REPORT No. 443

PRESSURE-DISTRIBUTION MEASUREMENTS ON THE HULL AND FINS OF A 1/40-SCALE MODEL OF THE U. S. AIRSHIP "AKRON"

By Hugh B. Freeman

SUMMARY

This report presents the results of measurements of pressure distribution conducted in the propeller-research wind tunnel of the National Advisory Committee for Aeronautics on a 1/40-scale model of the U. S. airship "Akron" ("ZRS-4"). The pressures, which were measured simultaneously at nearly 400 orifices located at 26 stations along one side of the hull, were recorded by two photographic multiple manometers placed inside the model. The hull pressures were measured both with and without the tail surfaces and the control car for eight angles of pitch varying from 0° to 20° and at air speeds of approximately 70 and 100 miles per hour. The pressures were also measured at approximately 160 orifices on one horizontal fin for the above speeds and pitch angles and for nine elevator angles.

The integrated transverse forces and the integrated moments about the center of buoyancy were in good agreement with the forces and moments measured on the balances in the force tests. The pressural drag of the hull was found to be practically zero within the accuracy of the tests. The pressure forces on the after portion of the hull in the presence of the tail surfaces were found to contribute more than 40 per cent of the total fin moments measured in the force tests. Negative pressures as great as seven times the dynamic pressure of the undisturbed air stream were measured on the leading edge of the horizontal fin at the 20° pitch angle with 20° down elevator.

INTRODUCTION

A knowledge of the pressure distribution over airship forms is of interest primarily to the airship designer in determining the stresses in the hull structure, the most important of which are due directly or indirectly to the aerodynamic forces on the hull. Experimental pressure-distribution results are also useful in checking theoretical methods of calculating the pressures on streamline forms, in checking the forces and moments measured on the balances in wind-tunnel tests and, indirectly, in computing the frictional forces on the surface of the hull. Previous measurements of pressure distribution on good streamline shapes at 0° pitch angle have shown that the resultant of the normal forces on the hull is practically zero; whereas, the tangential or frictional forces constitute nearly the entire drag of the hull.

The subject tests are a part of a program of research undertaken at the request of the Bureau of Aeronautics, Navy Department, on a 1/40-scale model of the U. S. airship *Akron* (*ZRS-4*), with the object of determining: (1) The forces and pitching moments on the bare hull and on the hull fitted with two different sets of tail surfaces, (2) the elevator forces and hinge moments, and (3) the pressure distribution over the hull and fins. This program was later extended to include (4) the measurement of total head in the boundary layer at ten stations on the hull. The results of (1) and (2) are presented in reference 1, those of (3) are the subject of the present report, and the results of the boundary-layer tests are given in reference 2.

The unusually large size of the model, 19.62 feet in length and 3.33 feet in maximum diameter, allowed the tests of pressure distribution to be conducted at a larger Reynolds Number than has previously been obtained in model tests of a similar nature. The large model also permitted the multiple manometers, which record simultaneously 400 pressures, to be installed inside the model, thus greatly expediting this work. The tests were conducted in the 20-foot propeller-research wind tunnel of the National Advisory Committee for Aeronautics and were completed in July, 1931.

APPARATUS AND TESTS

The model, built in the shops of the Washington Navy Yard, is of hollow wooden construction having 36 sides over the fore part of the hull fairing into 24 sides near the stern. The length of the hull is 19.62 feet, the maximum diameter 3.33 feet, and the fineness ratio 5.9. The principal dimensions of the hull and fins are given in Table I. Four hundred pressure orifices, distributed among 26 stations, were placed along one side of the hull. The location of the stations and the distribution of the orifices around the hull are shown in Figure 1. The orifices, 1/32 inch in diameter, were drilled into circular brass plates 1/2 inch in diameter set into and flush with the surface of the hull. The

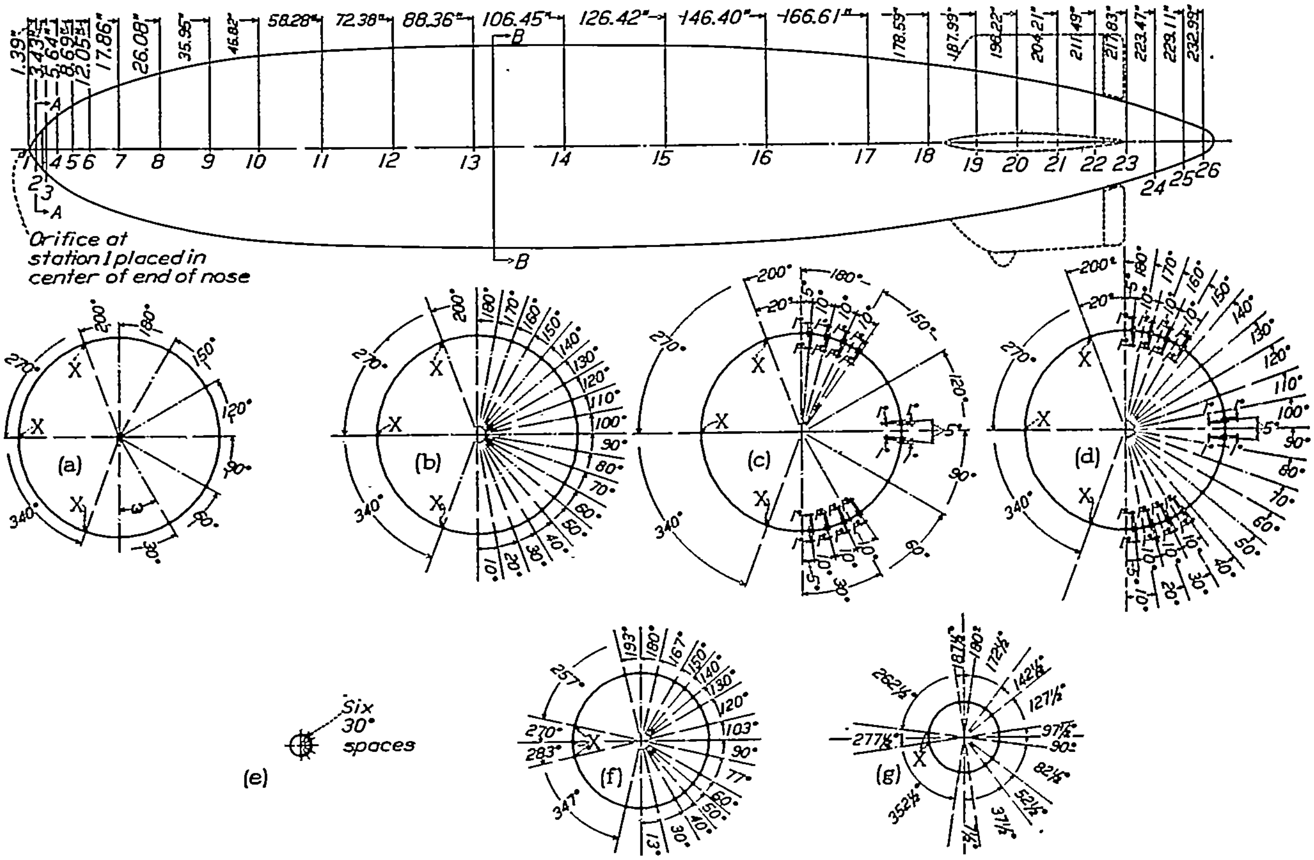

FIGURE 1.—Location of orifices for the pressure measurements on a 1/40 scale model of the *Akron*

(*a*) Typical sections in direction "B–B" at stations 3, 4, 6, 10, 14, and 16 showing radial locations of orifices in hull. Three orifices marked "x" placed at stations 4 and 6 only

(*b*) Typical sections in direction "B–B" at stations 7, 9, 11, 13, and 15 showing radial location of orifices in hull. Three orifices marked "x" placed at station 7 only. Orifices marked "x" at station 11 omitted

(*c*) Typical sections in direction "B–B" at stations 8 and 12 showing radial location of orifices in hull. Three orifices marked "x" placed at station 8 only.

(*d*) Typical sections in direction "B–B" at stations 5 and 17 showing radial location of orifices in hull. Three orifices marked "x" placed at station 5 only.

(*e*) Section "A–A" showing radial location of orifices at station 2

(*f*) Typical sections in direction "B–B" at stations 8 to 21 inclusive, showing radial location of orifices in hull. Three orifices marked "x" placed at station 21 only.

