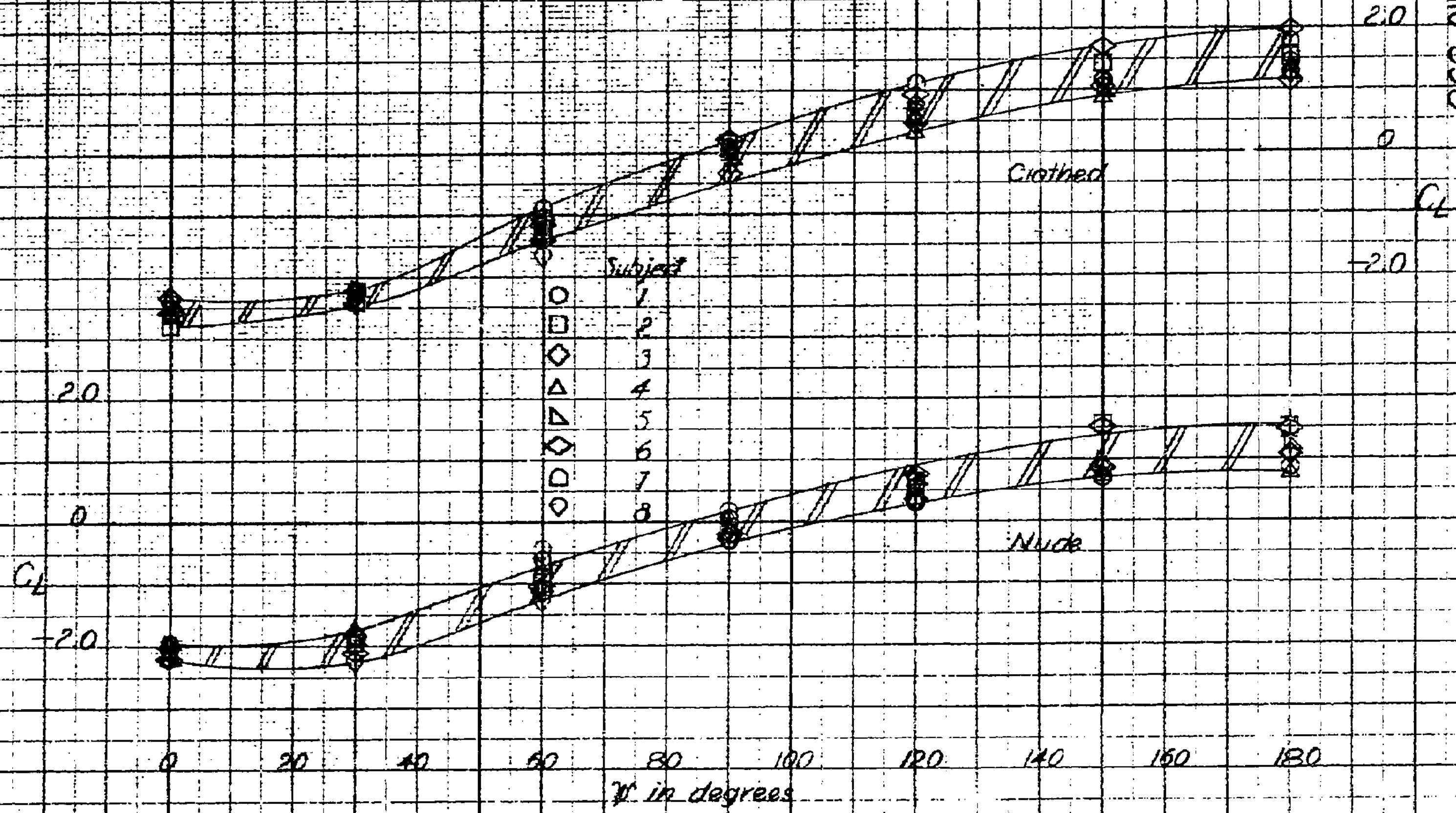

Figure 7 (Continued)

(b) Sitting Position, $q = 9.0$ lb/ft^2

BV 23 July '53

AERO 858

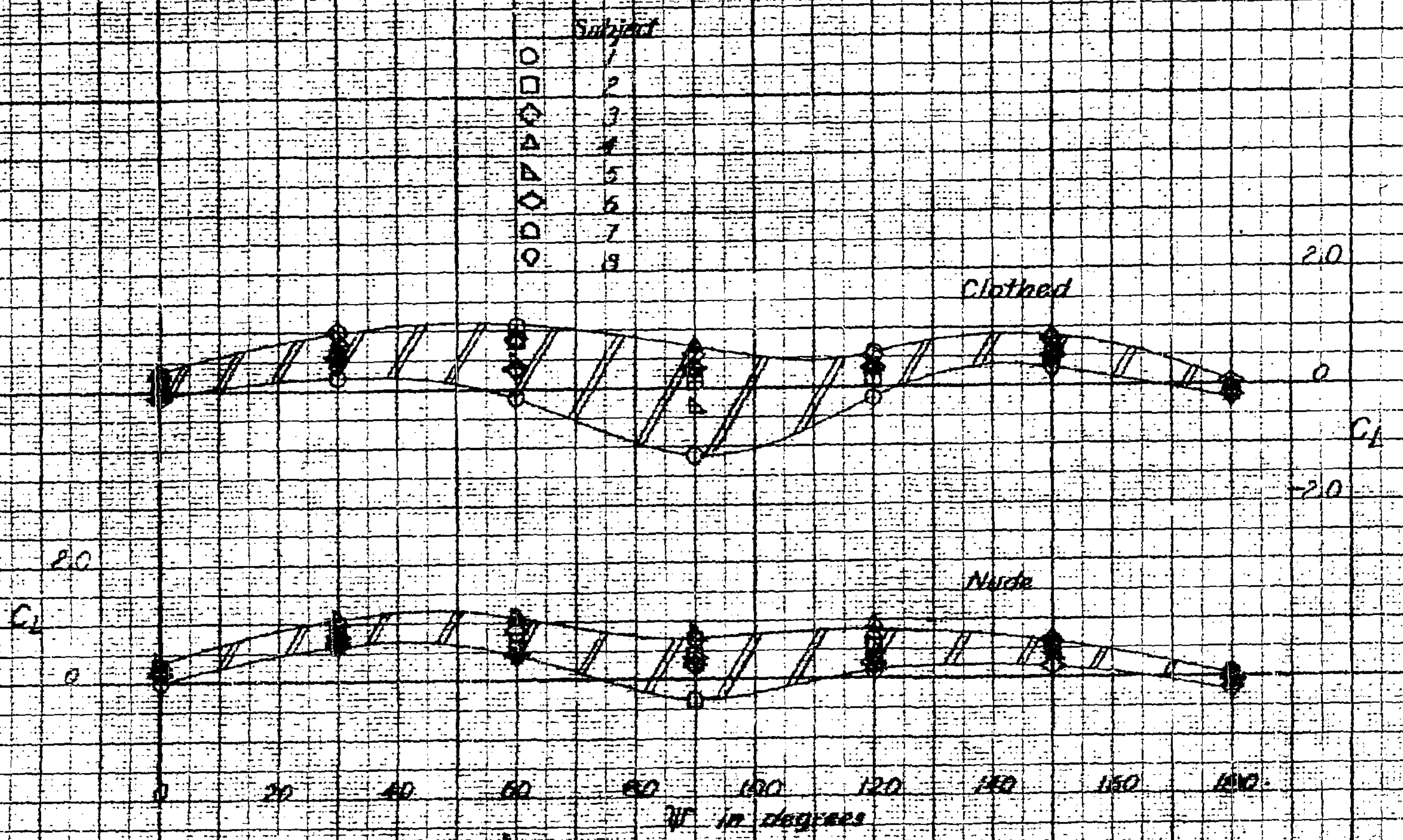

Figure 7 (Continued)

(c) Supine Position, $q = 9.0$ lb/ft^2

BK 29 July 53

FIGURE 7c

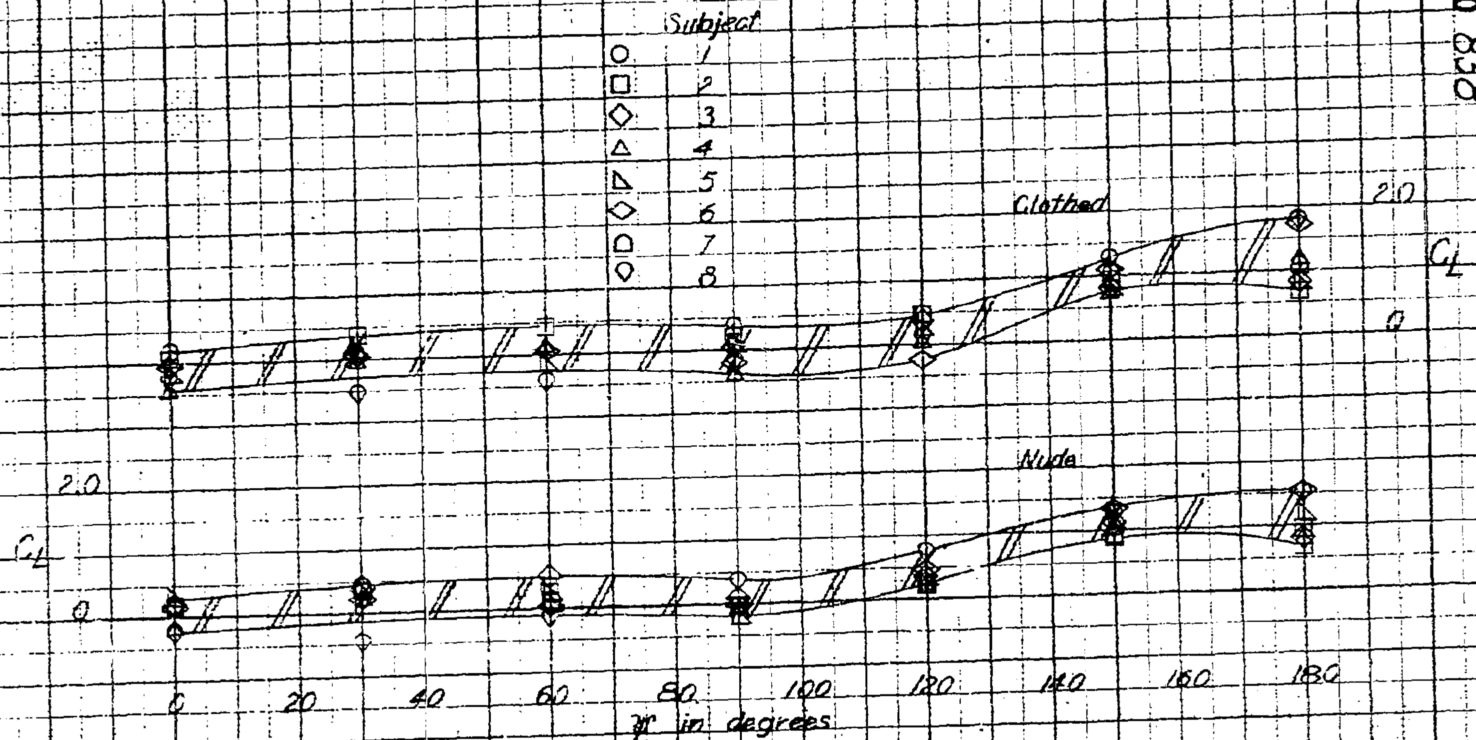

Figure 7 (Continued)