(*g*) Typical sections in direction "B–B" at stations 22 to 26 inclusive, showing radial location of orifices in hull. Two orifices marked "x" placed at stations 22 and 23 only,

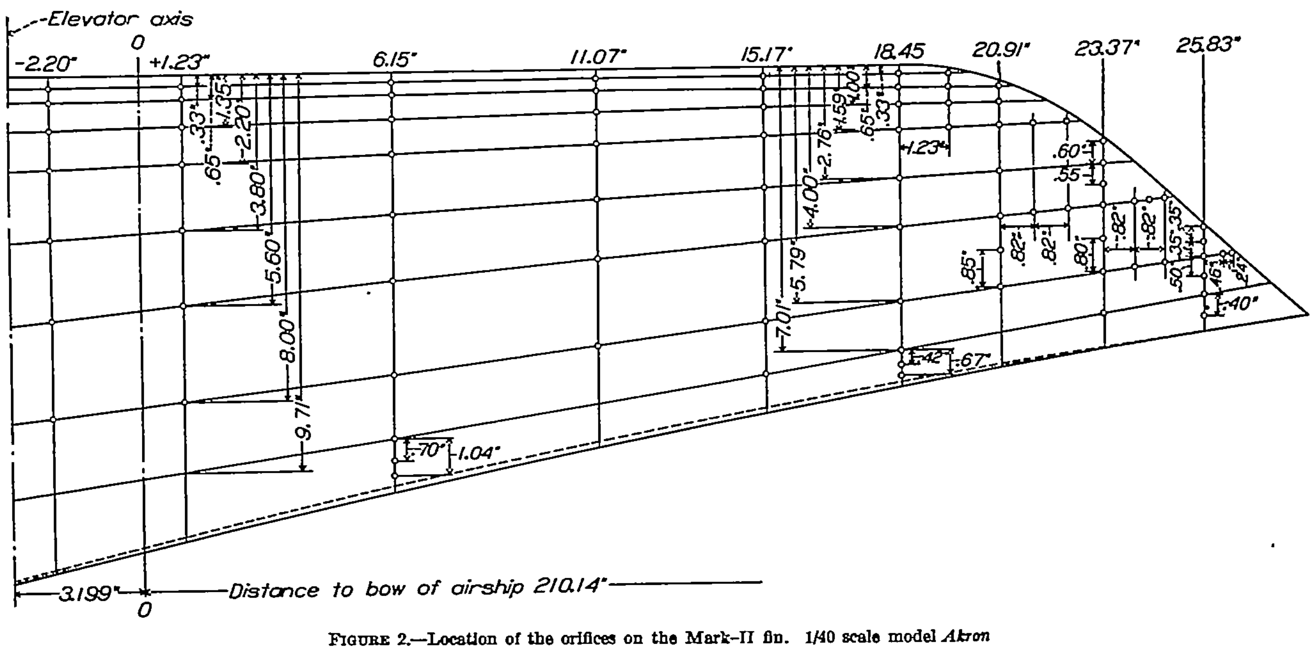

FIGURE 2.—Location of the orifices on the Mark-II fin. 1/40 scale model *Akron*

location of the fin orifices is given in Figure 2. The fin shown is of the Mark–II type, which is described in detail in reference 1.

The orifices were connected inside the hull to two photographic-recording multiple manometers of the type shown in Figure 3. Each manometer consisted of 200 glass tubes placed about the periphery of a drum, a long incandescent light bulb for making the exposures placed at the center of the drum, a reservoir to which the lower ends of the tubes were connected by means of a circular brass header, and a box which contained the photostat paper and the mechanism for changing the paper after each exposure. The photostat paper, wound initially on spool A, was passed around the metering spool B and then around the outside of the glass tubes on the drum and back into the box, and was wound on the spool C, which was driven by an electric motor. The metering spool was geared to a mechanism that broke the electric circuit and stopped the motor when the proper length of paper had been metered out to encircle the drum.

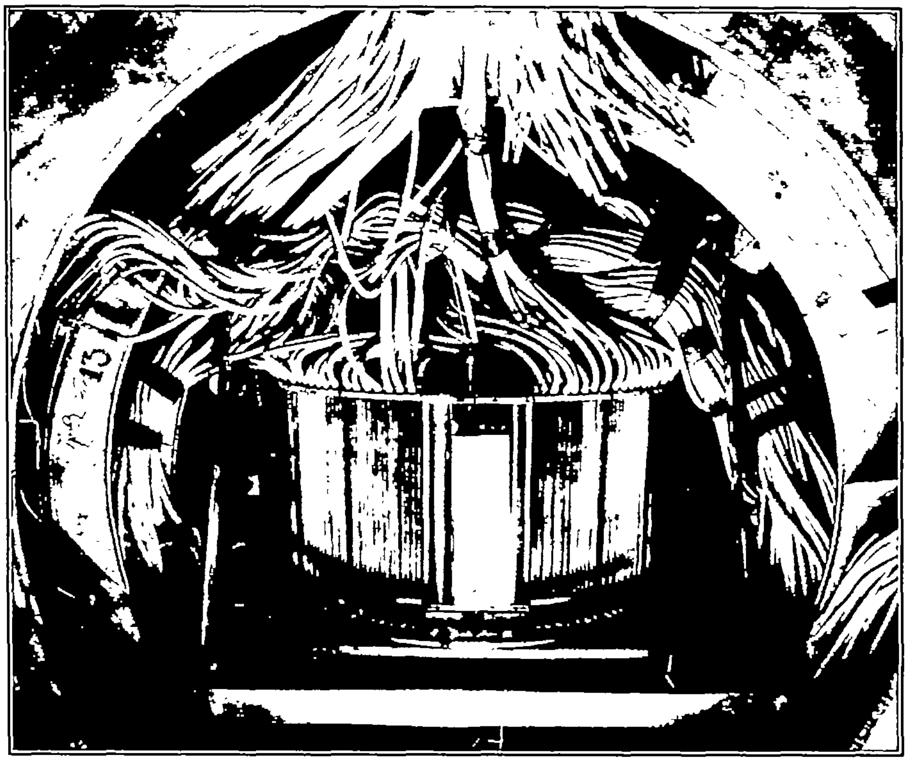

FIGURE 4.—Manometer installation within the hull of 1/40-scale model *Akron*

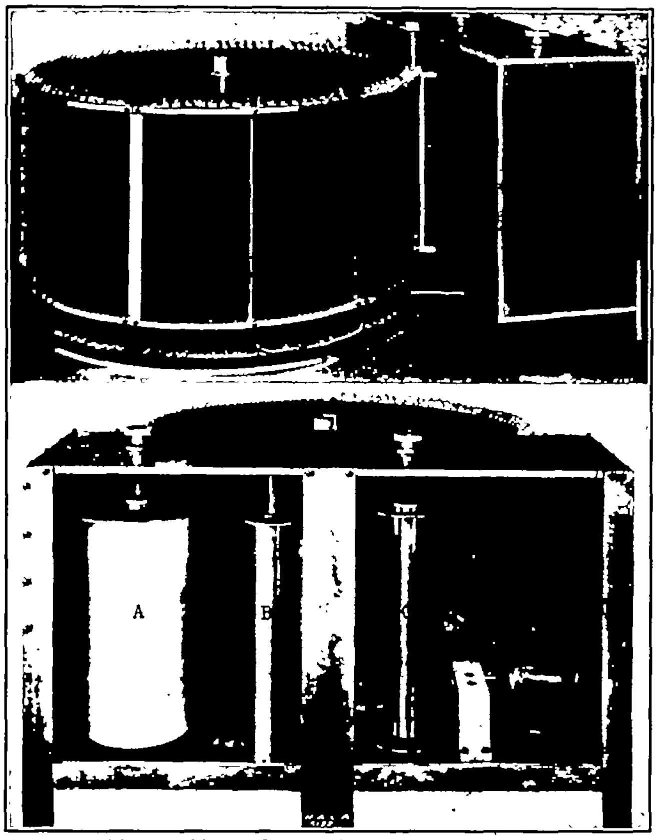

FIGURE 3.—Photographic-recording multiple manometer used for recording pressures on the 1/40-scale model *Akron*

The manometers were mounted inside the model on cradles, which were free to swing about a horizontal axis at right angles to the longitudinal axis of the hull, thus allowing the manometers to remain level for the various angles of pitch. (Fig. 4.) In order to provide a reference line on the records, six of the glass tubes spaced equidistant about the circumference of the drums were connected, together

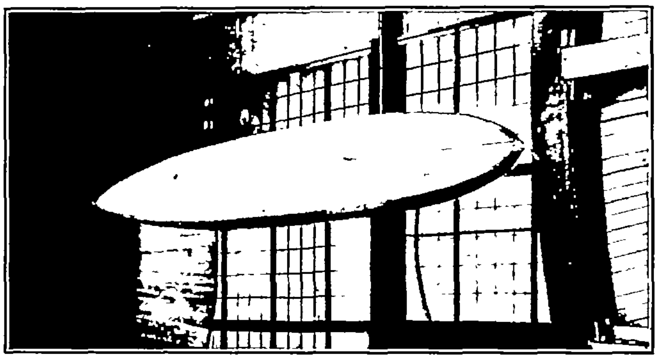

FIGURE 5.—The 1/40-scale model *Akron* mounted in the 20-foot propeller-research wind tunnel

with the reservoirs, to the reference pressure, which for these tests was the static pressure in the test chamber.

Two simultaneous records, one from each manometer, gave a complete diagram of the pressure distribution over one side of the hull at one angle of pitch and at one wind speed. The capacity of the manometers was 18 exposures. Thus, complete diagrams for nine angles of pitch and two wind speeds could be obtained in one run of about 30 minutes duration.

The method of mounting the model in the wind tunnel is shown in Figure 5, and is described in detail in reference 1.

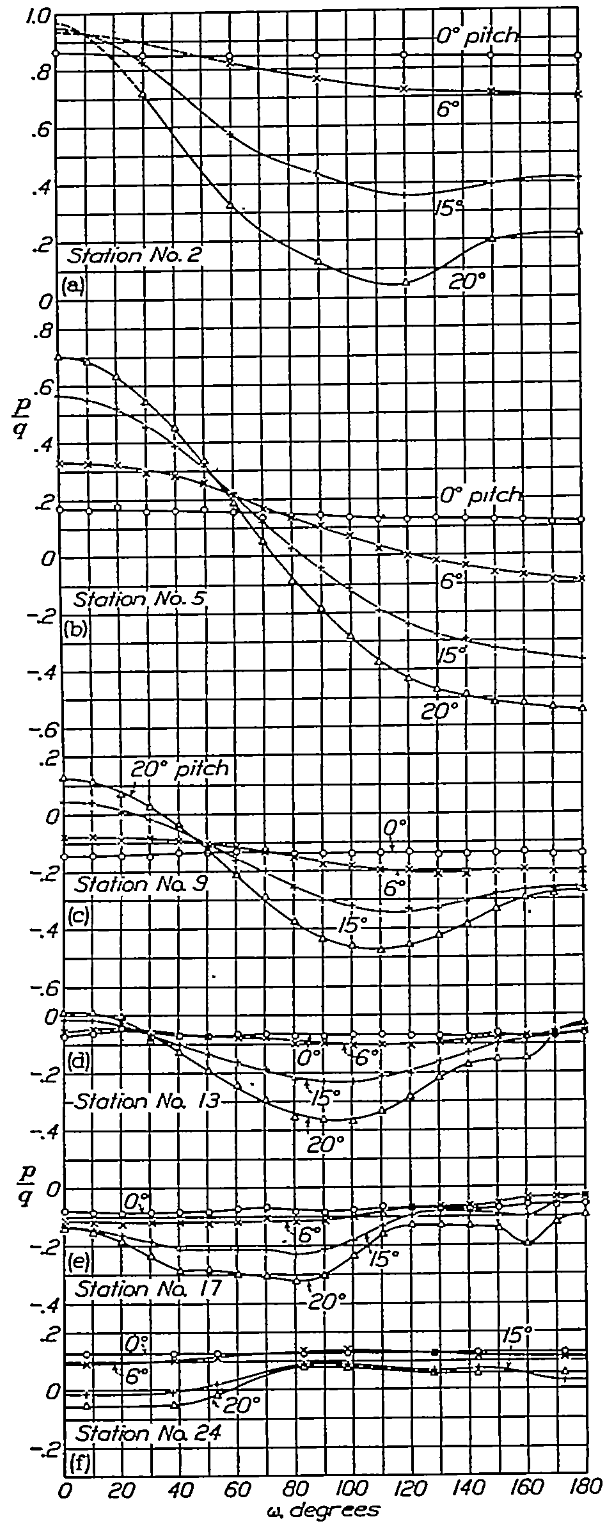

FIGURE 6.—Observed point pressures on bare hull at several stations for four angles of pitch of the 1/40-scale model *Akron*

The pressure distribution was measured (1) on the bare hull at nine angles of pitch ($\theta = -3°$, 0°, 3°, 6°, 9°, 12°, 15°, 18°, 20°) and at air speeds of approximately 70 and 100 miles per hour, (2) on the hull with fins and control car at the above pitch angles and speeds and for three elevator angles ($\delta = 0°$, 20°, and $-20°$), and (3) on one horizontal fin at the above angles of pitch and air speeds and for nine elevator angles ($\delta = -20°$, $-15°$, $-10°$, $-5°$, 0°, 5°, 10°, 15°, and 20°).

Because of the limited head (about 9 inches) that could be recorded by the manometers, which did not allow the low pressures on the suction side of the leading edge of the fin to be measured with the manometers containing alcohol, these pressures were measured in a separate test with the manometers containing mercury.

PRECISION OF MEASUREMENTS

The following sources of error affect the accuracy of the measured pressures:

a. Shrinkage of the photographic records.
b. Errors in measurements of the manometer deflections.
c. Oscillation of the manometers.
d. Fluctuations in the velocity and direction of the air stream.

The errors from a were found, in general, to be less than 1 per cent and those from b are believed to be within ±1 per cent. The combined errors due to a, c, and d, estimated from a comparison of the pressures over the nose of the hull from different test records were of the order of ±2.5 per cent. The portion of these errors contributed by the oscillation of the manometers is believed to be small except for the high-speed, high-pitch-angle condition when the model was observed to be quite unsteady. Additional small errors may have been introduced owing to the fact that some of the orifices had pulled into the surface slightly. The relative accuracy of the point pressures, for any particular test, is best shown by the plots of the observed values presented in Figure 6. The scattering of the values from a mean curve is small.

RESULTS AND DISCUSSION

Because of the great mass of observed and derived data obtained in the present tests, it has been necessary to limit the results presented here to relatively few data representative of the whole.

The results have been presented in terms of the dynamic pressure q of the air stream and have been corrected for the difference between the local static pressure in the air stream and the reference pressure. This correction consisted simply of subtracting from the pressures at any section of the model the static pressure of the air stream, measured in the absence of the model, at the corresponding position along the axis of the tunnel. This correction should reduce the pressure of the stagnation point at the nose of the hull, with the model at 0° pitch, to a value equal to the dynamic pressure q. The mean value of p/q for this station (where p is the pressure) obtained from eight different tests was 1.005.

The variation in static pressure along the hull, measured in the absence of the model, is given in the following table:

a/L	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
p/q	.032	.025	.020	.017	.015	.013	.011	.010	.010	.011	.013

where a is the axial distance from the nose of the model, L is the length of the model, and p is the static pressure at any point on the axis.

The observed values of the point pressures on the bare hull are presented in Table II and are plotted in

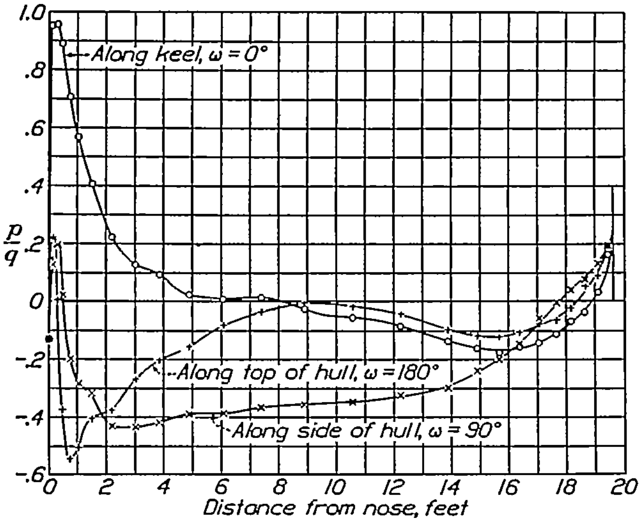

FIGURE 7.—Longitudinal distribution of pressure along three longitudinals of the bare hull of 1/40-scale model *Akron*. Pitch angle $\theta=20°$

Figure 6 for six stations and for four angles of pitch against the angular displacement ω of the orifices from the bottom center line of the hull. The longitudinal distribution of pressure along the hull at $\omega=0°$, 90°, and 180°, for an angle of pitch of 20°, is

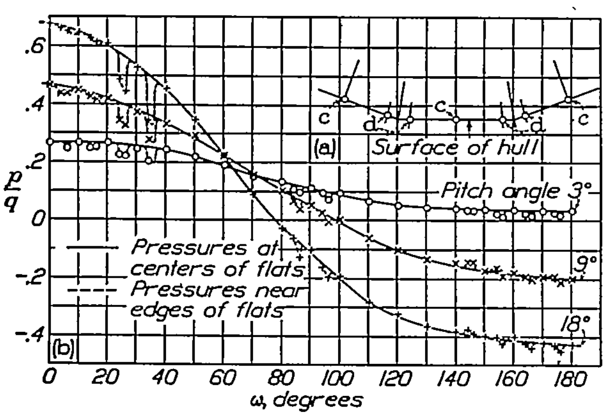

FIGURE 8.—Effect of polygonal form on the distribution of pressures at station 5 on 1/40-scale model *Akron*. o=orifices at centers of flat sides of hull. d=orifices 1° from edges of flat sides of hull

given in Figure 7. The values were taken from curves such as those given in Figure 6.

The effect of the polygonal form of the hull upon the pressure distribution around the hull is shown in Figure 8. Figure 8 (a) shows a typical layout of the orifices located near the corners of the polygonal hull. Figure 8 (b) shows the pressures measured at station 5 plotted against the angle ω. Continuous curves have been drawn through the pressures measured at the centers of the flats and broken lines through the pressures measured near the edges of the flats. In general, the pressures at the corners are slightly lower

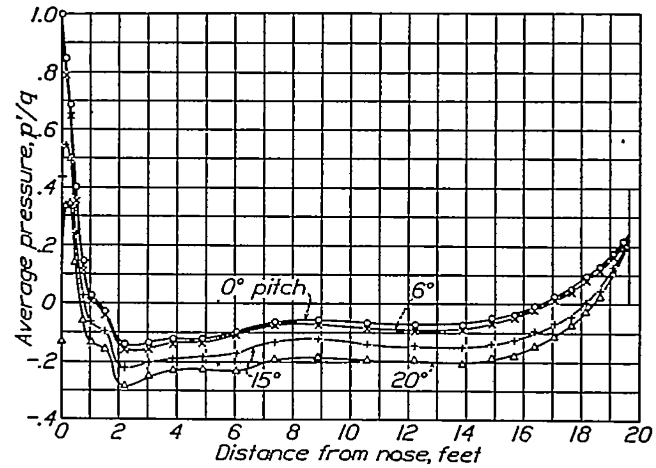

FIGURE 9.—Average pressures on bare hull of 1/40-scale model *Akron* for four angles of pitch

than those at the center. The difference is greatest on the lower side of the hull in the range of the values of ω between 20° and 40°. In this range the difference increases with both the angle of pitch and the angle of displacement from the keel. The maximum effect shown occurs at $\omega=34°$ for the 18° angle of pitch

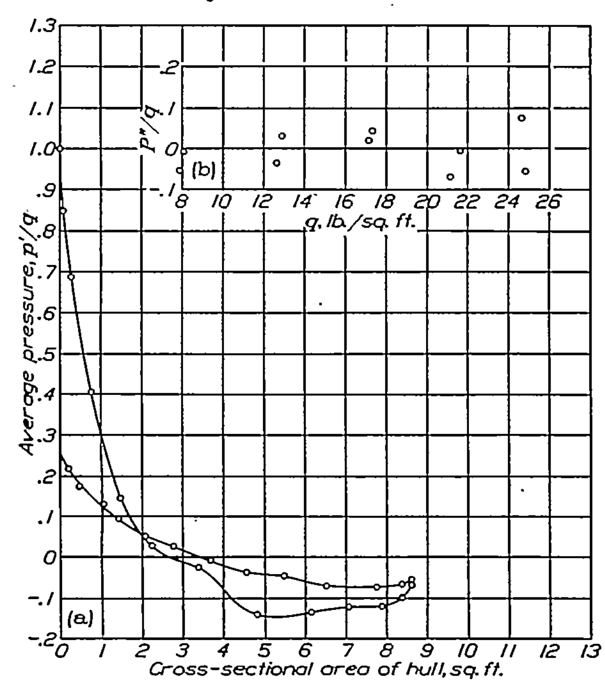

FIGURE 10.—(a) Average pressures plotted against cross-sectional area. (b) Longitudinal force on bare hull of 1/40-scale model *Akron*. Pitch angle $\theta=0°$

where the pressure near the corner is about 30 per cent less than that at the center. The trend of the results indicates that the maximum effect occurs at a still higher value of ω, probably around 45°, where there were no orifices at the corners. The results for the stations numbered 8, 12, and 17 were similar to those shown for station 5, except that the magnitude of the effect was somewhat smaller.