(d) Squat Position 1, $q = 9.0 \text{ lb/ft}^2$

BV 23 July '53

FIGURE 7d

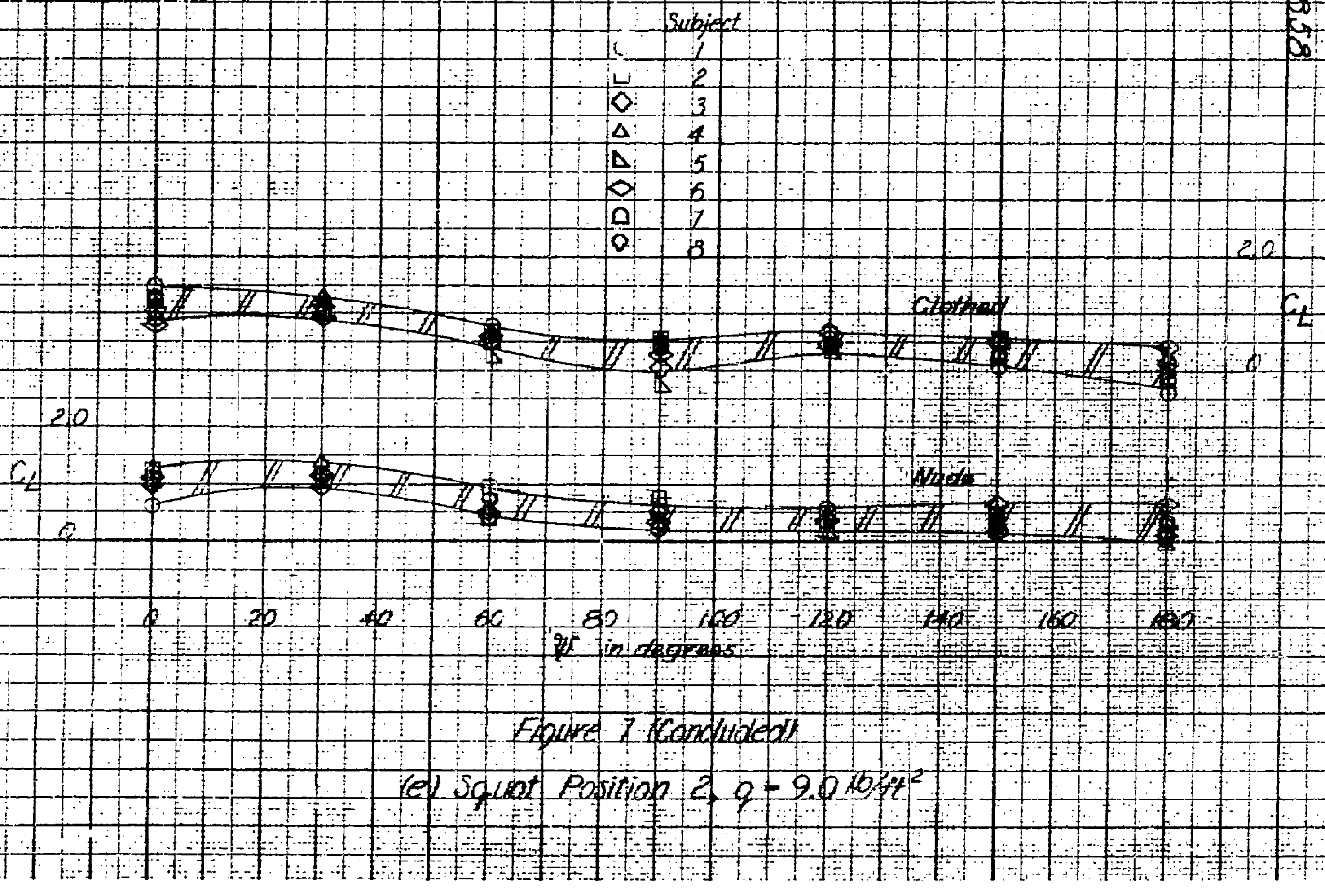

Figure 7 (Concluded)