The average pressure at any station, considering the hull as a body of revolution, is given by the equation (reference 3)

$$p'=\frac{1}{2\pi}\int_0^{2\pi} p \, d\omega \qquad (1)$$

or, for the present case, if it be assumed that the pressure diagrams are symmetrical on the two sides of the hull, the average pressure is given by

$$p'=\frac{1}{\pi}\int_0^{\pi} p \, d\omega$$

The average pressures, obtained by integrating graphically curves such as those given in Figure 6, are

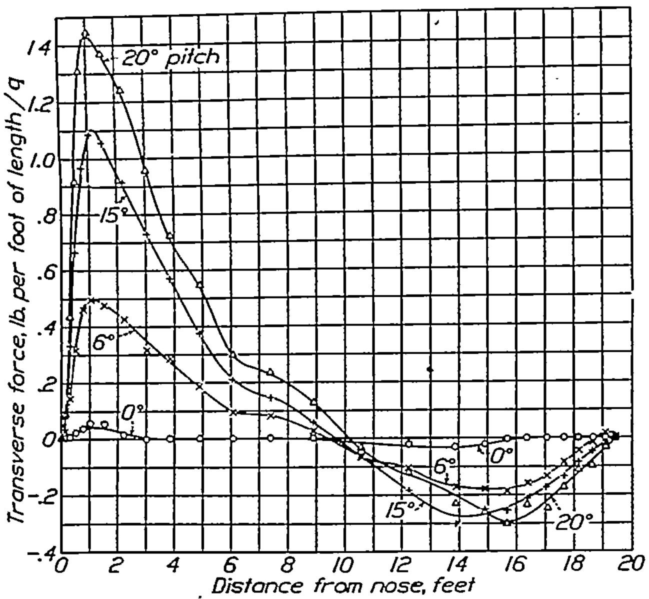

FIGURE 11.—Transverse force per foot of length on the bare hull of the 1/40 scale model *Akron*

presented in Table III and are plotted for four angles of pitch in Figure 9.

The pressure at station 7, which is approximately 1.5 feet from the bow, appears to be high in relation to those of the neighboring stations and causes an irregularity in the curves of average pressures. This characteristic, which appears in all the tests, could not be satisfactorily explained. It was thought perhaps to be due to an irregularity in the model. A careful check of the form of the hull in this region, however, showed the actual ordinates to be in close agreement with those specified and the form to be fair. Another possible explanation of the distortion of the curves in this region was the fact that many of the orifices at this station were not exactly flush with the surface, but had pulled into the surface slightly. An inspection of the pressures measured at station 7 at orifices that were flush with the surface showed that these pressures were slightly lower than the mean curve, but only by an average amount of $p/q=0.015$, a value too small to remove the hump in the curve.

The longitudinal force or, for 0° angle of pitch, the pressural drag is given by the equation

$$P''=\int_{O_1}^{O_2} p' \mathrm{d}A \qquad (2)$$

where A is the area of cross section of the hull. This integral was evaluated by integrating graphically the area under the curve of the average pressure plotted against the cross-sectional area of the hull. (Fig. 10 (a).) The pressural drag for ten observations made at five air speeds is plotted in Figure 10 (b) against the dynamic pressure of the air stream. The scattering of the values is probably due to errors in the measurements and in the graphical computation, which involves the subtraction of two approximately equal areas, very small errors in the pressures causing relatively large errors in the integrated results. The plotted values fall about a mean line which is coincident with the axis of the abscissa, indicating that within

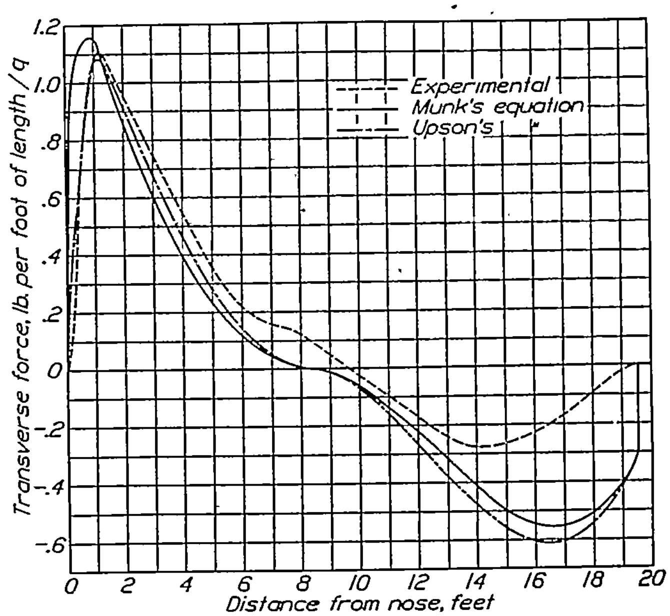

FIGURE 12.—Computed and experimental transverse forces on the bare hull of the 1/40 scale model *Akron*. $\theta=15°$

the accuracy of these tests the pressural drag is so small it may be considered zero. However, this result is also dependent upon the accuracy of the correction for the variation in static pressure along the hull. Without this correction the pressural drag amounts to about 21 per cent of the measured drag of the hull.

The longitudinal forces for the various angles of pitch are given in Table IV and compared to the longitudinal forces obtained from the force measurements. Here, as in the case for 0° angle of attack, the values of the integrated forces are small and quite erratic.

The transverse force, in a vertical plane through the longitudinal axis of the hull, for any station is given by the equation

$$f=\frac{\mathrm{d}F}{\mathrm{d}x}=\int_0^{2\pi} pr \cos\omega \mathrm{d}\omega \qquad (3)$$

where F is the total transverse force, x is the distance from the nose of the hull measured along the longitudinal axis, and r is the radius of the hull. The values of f determined graphically are given in Table V, and are plotted for four angles of pitch in Figure 11. The existence of the small transverse forces at the 0° angle of pitch indicates either that the air flow was not strictly axial or that the model was not exactly symmetrical. The curve for the 15° angle of pitch is re-

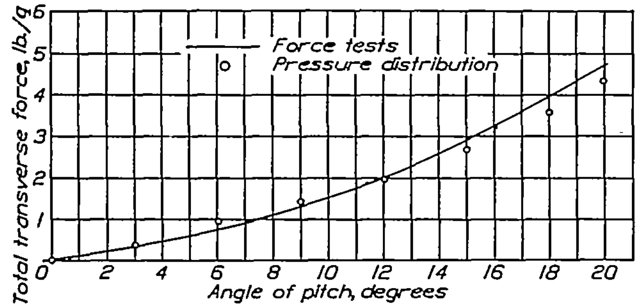

FIGURE 13.—Comparison of total transverse forces obtained from pressure distribution and from force tests on the bare hull of 1/40-scale model *Akron*

plotted in Figure 12 and compared to the transverse forces computed from Munk's equation (reference 4)

$$f=\frac{\mathrm{d}F}{\mathrm{d}x}=\frac{\mathrm{d}A}{\mathrm{d}x}q\,(k_2-k_1)\sin 2\theta$$

where A is the cross-sectional area of the hull

θ is the angle of pitch

k_2 and k_1 are the coefficients of additional mass of air transversely and longitudinally, respectively,

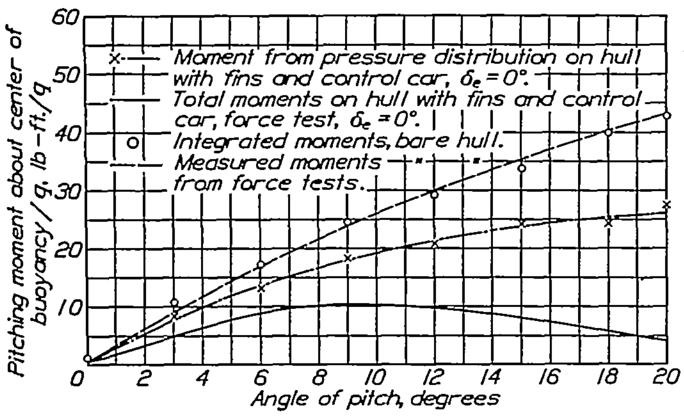

FIGURE 14.—Comparison of pitching moments obtained from pressure distribution and from force tests on 1/40-scale model *Akron*

and also from the alternative form of this equation due to Upson and Klikoff (reference 5)

$$f=\frac{\mathrm{d}F}{\mathrm{d}x}=\frac{\mathrm{d}A}{\mathrm{d}x}q\cos^2\alpha\sin 2\theta$$

where α is the inclination of the surface of the hull to the longitudinal axis. The latter equation, as has been found in previous experiments, gives somewhat better agreement over the fore part of the hull than the former.

The total transverse forces on the hull, which were obtained by integrating the areas under curves such as those in Figure 11, are plotted against angle of pitch in Figure 13 and compared to the values computed from the lift and drag taken from the force tests. (Reference 1.) The integrated values are in fairly good agreement with the measured forces at the low angles of pitch but are somewhat lower than the measured forces at the high angles. These results are what would be expected as the integrated values do not take into account the frictional forces, which at the high

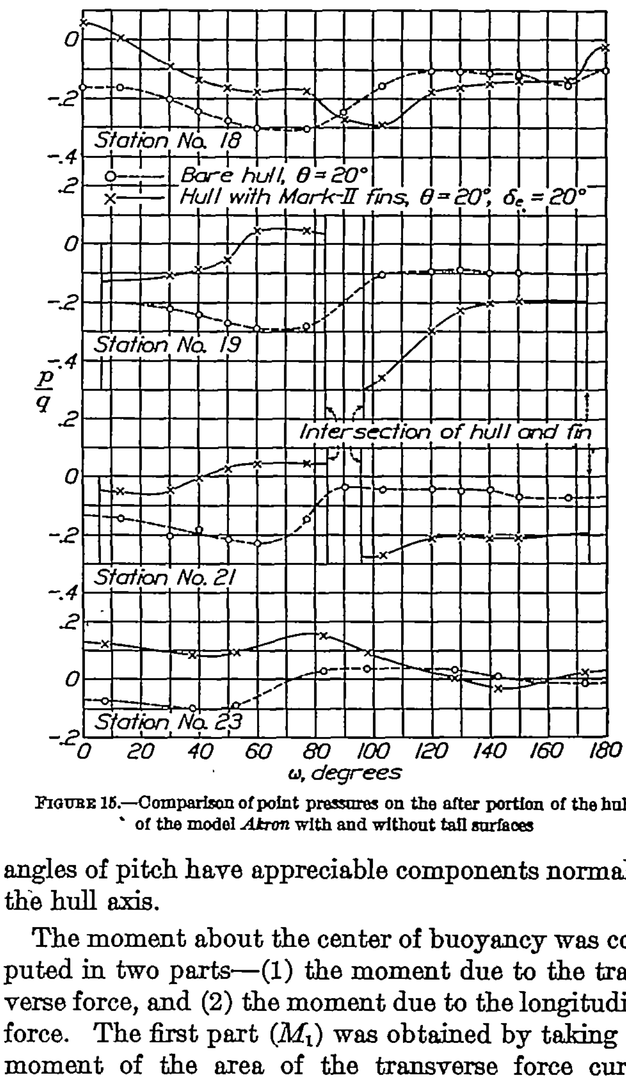

FIGURE 15.—Comparison of point pressures on the after portion of the hull of the model *Akron* with and without tail surfaces

angles of pitch have appreciable components normal to the hull axis.

The moment about the center of buoyancy was computed in two parts—(1) the moment due to the transverse force, and (2) the moment due to the longitudinal force. The first part (M_1) was obtained by taking the moment of the area of the transverse force curves (fig. 11) about the center of buoyancy by means of a mechanical integrator. The second part is given by

$$M_2=\frac{1}{2\pi}\int_{0_1}^{0_2}f\mathrm{d}A \qquad (4)$$

where A is the cross-sectional area of the hull. This equation was solved graphically by plotting f determined from equation (3) for the different stations against the corresponding cross-sectional area and integrating the area under the resulting curve. The moments due to the longitudinal forces amount to about 4 per cent of the total and are in the opposite

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direction to those due to the transverse forces. The total moment is then

$$M=M_1+M_2$$

Figure 14 (upper curve) shows the integrated moments for the various angles of pitch compared to the mo-

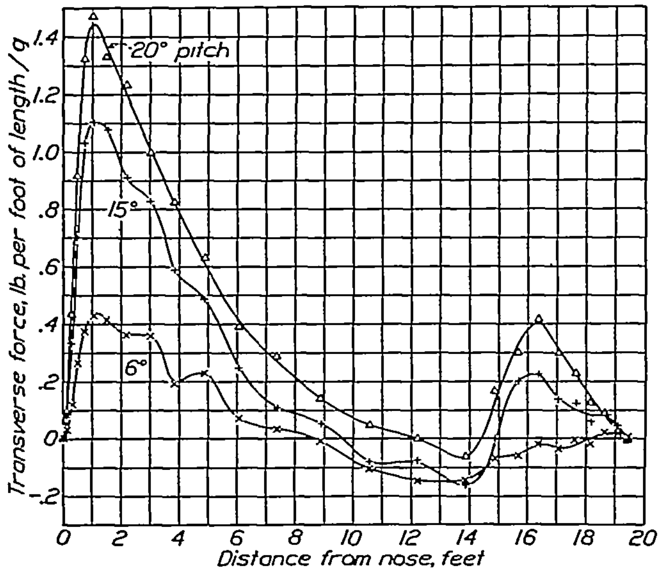

FIGURE 16.—Transverse force per unit length on the hull of 1/40-scale model *Akron* with the control car and tail surfaces in place. Elevator angle $\delta_e=0°$

ments determined by the force tests. In general, the two sets of results are in very close agreement.

The influence of the fins and control car upon the pressure distribution over the hull is shown in Figures 15 to 17, inclusive. The point pressures observed at

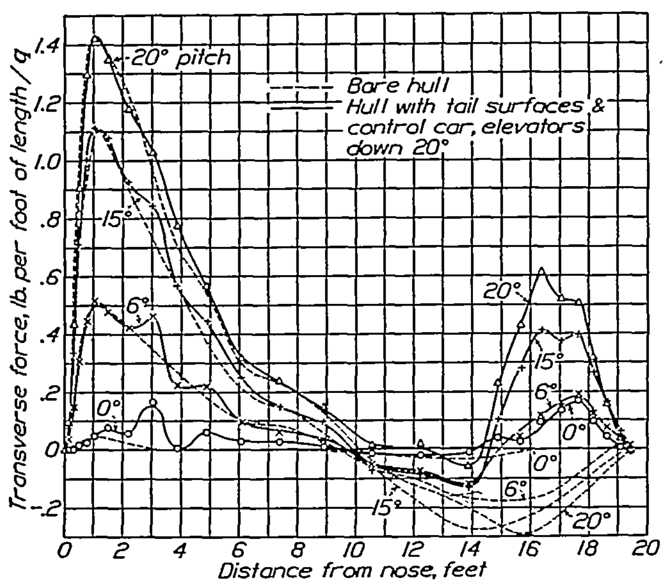

FIGURE 17.—Comparison of transverse forces on the hull of the 1/40-scale model *Akron* with and without control car and tail surfaces

four stations in the vicinity of the fins are shown in Figure 15 for the 20° pitch angle and compared to the pressures on the bare hull. The greatest change in the point pressures due to the presence of the fins occurs, as was to be expected, in the vicinity of the leading edges of the fins which are just forward of station 19.

The transverse forces on the hull with the fins in place are presented in Tables VI, VII, and VIII, and are shown for several angles of pitch in Figure 16 for an elevator angle δ_e of 0°. Figure 17 shows the transverse forces when the elevators were down 20°. For comparison, the curves for the bare hull are replotted on the same diagram. The influence of the tail surfaces on these forces on the after portion of the hull is very marked, the forces being of equal or greater magnitude than those on the bare hull but acting in the opposite direction. The influence of the control car

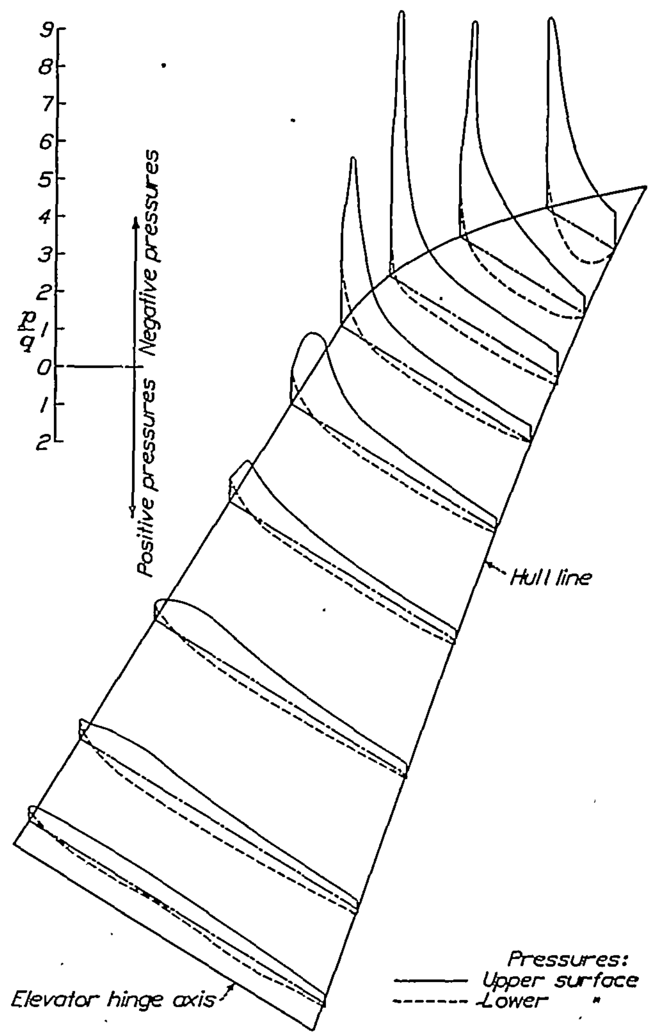

FIGURE 18.—Pressure distribution on horizontal fin surface of the 1/40-scale model *Akron*. Pitch angle $\theta=20°$. Elevator angle $\delta_e=20°$

on the transverse forces over the fore part of the hull is also quite pronounced, especially at the low angles of pitch.