(e) Squat Position 2, $q = 9.0$ lb/ft^2

AERO 858

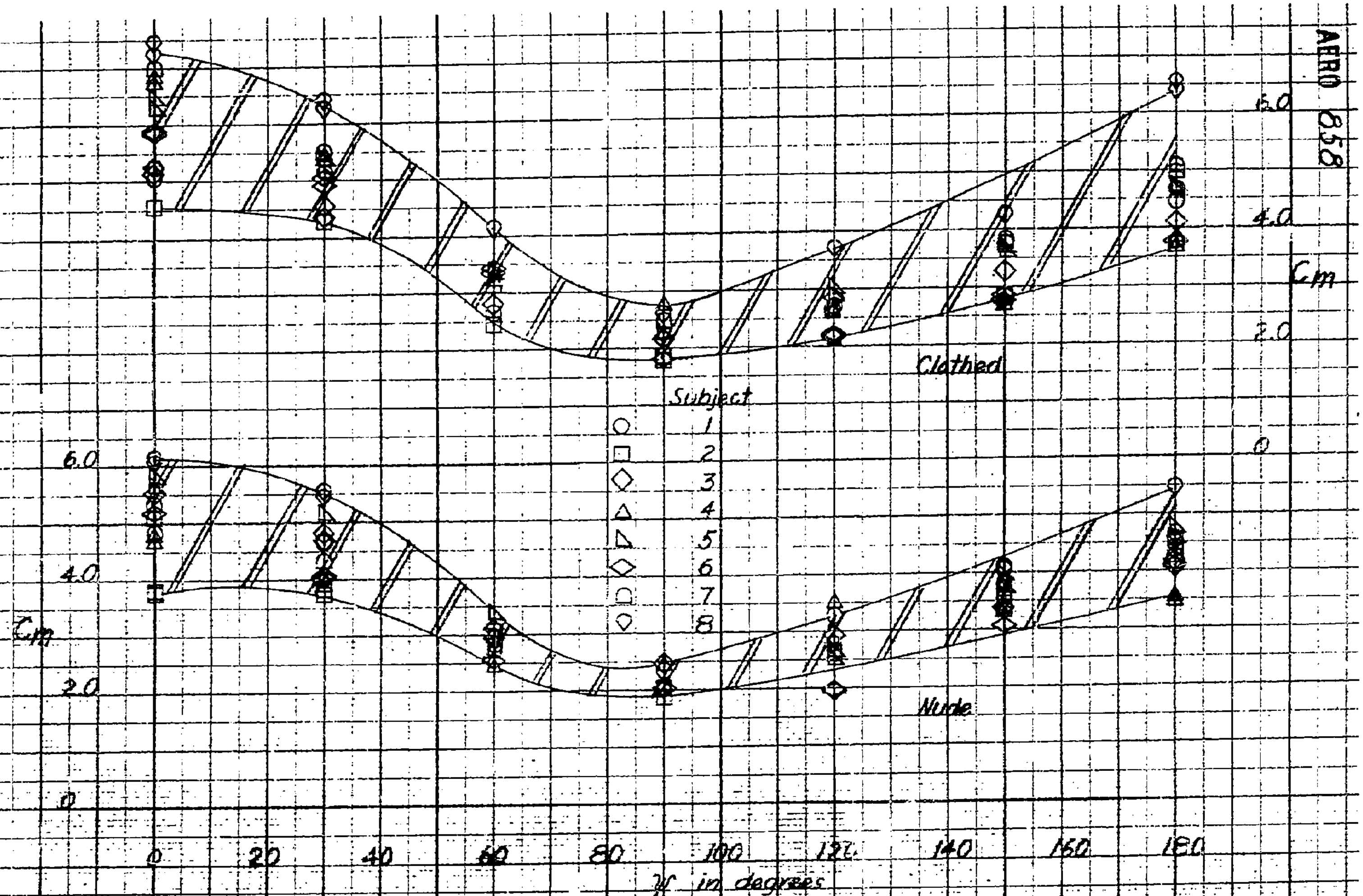

Figure 8 — Pitching-Moment Coefficient of Subjects 1 through 8

(a) Standing Position, $q = 9.0 \text{ lb/ft}^2$

BV 24 July '53

FIGURE 8a

AERO 858

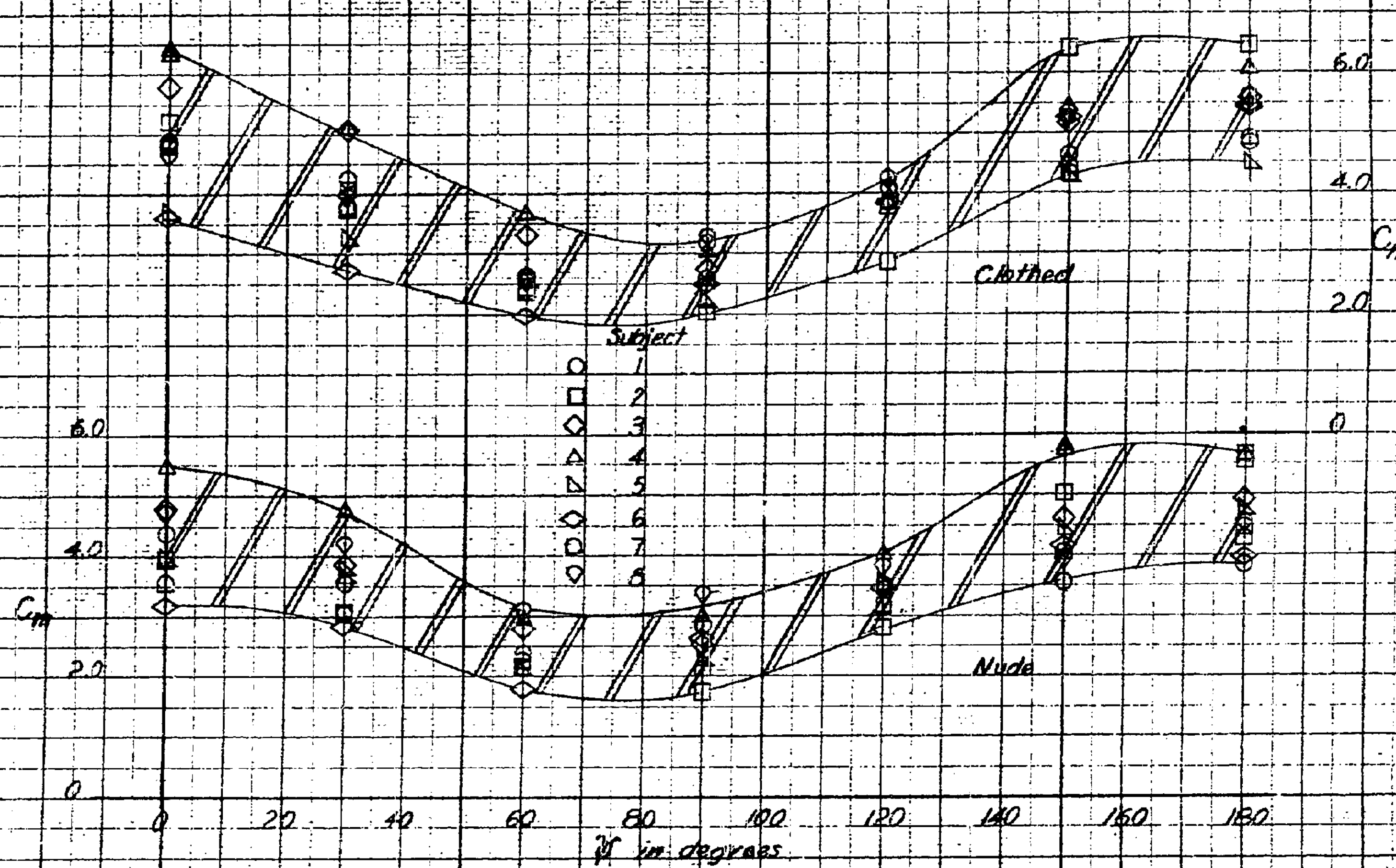

Figure 8 (Continued)

(b) Sitting Position, $q = 9.0\ \mathrm{lb/ft^2}$

BV 24 July '53

FIGURE 8b

AERO 858

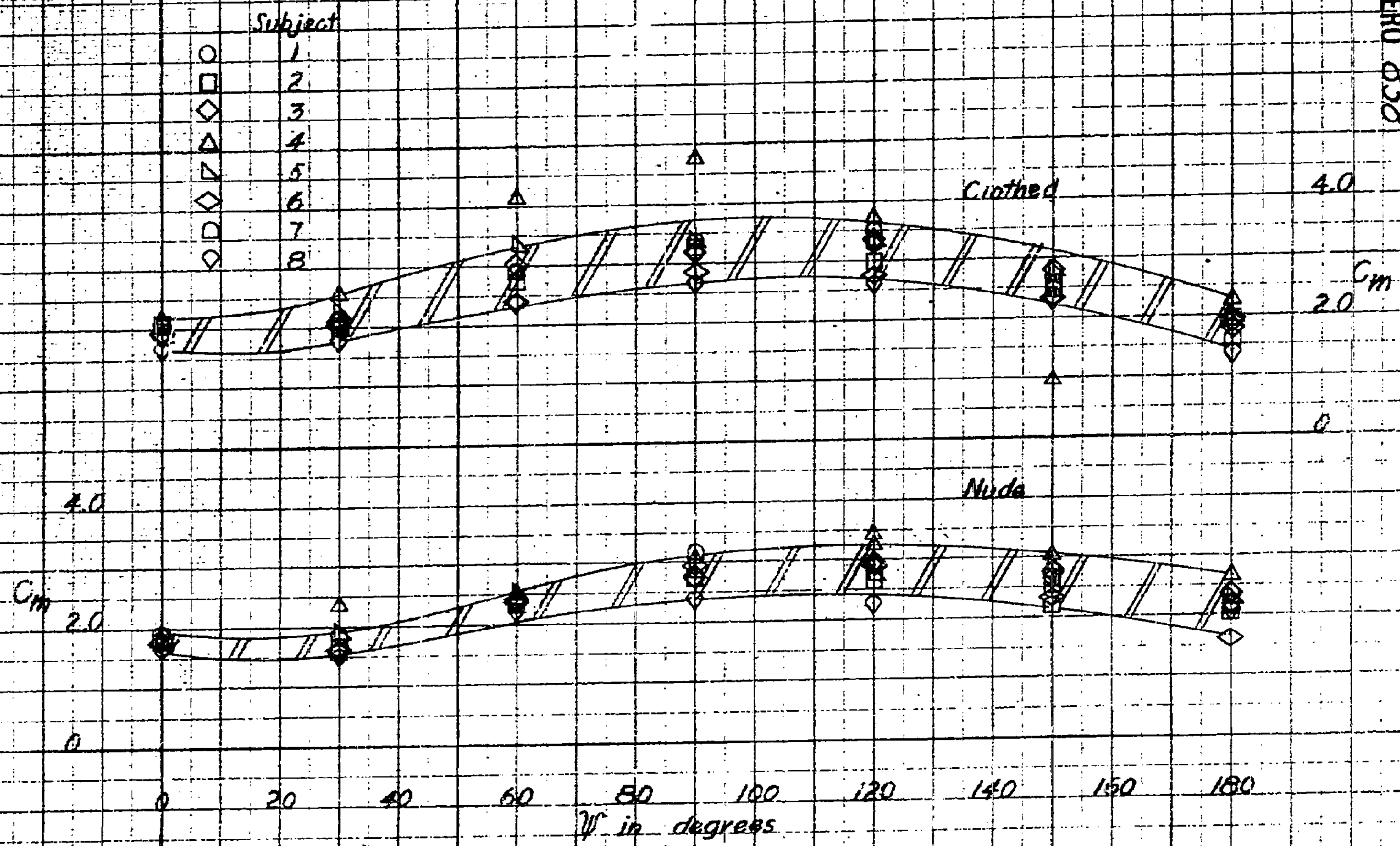

Figure 8 (Continued)

(c) Supine Position, $q = 9.0\ lb/ft^2$

BW 24 July '53

FIGURE 8c

AERO 858

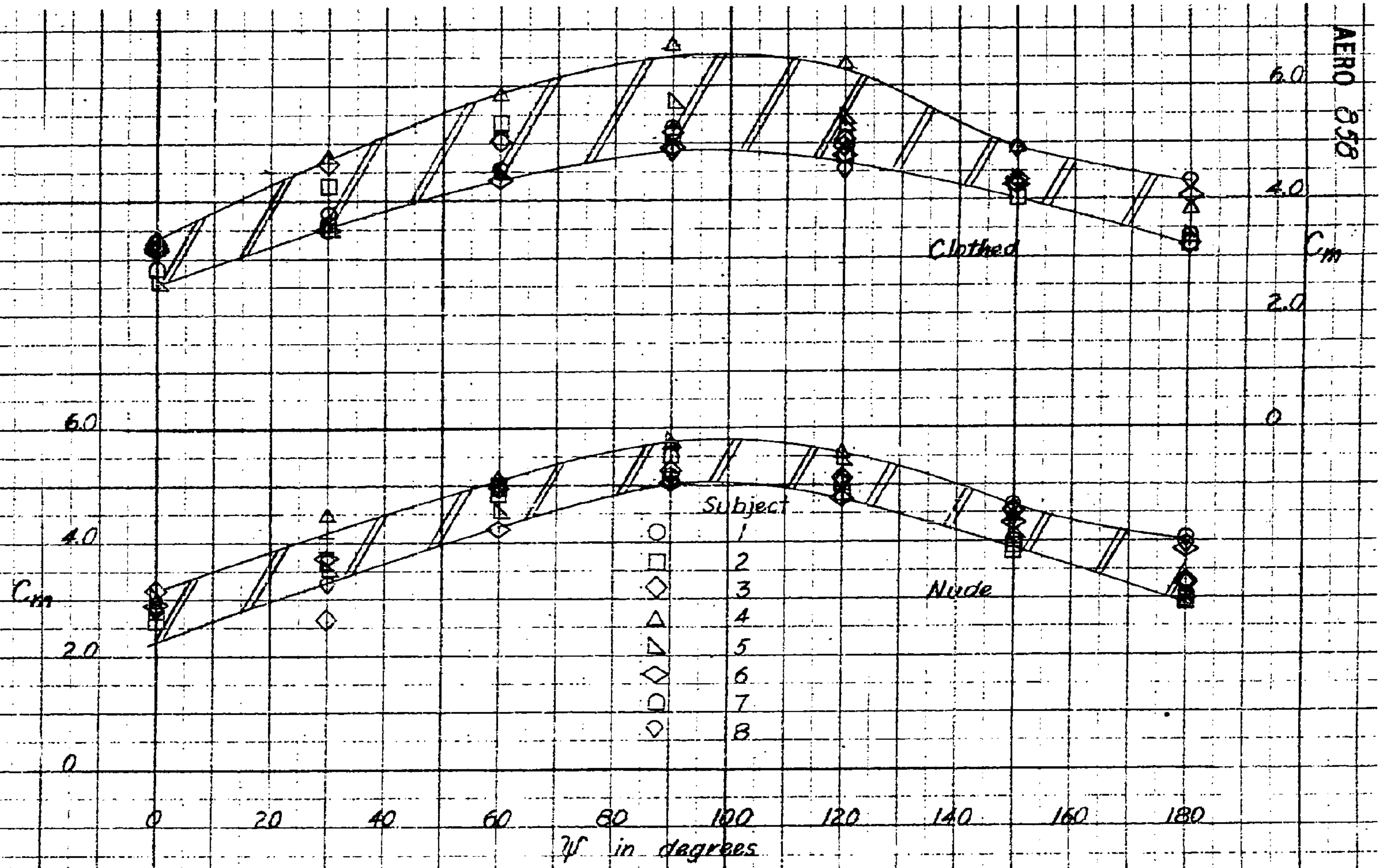

Figure 8 (Continued)

(d) Squat Position 1, $q = 9.0\ lb/ft^2$

BV 24 July '53

FIGURE 8 d

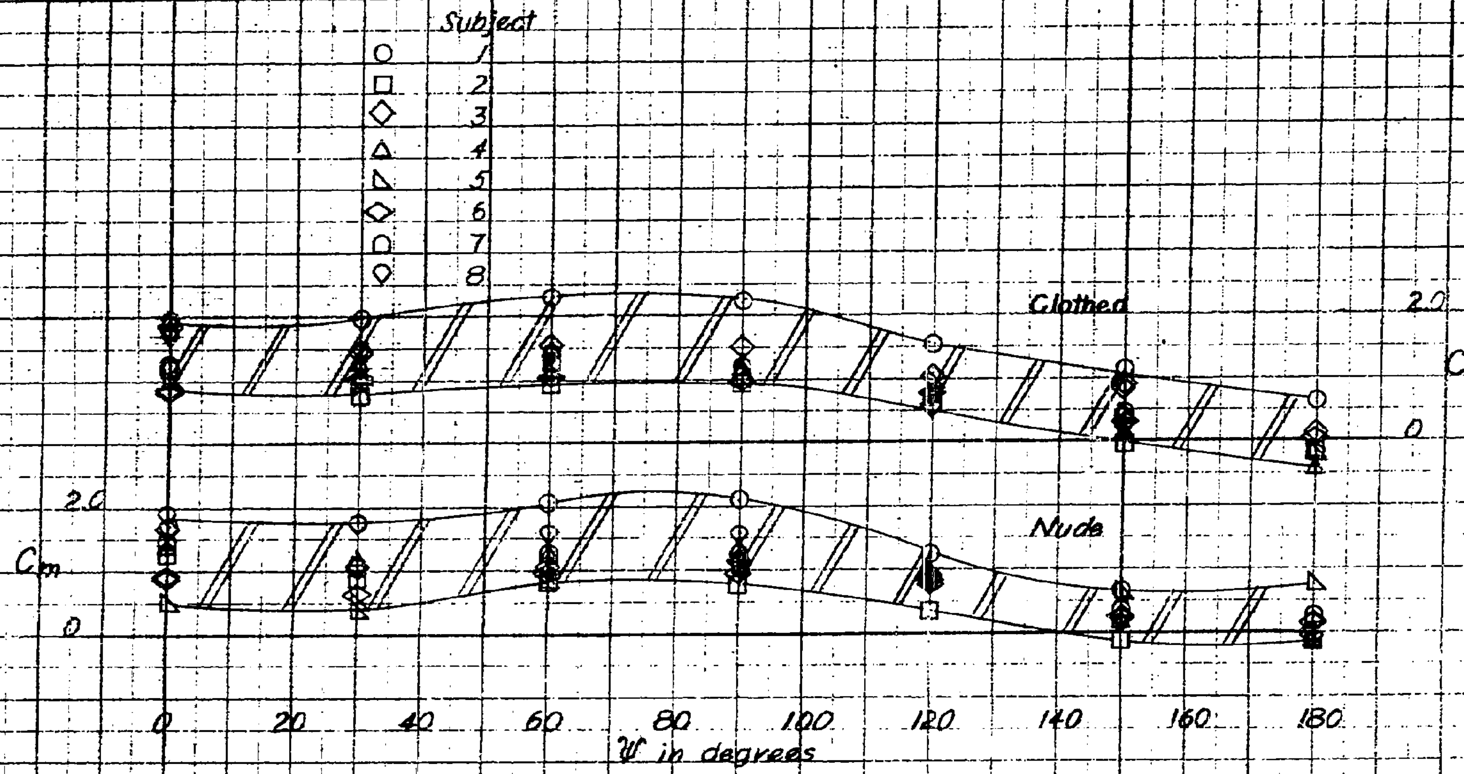

Figure 8 (Concluded)