The integrated pitching moments on the hull, with the fins and control car in place, are compared in Figure 14 with the moments on the bare hull and with the total pitching moments of the hull with the fins and control car obtained from the force tests. The difference between the upper curve and the lower one, for any particular angle of pitch, represents the total moment due to the fins. The difference between the upper curve and the intermediate one represents the portion of the moment due to the influence of the fins and control car on the pressural forces on the hull. The latter forces are seen to contribute more than 40 per cent of the total fin moment. The large magnitude of the fin action of the hull suggests the possibility of augmenting this effect and thereby increasing the effectiveness of the fin surfaces, and also of distributing the forces more widely over the after portion of the hull. In this connection, it would be of interest to test the airship model with eight tail surfaces instead of four, the four additional fins to be placed on the 45° diameters of the hull and the total fin area to be the same as

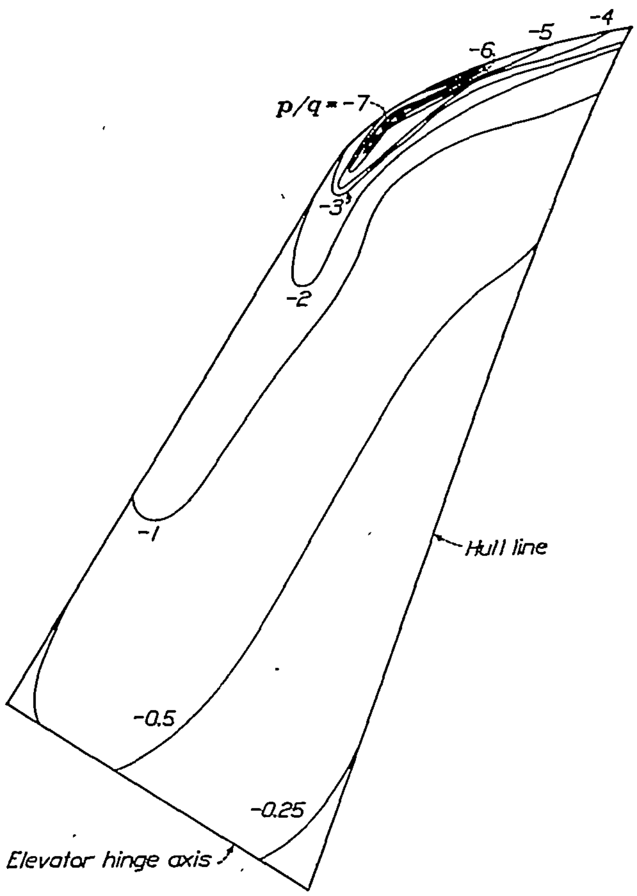

FIGURE 19.—Pressure contours on negative pressure side of horizontal fin surface of the 1/40-scale model *Akron*. Pitch angle $\theta=20°$. Elevator angle $\delta_e=20°$

before. With this fin arrangement and with the model at an angle of pitch, the pressure decrease over the top of the hull and the pressure increase over the bottom of the hull due to the influence of the tail surfaces should produce much larger components in the vertical plane than the present fins. The fin action of the hull should be increased, whereas the forces on the fins should be decreased, thus shifting the greater part of the fin forces directly onto the hull. The *ZMC-2* metal-clad airship actually has a system of eight tail surfaces similar to that described above, except that the fins are all shifted around the hull by 22½°.

The results of the measurements of the fin pressures are presented in Figures 18, 19, and 20. The isometric chart in Figure 18 shows the pressures over the fin for the 20° angle of pitch and 20° down elevator. The maximum negative pressure recorded was on the leading edge and amounted to seven times the dynamic pressure of the undisturbed air stream. Figure 19 shows the pressure contours on the suction side of the fin for the same pitch and elevator angles. The integrated normal-force coefficients

$$C_N=\frac{\text{normal force on fin}}{qS}$$

where S is the area of the fin, are plotted in Figure 20 against the elevator angle for the various pitch angles tested. The variation of the normal-force coefficient with the elevator angle is approximately linear over the range of angles from elevators down 20° to elevators up 15°. The elevators apparently lose much of

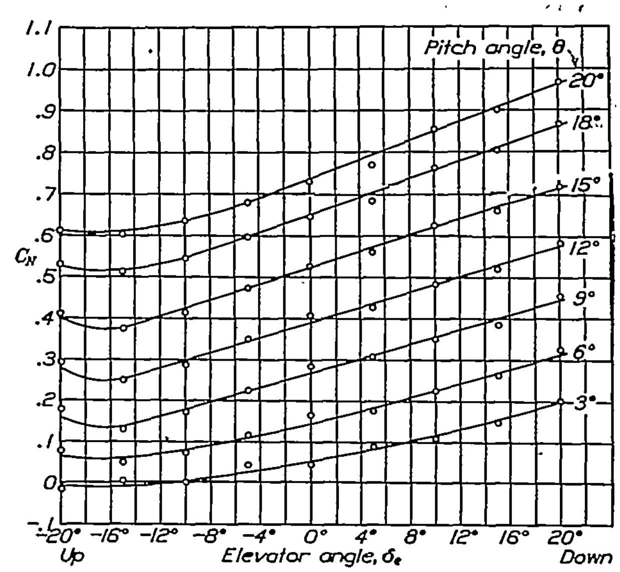

FIGURE 20.—Normal-force coefficients for horizontal fin surfaces on the 1/40-scale model *Akron*

their effectiveness when deflected upward 20°, the normal-force coefficient for this elevator angle being about the same as with the elevators up 10°.

CONCLUSIONS

1. The integrated transverse forces and the moments about the center of buoyancy were found to be in good agreement with the forces and moments determined in the force tests.

2. The pressural drag of the hull at 0° pitch was found to be practically zero, within the accuracy of the tests.

3. The fin action of the after portion of the hull in the presence of the tail surfaces was found to contribute more than 40 per cent of the total fin moment measured on the balances.

4. Negative pressures as great as seven times the dynamic pressure of the undisturbed air stream were measured on the leading edge of the horizontal fin at the 20° pitch angle with 20° down elevator.

LANGLEY MEMORIAL AERONAUTICAL LABORATORY,
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
LANGLEY FIELD, VA., *June 28, 1932*.

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TABLE I

DIMENSIONS OF MODEL U. S. S. "AKRON"

[Scale=1/40]

Distance from nose / length	Radius (circumscribed circle)	
a/L	*Inches*	
0	0	
0.02	4.95	Length, 19.62 feet.
.05	9.96	Volume, 115.0 cubic feet.
.10	14.20	
.15	16.65	
.20	18.39	Total horizontal tail surface area (square feet):
.25	19.12	Mark-I: 5.074; Mark-II: 4.590
.30	19.61	
.35	19.85	
.40	19.90	Elevators (including balance vanes) square feet:
.45	19.90	1.004; 0.932
.50	19.80	
.55	19.69	Elevator balance vanes square feet:
.60	19.12	0.234; 0.220
.65	18.46	
.70	17.50	Elevator chord length (feet):
.75	16.15	$c=0.410$; $c=0.369$
.80	14.44	
.85	12.29	Location of elevator axis:
.90	9.61	$a/L=0.9090$; $a/L=0.9059$
.95	6.52	Center of buoyancy:
1.00	0	$a/L=0.464$
		Leading edge of control car: $a/L=0.1555$
		Length of control car=1.238 (feet).

TABLE II. 1/40-SCALE MODEL U. S. S. "AKRON"

OBSERVED PRESSURES p/q

BARE HULL

[100 m. p. h. approximately]

Station No.	ω	Angle of pitch, θ: 0°	3°	6°	9°	12°	15°	18°	20°
1	Nose.	--------	[1]0.967	[1]0.900	0.785	0.682	0.434	0.098	−0.132
	0	0.866	[1].934	[1].956	[1].975	[1].983	[1].990	[1].985	[1].960
	30	.853	[1].891	[1].901	[1].890	.865	.829	.783	.720
	60	.849	.850	.826	.771	.695	.575	.451	.330
2	90	.846	.825	.769	.674	.596	.432	.282	.128
	120	.844	.799	.728	.606	.519	.353	.164	.049
	150	.840	.786	.716	.601	.519	.393	.284	.197
	180	.834	.770	.700	.589	.521	.413	.294	.220
	0	.702	.779	.834	.888	[1].920	[1].944	[1].962	[1].970
	30	.698	.749	.800	.838	.822	.836	.854	.837
	60	.681	.699	.712	.713	.661	.619	.579	.515
3	90	.681	.668	.625	.576	.499	.396	.291	.190
	120	.681	.633	.563	.474	.399	.275	.144	.043
	150	.678	.599	.513	.404	.329	.206	.067	−.014
	180	.681	.590	.505	.389	.312	.200	.079	.004
	0	.414	.507	.580	.674	.704	.774	.845	[1].878
	30	.417	.480	.550	.627	.625	.676	.733	.737
	60	.408	.433	.465	.489	.446	.436	.433	.390
4	90	.393	.370	.346	.325	.416	.177	.103	.024
	120	.386	.312	.238	.162	.080	−.032	−.150	−.245
	150	.382	.279	.180	.077	−.003	−.115	−.250	−.338
	180	.376	.254	.158	.032	−.052	−.160	−.290	−.373

[1] Value taken from faired curve.

TABLE II. 1/40-SCALE MODEL U. S. S. "AKRON"—Con.

OBSERVED PRESSURES p/q

BARE HULL

[100 m. p. h. approximately]

Station No.	ω	Angle of pitch, θ: 0°	3°	6°	9°	12°	15°	18°	20°
	0	.170	.257	.332	.434	.477	.567	.652	.703
	10	.164	.247	.330	.429	.466	.550	.633	.684
	20	.177	.244	.324	.416	.440	.552	.595	.634
	30	.158	.219	.294	.374	.386	.455	.505	.541
	40	.160	.217	.282	.349	.342	.389	.428	.451
	50	.165	.211	.260	.310	.288	.318	.341	.337
	60	.152	.184	.215	.249	.210	.216	.202	.180
	70	.134	.148	.167	.184	.135	.116	.082	.049
	80	.140	.131	.132	.129	.068	.024	−.038	−.088
5	90	.142	.123	.102	.085	.015	−.046	−.115	−.185
	100	.136	.098	.070	.032	−.040	−.117	−.206	−.285
	110	.128	.073	.023	−.035	−.103	−.195	−.301	−.379
	120	.125	.056	−.001	−.076	−.148	−.242	−.353	−.430
	130	.131	.055	−.018	−.105	−.176	−.280	−.393	−.476
	140	.128	.041	−.035	−.131	−.199	−.297	−.415	−.490
	150	.123	.025	−.063	−.163	−.233	−.330	−.446	−.520
	160	.121	.018	−.071	−.176	−.244	−.340	−.453	−.523
	170	.111	.003	−.086	−.198	−.266	−.360	−.471	−.540
	180	.112	−.002	−.091	−.203	−.275	−.372	−.478	−.550
	0	.049	.132	.201	.298	.338	.433	.508	.569
	30	.056	.117	.183	.250	.270	.336	.386	.413
	60	.037	.074	.101	.121	.093	.097	.075	.062
6	90	.035	.028	.005	−.017	−.077	.134	−.210	−.274
	120	.008	−.047	−.095	−.174	−.232	−.316	−.417	−.490
	150	.008	−.070	−.142	−.234	−.287	−.366	−.462	−.518
	180	−.004	−.077	−.152	−.242	−.300	−.372	−.452	−.504
	0	−.027	.043	.107	.171	.222	.305	.372	.405
	10	−.003	.058	.122	.184	.232	.306	.367	.394
	20	−.015	.043	.104	.161	.200	.270	.321	.352
	30	−.029	.025	.034	.131	.155	.211	.251	.278
	40	−.017	.034	.080	.117	.124	.159	.176	.198
	50	−.010	.034	.067	.087	.080	.098	.089	.101
	60	−.018	.015	.034	.042	.017	.017	−.016	−.029
	70	−.027	−.001	.006	.004	−.034	−.053	−.109	−.130
	80	−.030	−.021	−.028	−.046	−.091	−.126	−.194	−.240
7	90	−.011	−.019	−.031	−.063	−.113	−.163	−.241	−.290
	100	−.018	−.041	−.063	−.113	−.164	−.226	−.314	−.370
	110	−.044	−.071	−.103	−.166	−.217	−.283	−.377	−.441
	120	−.051	−.096	−.133	−.208	−.254	−.325	−.419	−.484
	130	−.030	−.081	−.119	−.198	−.241	−.305	−.394	−.449
	140	−.047	−.103	−.149	−.228	−.269	−.330	−.416	−.462
	150	−.046	−.103	−.153	−.229	−.268	−.323	−.396	−.434
	160	−.066	−.134	−.183	−.254	−.296	−.345	−.404	−.437
	170	−.044	−.109	−.159	−.227	−.263	−.317	−.309	−.402
	180	−.049	−.119	−.169	−.239	−.283	−.331	−.377	−.409
	0	−.139	−.092	−.041	.014	.058	.124	.199	.220
	4	−.144	−.097	−.044	.009	.054	.120	.189	.215
	6	−.144	−.097	−.044	.008	.052	.120	.186	.210
	14	−.142	−.097	−.044	.006	.046	.105	.162	.187
	16	−.137	−.096	−.044	.006	.042	.100	.156	.179
	24	−.139	−.099	−.057	−.021	.004	.045	.081	.100
	26	−.134	−.097	−.059	−.029	−.014	.015	.036	.050
	30	−.132	−.097	−.061	−.031	−.017	.010	.033	.045
	34	−.148	−.113	−.092	−.064	−.062	−.047	−.033	−.042
	36	−.149	−.113	−.097	−.071	−.079	−.074	−.091	−.081
	60	−.130	−.106	−.094	−.086	−.109	−.113	−.147	−.101
	84	−.132	−.134	−.151	−.182	−.234	−.283	−.374	−.435
	86	−.146	−.155	−.172	−.206	−.257	−.314	−.402	−.469
8	90	−.137	−.147	−.166	−.199	−.246	−.293	−.379	−.435
	94	−.151	−.167	−.194	−.244	−.294	−.366	−.461	−.535
	96	−.154	−.175	−.204	−.251	−.302	−.370	−.462	−.538
	120	−.136	−.175	−.207	−.269	−.309	−.366	−.447	−.501
	144	−.149	−.198	−.264	−.302	−.336	−.389	−.467	−.511
	146	−.163	−.212	−.251	−.317	−.351	−.404	−.481	−.520
	150	−.171	−.223	−.261	−.319	−.351	−.395	−.459	−.492
	154	−.144	−.197	−.232	−.296	−.326	−.369	−.430	−.402
	156	−.158	−.210	−.246	−.301	−.330	−.369	−.417	−.445
	164	−.158	−.210	−.246	−.294	−.321	−.352	−.381	−.402
	166	−.158	−.210	−.247	−.296	−.321	−.352	−.381	−.402
	174	−.164	−.215	−.252	−.297	−.322	−.352	−.375	−.395
	176	−.163	−.213	−.251	−.297	−.321	−.350	−.369	−.390
	180	−.156	−.205	−.244	−.286	−.314	−.345	−.364	−.382
	0	−.147	−.117	−.080	−.042	−.005	.042	.100	.125
	10	−.144	−.115	−.079	−.040	−.005	.040	.093	.110
	20	−.149	−.128	−.090	−.057	−.032	.007	.040	.008
	30	−.150	−.120	−.087	−.062	−.044	−.020	.005	.022
	40	−.137	−.119	−.094	−.077	−.069	−.060	−.052	−.040
	50	−.137	−.123	−.105	−.100	−.114	−.114	−.134	−.132
	60	−.134	−.127	−.119	−.122	−.147	−.162	−.207	−.219
	70	−.128	−.128	−.129	−.137	−.175	−.201	−.262	−.291
	80	−.144	−.148	−.159	−.179	−.225	−.260	−.337	−.380
9	90	−.140	−.160	−.179	−.210	−.259	−.305	−.390	−.443
	100	−.140	−.165	−.185	−.229	−.274	−.325	−.409	−.405
	110	−.140	−.175	−.200	−.250	−.292	−.347	−.426	−.480
	120	−.137	−.175	−.200	−.252	−.290	−.338	−.412	−.460
	130	−.147	−.190	−.215	−.262	−.295	−.335	−.399	−.431
	140	−.144	−.186	−.212	−.250	−.283	−.313	−.305	−.390
	150	−.140	−.180	−.204	−.238	−.267	−.286	−.324	−.339
	160	−.139	−.178	−.199	−.230	−.255	−.270	−.290	−.290
	170	−.149	−.188	−.210	−.234	−.259	−.270	−.277	−.285
	180	−.145	−.181	−.205	−.229	−.252	−.261	−.264	−.271
	0	−.125	−.107	−.075	−.045	−.023	.017	.075	.090
	30	−.109	−.093	−.072	−.055	−.045	−.030	−.010	−.001
	60	−.120	−.111	−.110	−.113	−.148	−.165	−.205	−.227
10	90	−.126	−.140	−.157	−.190	−.238	−.283	−.367	−.420
	120	−.126	−.156	−.177	−.225	−.258	−.310	−.373	−.414
	150	−.130	−.160	−.175	−.200	−.225	−.241	−.267	−.277

TABLE II. 1/40-SCALE MODEL U. S. S. "AKRON"—Con.

OBSERVED PRESSURES p/q

BARE HULL

[100 m. p. h. approximately]