(e) Squat Position 2, $q = 9.0$ lb/ft^2

BV 24 July '53

AERO 858

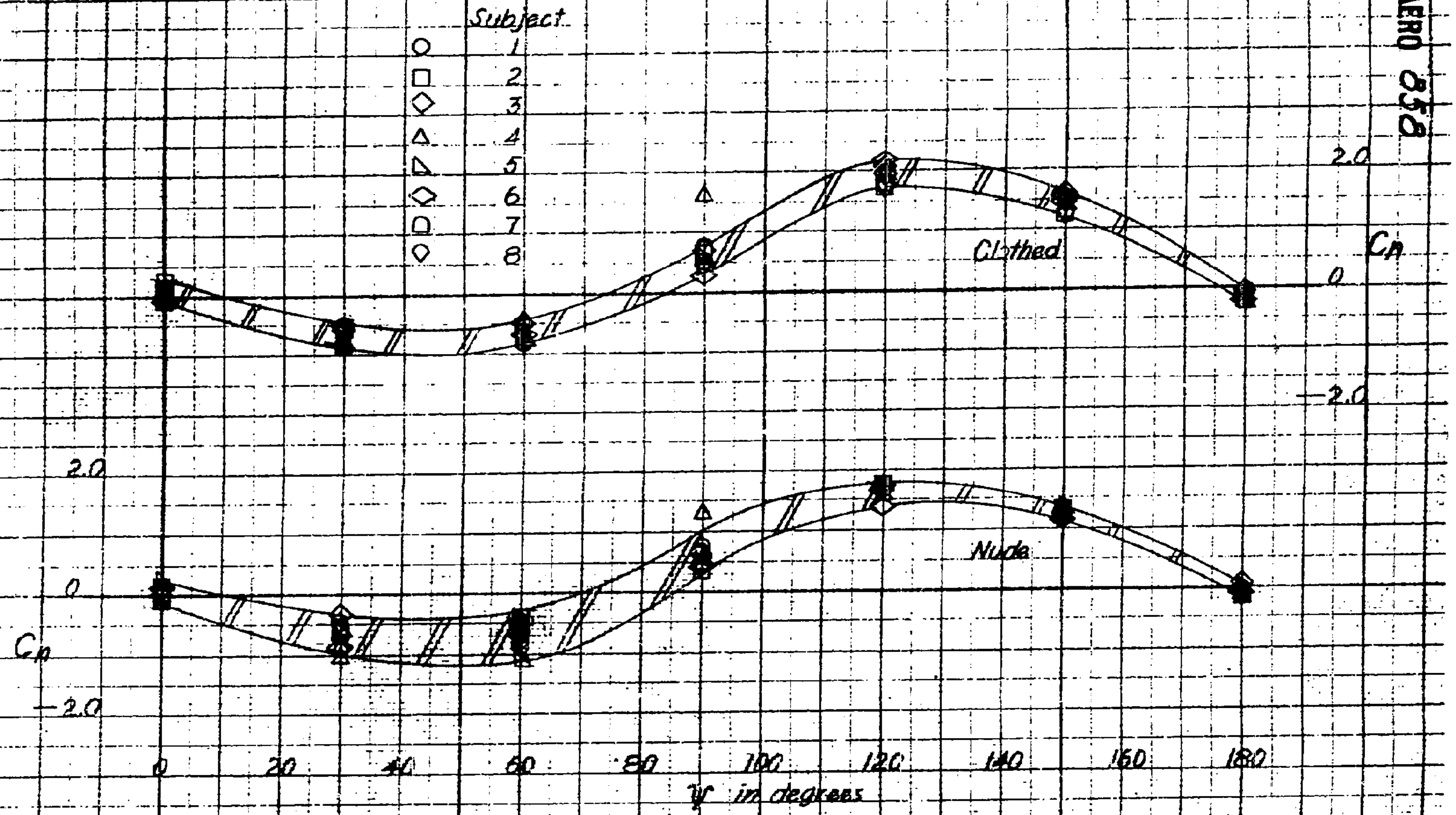

Figure 9 — Yawing-Moment Coefficient of Subjects 1 through 8

(a) Standing Position, $q = 9.0$ lb/ft^2

BV 27 July '53

FIGURE 9 a

AERO 858

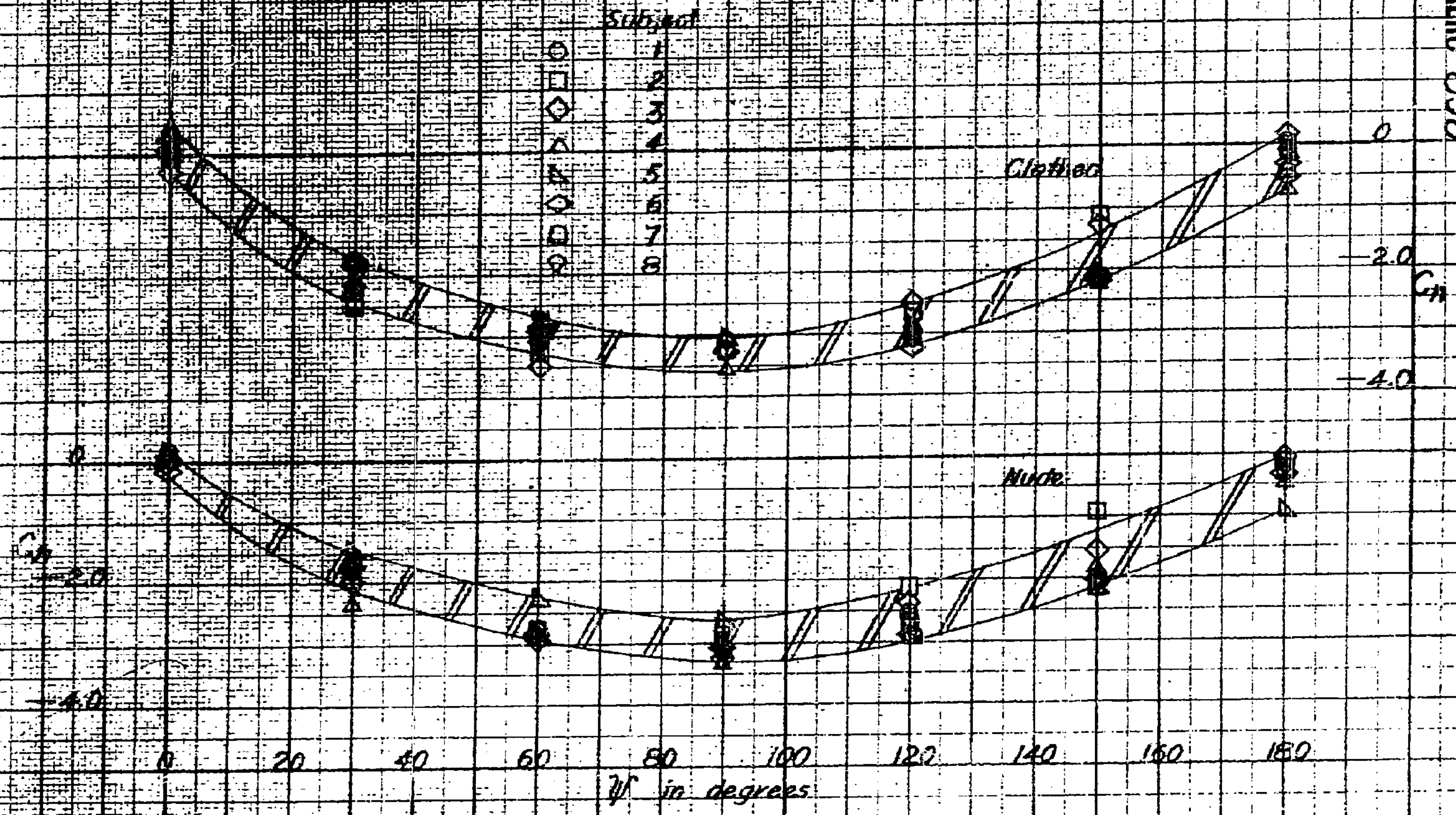

Figure 9 (Continued)

(b) Sitting Position, $q = 9.0$ lb/ft^2

BK 27 July '53

FIGURE 9b

AERO 858

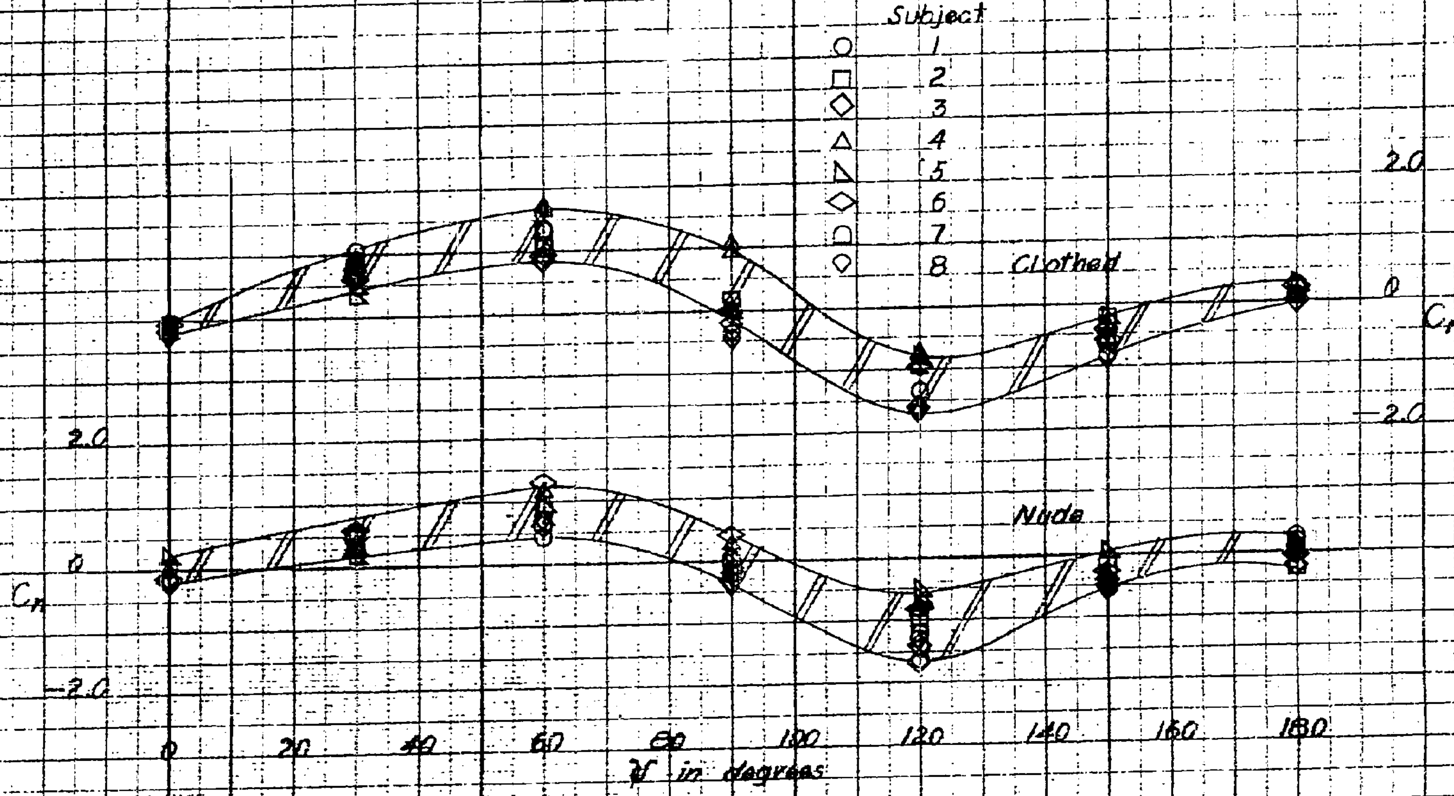

Figure 9 (Continued)

(c) Supine Position, $q = 9.0$ lb/ft^2

BV 27 July '53

FIGURE 9C

AERO 858

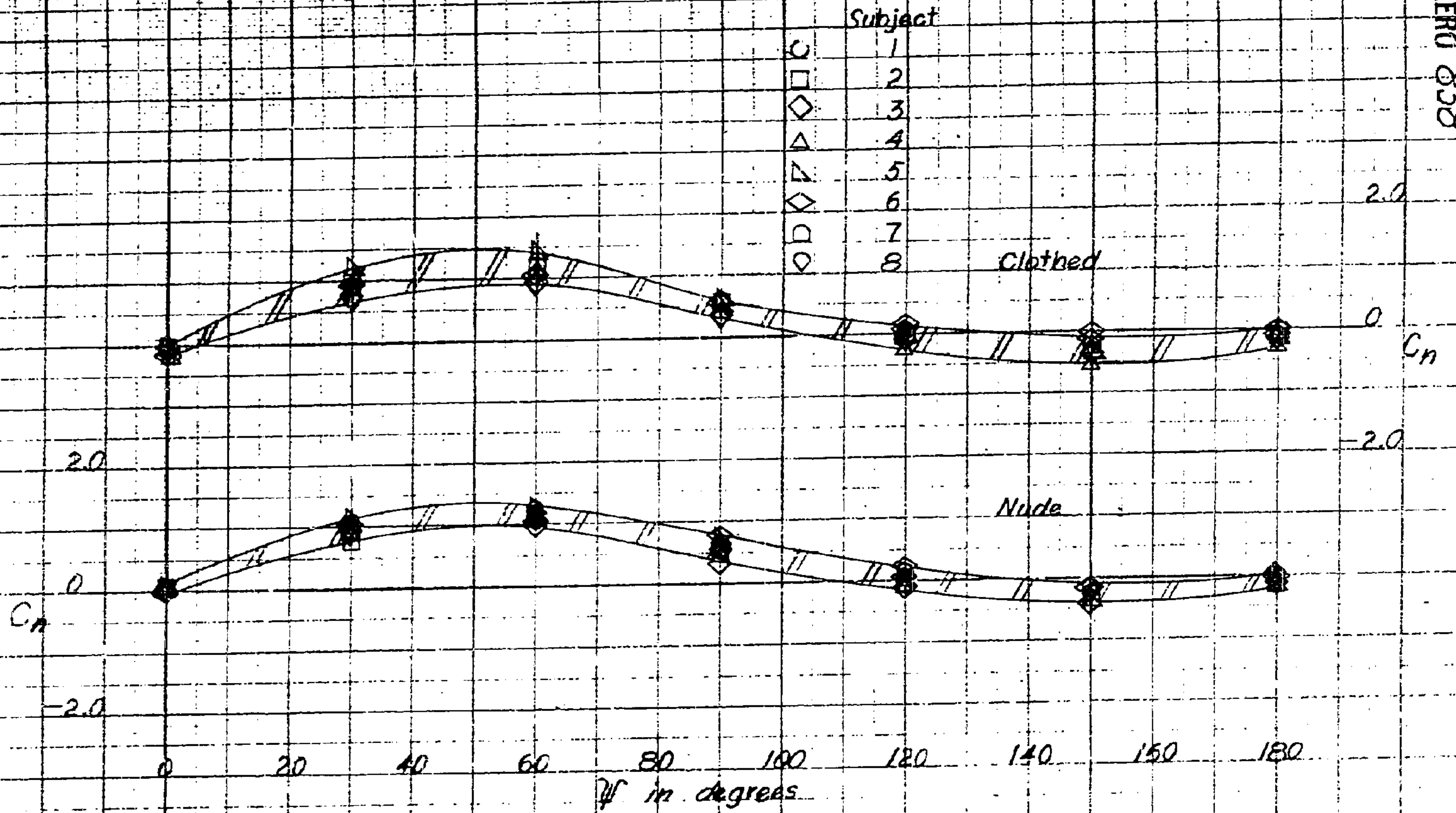

Figure 9 (Continued)

(d) Squat Position I, $q = 9.0$ lb/ft^2

BK 27 July '53

FIGURE 9d

AERO 858

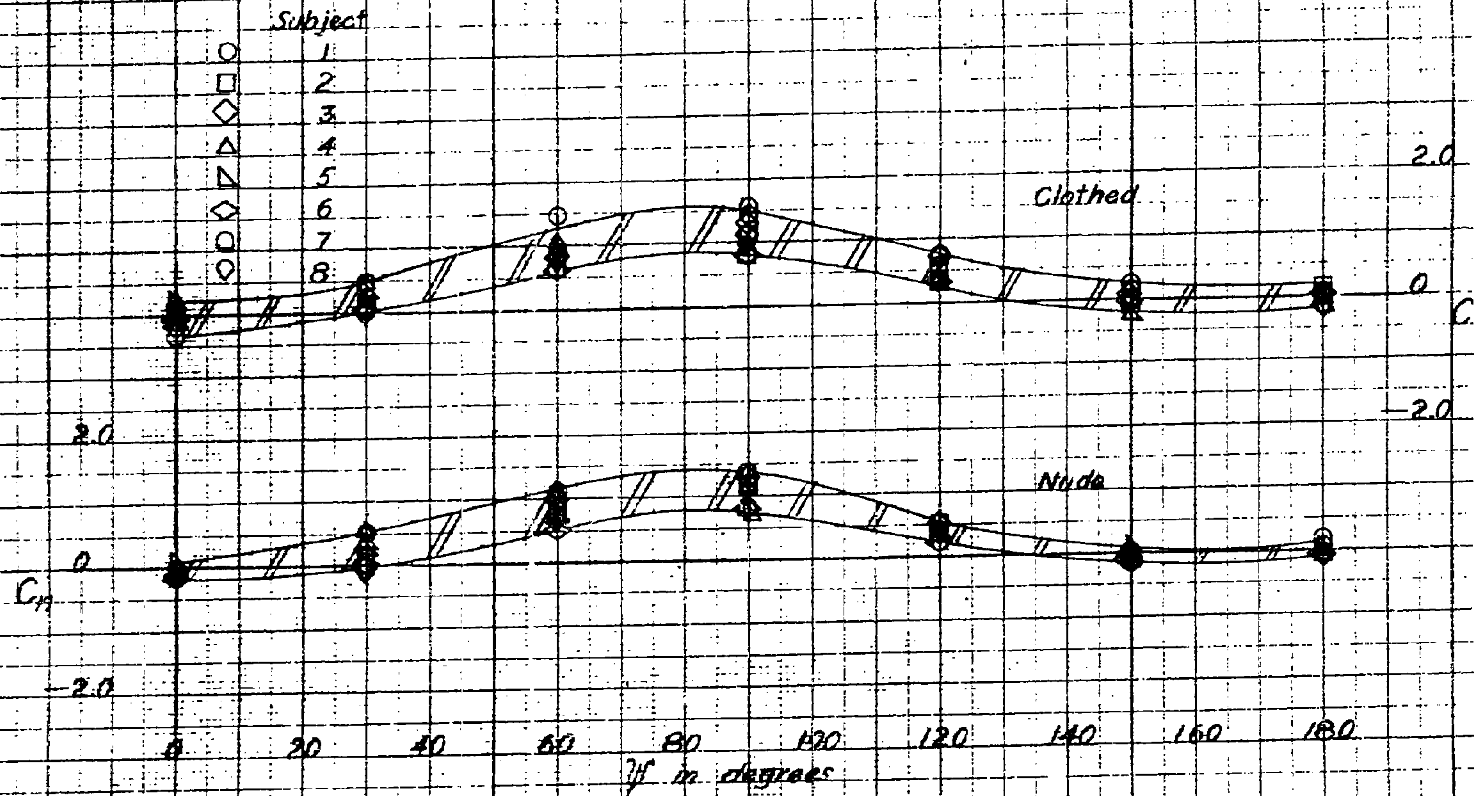

Figure 9 (Concluded)

(e) Squat Position 2, $q = 9.0$ lb/ft^2

BY 28 July '53

FIGURE 9e

AERO 858

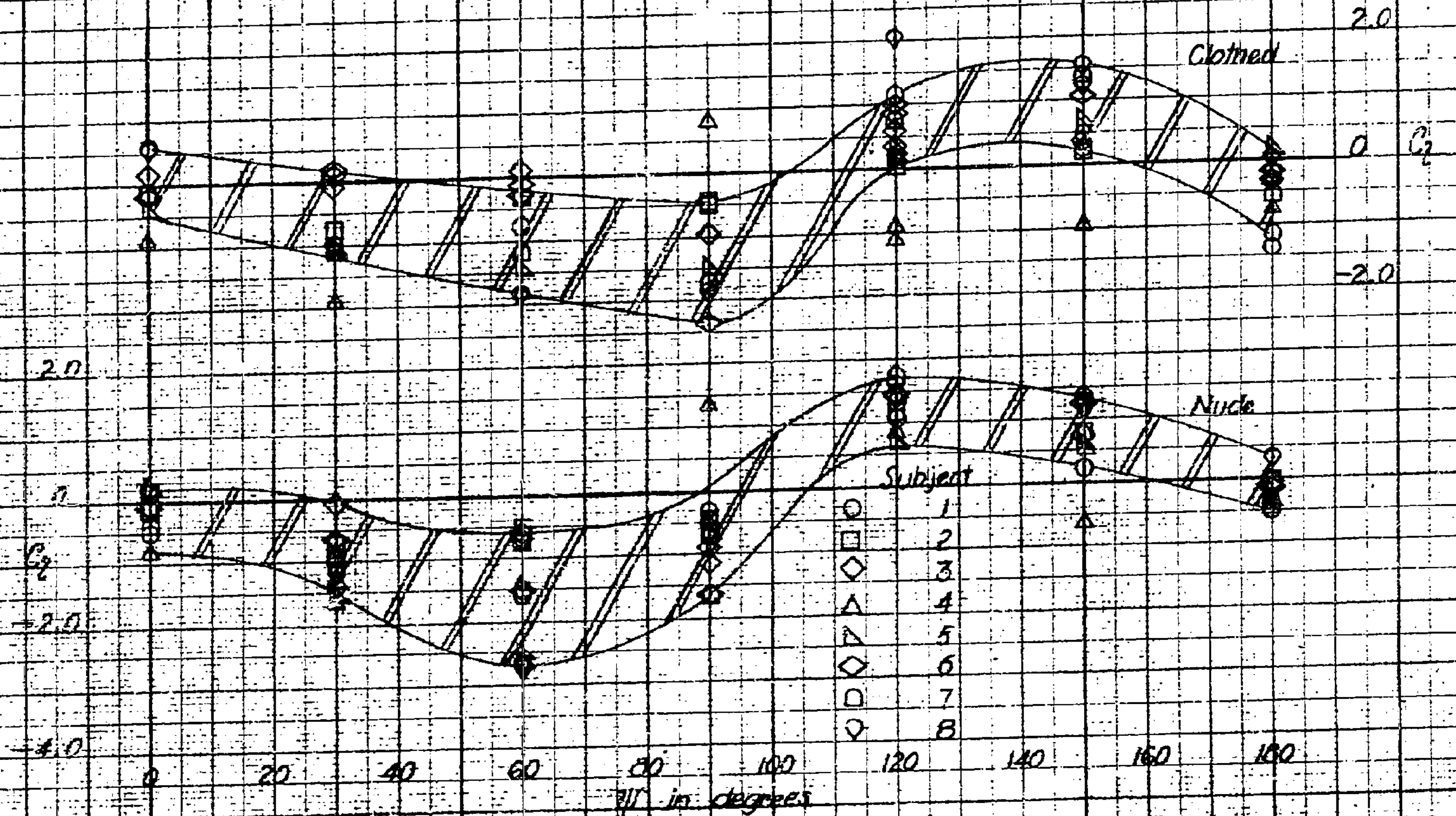

Figure 10 — Rolling Moment Coefficient of Subjects 1 Through 8

(a) Standing Position, $q = 9.0$ lb/ft^2

BK 28 July '53

FIGURE 10a

AERO 858

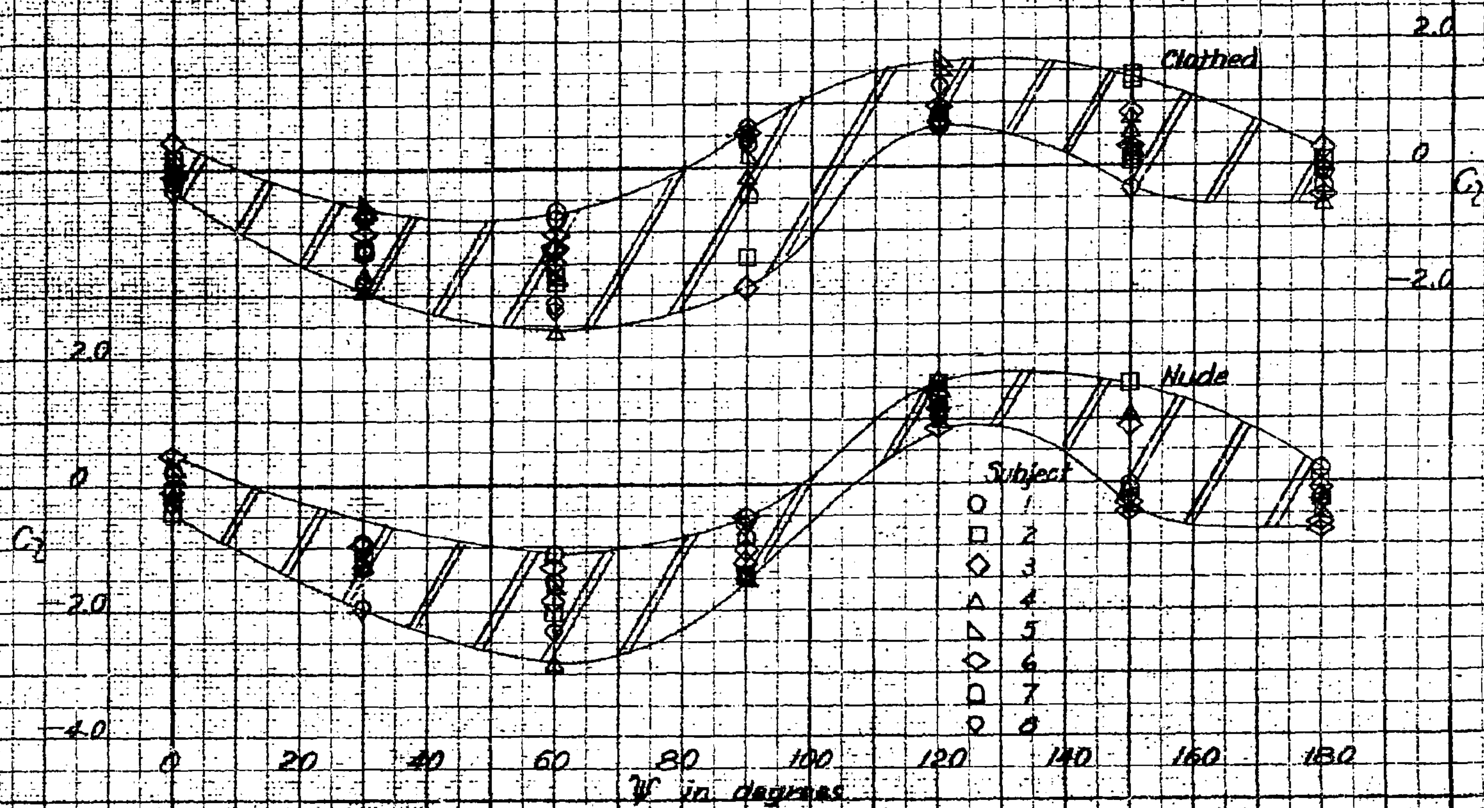

Figure 10 (Continued)

(b) Sitting Position, $q = 9.0$ lb/ft^2

BK 28 July 53

FIGURE 10 b

AERO 858

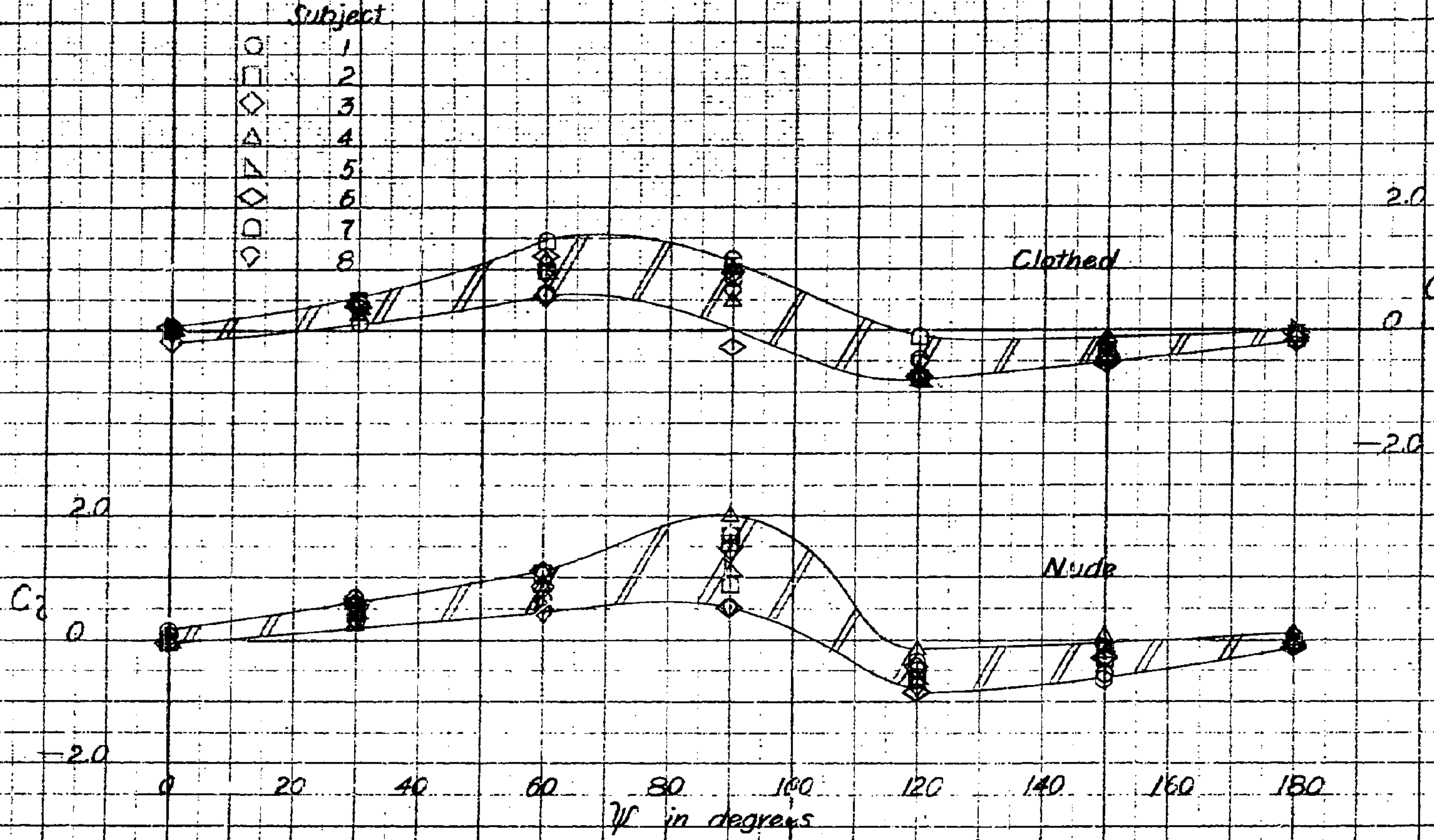

Figure 10 (Continued)

(c) Supine Position, $q = 9.0$ lb/ft^2

BV 28 July '53

FIGURE 10c

AERO 858

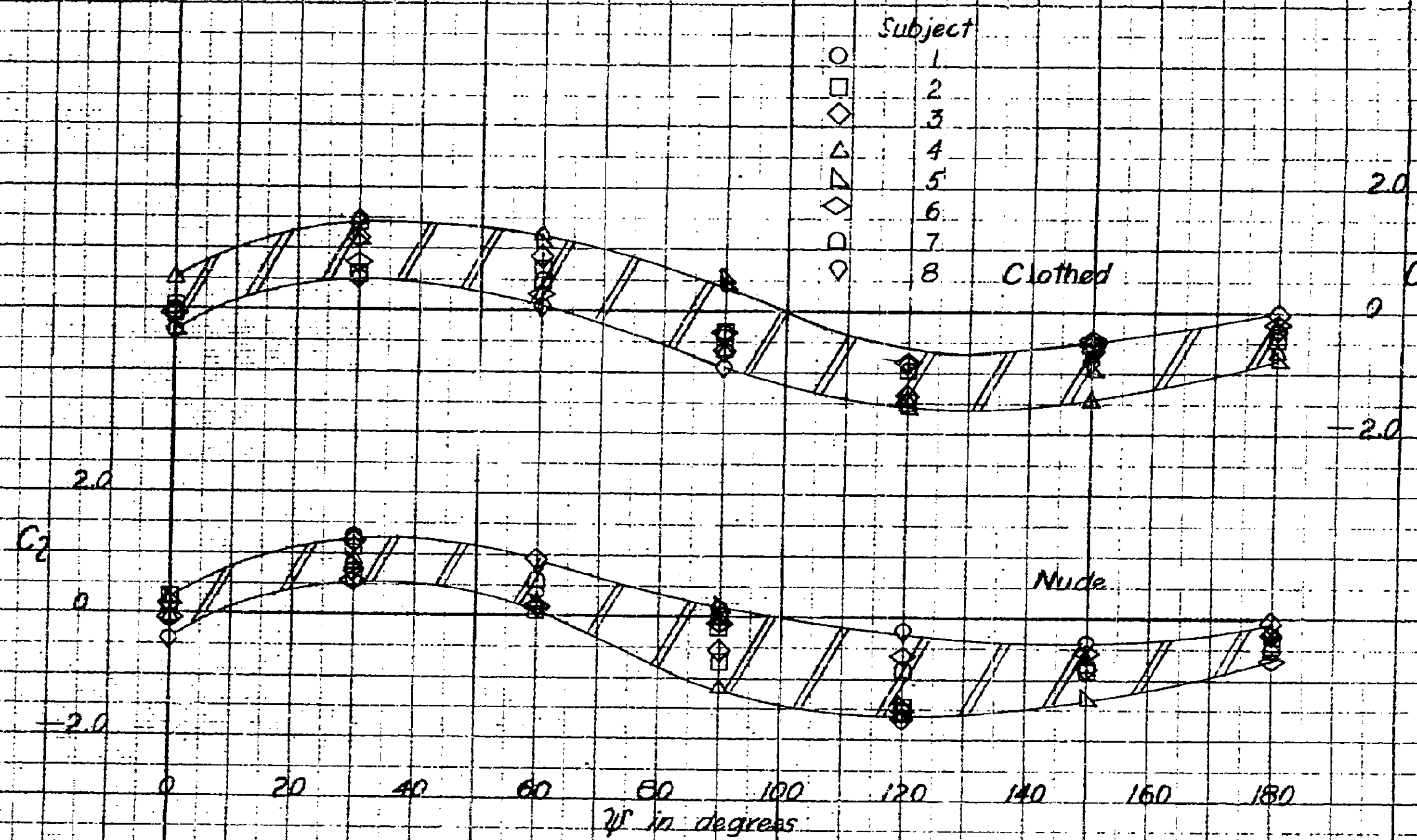

Figure 10 (Continued)

(d) Squat Position 1, $q = 9.0$ lb/ft^2

BV 28 July '53

FIGURE 10d

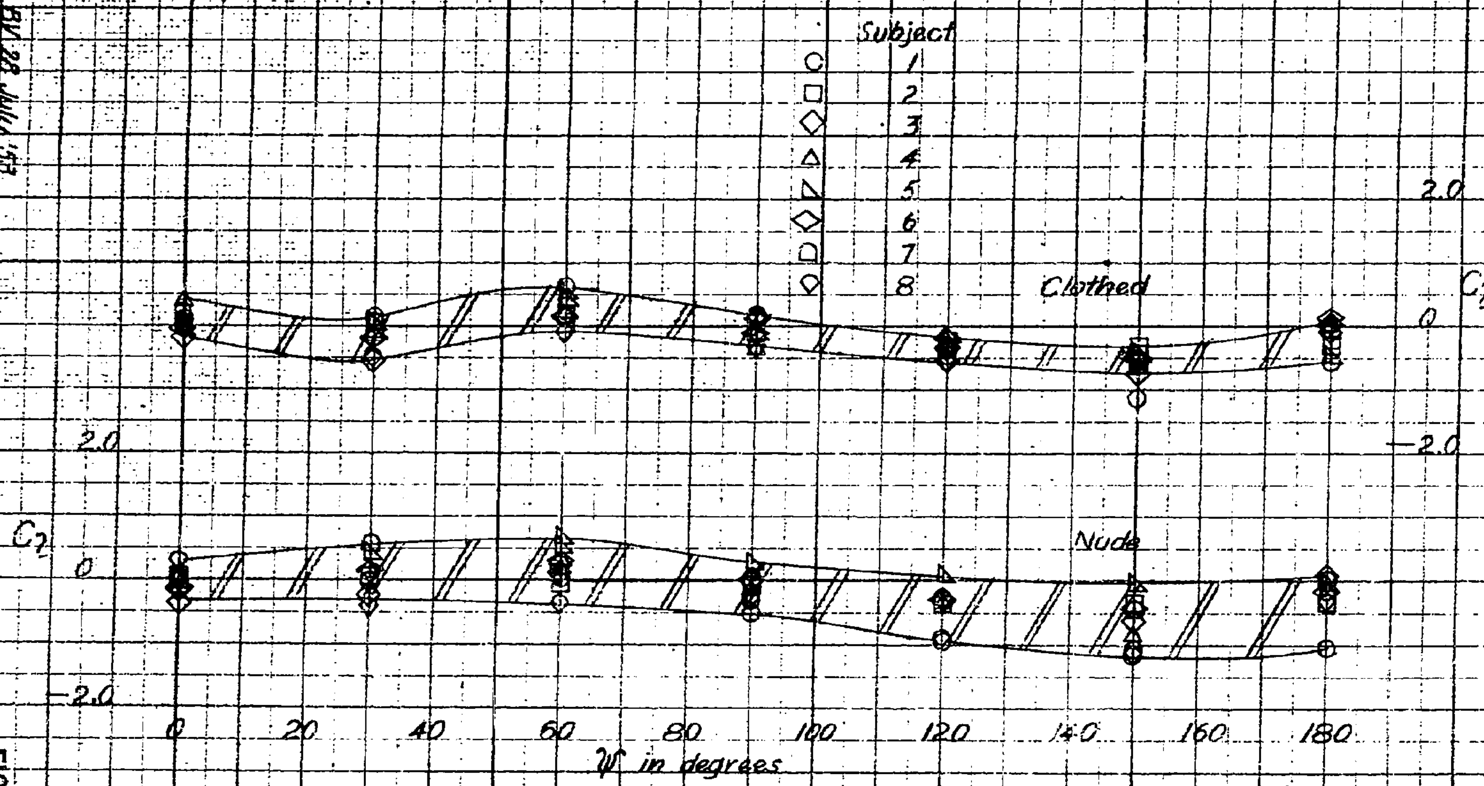

Figure 10 (Concluded)

(e) Squat Position 2, $q = 9.0$ lb/ft^2

BV 28 July '53

FIGURE 10e

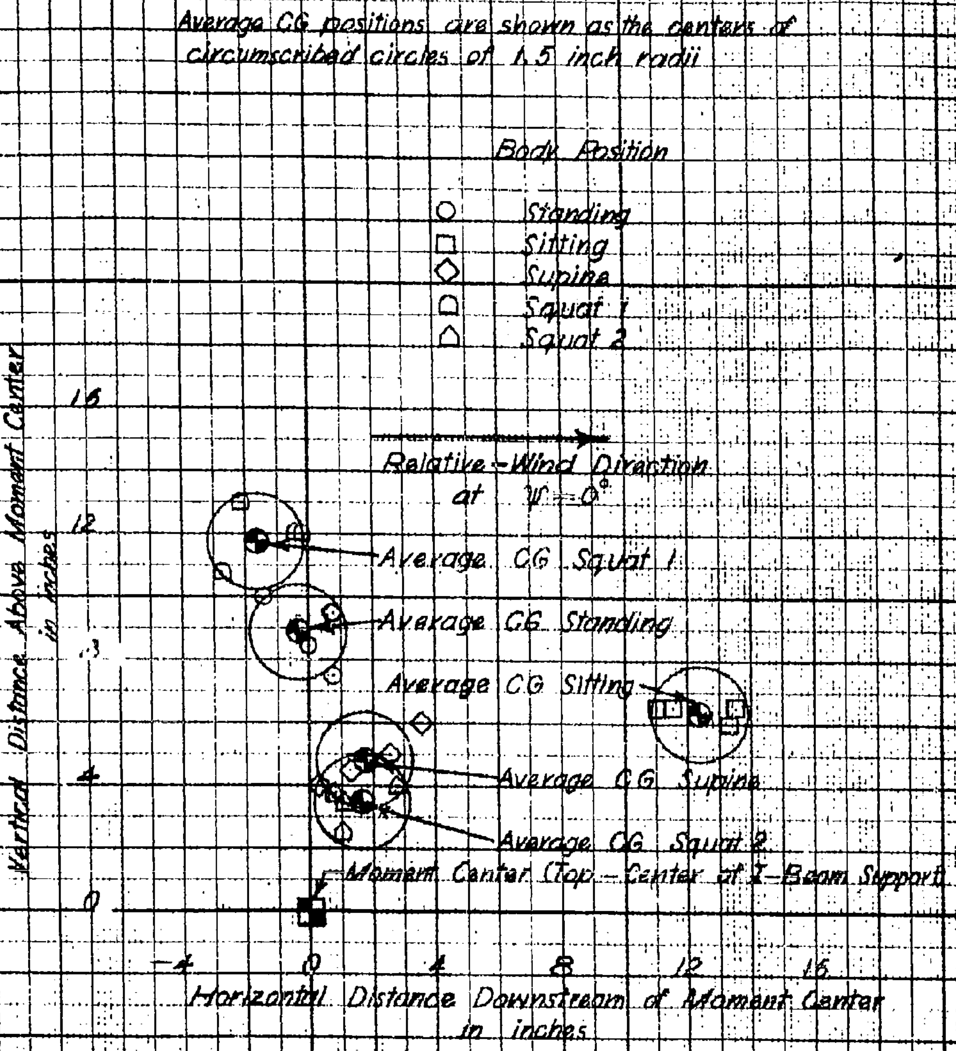

Figure 11 — Graphical Location of the Centers of Gravity of Four Subjects in the Plane of Symmetry of Five Body Positions at Ψ = 0°

T.J.S 14 Oct '53

NAVY DPPO PRNC WASH DC

DTMB Aero Rpt 858

David W. Taylor Model Basin. Rpt 892
WIND-TUNNEL INVESTIGATION OF AIR LOADS ON HUMAN BEINGS, by Thomas J. Schmitt. Wash., Jan 1954. [4]14 l. [39]plates (photos., graphs) 3 tables. 4 refs. (Aerodynamics Lab. Aero Rpt 858. Aero Test A-302)
ONR request authorized by BuAer.

To (a) determine drag coefficient (b) evaluate decompression technique as a means of determining tolerance to disorientation forces. Lift, side force, and moments were also obtained. Supplementary to CAA tests using momentary air blasts.

1. HUMAN BODY--LOADS
I. Schmitt, Thomas J.
II. DTMB Aero Rpt 858
III. DTMB Aero Test A-302

DTMB Aero Rpt 858

David W. Taylor Model Basin. Rpt 892
WIND-TUNNEL INVESTIGATION OF AIR LOADS ON HUMAN BEINGS, by Thomas J. Schmitt. Wash., Jan 1954. [4]14 l. [39]plates (photos., graphs) 3 tables. 4 refs. (Aerodynamics Lab. Aero Rpt 858. Aero Test A-302)
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