Station No.	ω	0°	3°	6°	9°	12°	15°	18°	20°
11	0	−.143	−.133	−.111	−.091	−.075	−.045	.005	.011
	10	−.107	−.095	−.075	−.055	−.040	−.009	.029	.032
	20	−.111	−.105	−.081	−.065	−.058	−.038	−.003	−.006
	30	−.124	−.116	−.106	−.105	−.110	−.115	−.121	−.122
	40	−.124	−.114	−.098	−.090	−.086	−.076	−.065	−.061
	50	−.123	−.114	−.111	−.118	−.136	−.150	−.176	−.188
	60	−.136	−.131	−.136	−.148	−.185	−.209	−.260	−.282
	70	−.121	−.121	−.128	−.146	−.188	−.222	−.285	−.319
	80	−.111	−.111	−.125	−.143	−.190	−.224	−.291	−.334
	100	−.111	−.131	−.156	−.200	−.243	−.292	−.381	−.441
	110	−.116	−.136	−.156	−.201	−.238	−.286	−.360	−.411
	120	−.123	−.144	−.163	−.208	−.238	−.286	−.346	−.386
	130	−.136	−.156	−.173	−.208	−.230	−.266	−.320	−.342
	140	−.131	−.149	−.161	−.190	−.209	−.230	−.271	−.282
	150	−.143	−.158	−.168	−.184	−.203	−.210	−.235	−.242
	160	−.121	−.139	−.143	−.156	−.173	−.173	−.191	−.295
	170	−.138	−.158	−.171	−.175	−.185	−.173	−.175	−.173
12	0	−.100	−.094	−.079	−.065	−.057	−.034	.001	.007
	4	−.091	−.085	−.072	−.057	−.052	−.024	.010	.010
	6	−.093	−.087	−.072	−.057	−.052	−.025	.003	.010
	14	−.091	−.087	−.072	−.059	−.057	−.037	.003	−.010
	16	−.103	−.094	−.080	−.072	−.070	−.052	−.034	−.032
	24	−.103	−.095	−.088	−.087	−.090	−.087	−.087	−.085
	26	−.103	−.095	−.090	−.094	−.104	−.101	−.129	−.124
	30	−.191	−.087	−.077	−.085	−.092	−.102	−.120	−.121
	34	−.118	−.117	−.122	−.132	−.155	−.172	−.225	−.229
	36	−.105	−.099	−.099	−.110	−.134	−.154	−.194	−.202
	60	−.098	−.094	−.100	−.119	−.152	−.179	−.222	−.253
	84	−.105	−.112	−.134	−.172	−.229	−.285	−.390	−.445
	86	−.105	−.110	−.134	−.174	−.230	−.287	−.390	−.452
	90	−.096	−.107	−.124	−.162	−.208	−.255	−.343	−.393
	94	−.100	−.107	−.125	−.175	−.229	−.288	−.397	−.460
	96	−.103	−.118	−.132	−.184	−.237	−.295	−.403	−.464
	120	−.105	−.118	−.132	−.174	−.200	−.241	−.305	−.337
	144	−.105	−.118	−.124	−.160	−.175	−.204	−.250	−.256
	146	−.103	−.122	−.127	−.162	−.175	−.201	−.240	−.246
	150	−.101	−.112	−.115	−.140	−.152	−.161	−.193	−.199
	154	−.103	−.112	−.117	−.138	−.150	−.157	−.188	−.194
	156	−.103	−.109	−.110	−.124	−.139	−.142	−.172	−.179
	164	−.106	−.109	−.107	−.112	−.124	−.112	−.140	−.141
	166	−.103	−.107	−.104	−.107	−.119	−.109	−.132	−.129
	174	−.103	−.105	−.102	−.102	−.110	−.096	−.107	−.095
	176	−.101	−.100	−.100	−.100	−.109	−.092	−.095	−.087
13	0	−.070	−.065	−.055	−.050	−.040	−.016	.008	.010
	10	−.060	−.055	−.048	−.040	−.037	−.015	.005	.009
	20	−.041	−.068	−.032	−.055	−.030	−.015	−.005	−.003
	30	−.077	−.073	−.072	−.075	−.083	−.080	−.088	−.090
	40	−.070	−.070	−.068	−.078	−.093	−.102	−.128	−.132
	50	−.072	−.071	−.073	−.097	−.120	−.139	−.187	−.197
	60	−.067	−.068	−.073	−.102	−.135	−.165	−.227	−.247
	70	−.067	−.070	−.078	−.103	−.152	−.190	−.266	−.296
	80	−.072	−.082	−.100	−.133	−.182	−.227	−.318	−.356
	90	−.072	−.083	−.097	−.137	−.185	−.231	−.321	−.366
	100	−.069	−.087	−.102	−.132	−.178	−.232	−.310	−.371
	110	−.069	--------	−.102	−.137	−.172	−.217	−.290	−.337
	120	−.072	−.095	−.105	−.137	−.160	−.206	−.256	−.287
	130	−.074	−.095	−.095	−.120	−.138	−.165	−.189	−.221
	140	−.079	−.102	−.092	−.107	−.122	−.135	−.161	−.179
	150	−.065	−.080	−.072	−.078	−.090	−.100	−.135	−.159
	160	−.082	−.080	−.077	−.075	−.087	−.088	−.126	−.154
	170	−.074	−.052	−.070	−.063	−.072	−.060	−.072	−.068
	180	−.065	−.073	−.062	−.053	−.062	−.043	−.038	−.033
14	30	−.057	−.069	−.061	−.062	−.072	−.071	−.082	−.088
	60	−.059	−.071	−.074	−.099	−.134	−.161	−.225	−.251
	90	−.059	−.082	−.101	−.124	−.176	−.225	−.309	−.357
	120	−.059	−.081	−.094	−.113	−.136	−.171	−.216	−.237
	150	−.063	−.074	−.066	−.071	−.081	−.091	−.136	−.168
	180	−.054	−.059	−.046	−.037	−.042	−.024	−.014	−.007
15	0	−.076	−.092	−.087	−.082	−.082	−.069	−.044	−.052
	10	−.081	−.099	−.094	−.089	−.090	−.077	−.080	−.065
	20	−.073	−.089	−.085	−.085	−.092	−.082	−.075	−.082
	30	−.092	−.109	−.111	−.119	−.135	−.139	−.153	−.160
	40	−.085	−.100	−.100	−.116	−.134	−.147	−.173	−.185
	50	−.081	−.099	−.100	−.119	−.149	−.169	−.216	−.232
	60	−.081	−.100	−.104	−.132	−.165	−.198	−.256	−.286
	70	−.089	−.085	−.094	−.119	−.159	−.199	−.266	−.294
	80	−.085	−.105	−.117	−.146	−.194	−.237	−.318	−.355
	90	−.074	−.100	−.109	−.139	−.185	−.233	−.303	−.349
	100	−.069	−.090	−.101	−.132	−.172	−.218	−.281	−.319
	110	−.062	−.080	−.087	−.117	−.149	−.186	−.235	−.259
	120	−.069	−.085	−.092	−.119	−.134	−.168	−.186	−.202
	130	−.073	−.085	−.084	−.102	−.110	−.131	−.144	−.160
	140	−.057	−.069	−.065	−.089	−.084	−.099	−.124	−.143
	150	−.067	−.070	−.064	−.069	−.082	−.082	−.152	−.200
	160	−.059	−.064	−.052	−.054	−.059	−.085	−.137	−.165
	170	−.073	−.072	−.055	−.062	−.055	−.055	−.055	−.055
	180	−.049	−.052	−.035	−.022	−.032	−.010	−.012	−.018
16	0	−.077	−.098	−.098	−.101	−.104	−.098	−.081	−.086
	30	−.083	−.101	−.105	−.118	−.134	−.138	−.153	−.158
	60	−.084	−.101	−.111	−.140	−.176	−.210	−.270	−.293
	90	−.079	−.098	−.110	−.138	−.181	−.223	−.287	−.323
	120	−.083	−.096	−.096	−.115	−.121	−.148	−.148	−.165
	150	−.070	−.068	−.059	−.063	−.074	−.088	−.165	−.201
	180	−.060	−.053	−.038	−.025	−.031	−.016	−.031	−.046

TABLE II. 1/40-SCALE MODEL U. S. S. "AKRON"—Con.

OBSERVED PRESSURES p/q

BARE HULL

[100 m. p. h. approximately]

Station No.	ω	0°	3°	6°	9°	12°	15°	18°	20°
17	0	−.079	−.103	−.114	−.125	−.133	−.134	−.129	−.139
	4	−.079	−.103	−.110	−.125	−.133	−.134	−.130	−.137
	6	−.084	−.112	−.117	−.134	−.143	−.140	−.137	−.149
	10	−.084	−.110	−.119	−.135	−.147	−.147	−.142	−.154
	14	−.096	−.125	−.134	−.157	−.173	−.181	−.183	−.194
	16	−.083	−.107	−.117	−.134	−.150	−.150	−.152	−.168
	20	−.088	−.115	−.124	−.145	−.163	−.167	−.169	−.185
	24	−.091	−.115	−.130	−.157	−.180	−.187	−.214	−.227
	26	−.091	−.117	−.132	−.167	−.199	−.214	−.251	−.268
	30	−.083	−.102	−.117	−.147	−.173	−.187	−.226	−.238
	34	−.084	−.105	−.120	−.151	−.177	−.194	−.231	−.248
	36	−.084	−.105	−.120	−.154	−.187	−.214	−.268	−.285
	40	−.084	−.105	−.119	−.154	−.187	−.214	−.269	−.289
	50	−.084	−.107	−.122	−.154	−.183	−.214	−.266	−.285
	60	−.074	−.098	−.117	−.149	−.182	−.214	−.273	−.302
	70	−.067	−.087	−.104	−.135	−.170	−.214	−.278	−.309
	80	−.083	−.100	−.119	−.151	−.185	−.231	−.294	−.327
	84	−.083	−.100	−.119	−.154	−.197	−.249	−.321	−.361
	86	−.091	−.117	−.134	−.167	−.208	−.261	−.330	−.369
	90	−.084	−.102	−.115	−.147	−.180	−.217	−.266	−.302
	94	−.077	−.093	−.109	−.139	−.173	−.217	−.268	−.304
	96	−.077	−.092	−.104	−.137	−.172	−.217	−.264	−.300
	100	−.079	−.080	−.100	−.129	−.153	−.184	−.209	−.240
	110	−.067	−.077	−.080	−.102	−.117	−.134	−.135	−.161
	120	−.072	−.077	−.075	−.087	−.092	−.100	−.109	−.132
	130	−.074	−.070	−.067	−.073	−.077	−.084	−.109	−.134
	140	−.079	−.070	−.067	−.070	−.073	−.084	−.109	−.136
	144	−.081	−.073	−.067	−.070	−.080	−.087	−.110	−.137
	146	−.077	−.068	−.060	−.065	−.077	−.087	−.120	−.148
	150	−.074	−.067	−.055	−.063	−.080	−.094	−.120	−.146
	154	−.071	−.063	−.053	−.060	−.080	−.085	−.117	−.141
	156	−.065	−.058	−.050	−.053	−.075	−.102	−.139	−.151
	160	−.060	−.050	−.037	−.048	−.057	−.102	−.174	−.200
	164	−.071	−.038	−.048	−.058	−.063	−.122	−.181	−.205
	166	−.069	−.040	−.047	−.053	−.055	−.102	−.147	−.171
	170	−.065	−.047	−.038	−.042	−.038	−.058	−.100	−.124
	174	−.067	−.047	−.040	−.037	−.038	−.037	−.087	−.112
	176	−.062	−.048	−.035	−.032	−.033	−.040	−.077	−.099
	180	−.060	−.050	−.033	−.027	−.030	−.032	−.070	−.097
18	0	−.064	−.093	−.107	−.134	−.147	−.150	−.157	−.166
	13	−.053	−.080	−.097	−.122	−.137	−.139	−.147	−.164
	30	−.053	−.078	−.097	−.129	−.150	−.165	−.198	−.203
	40	−.060	−.083	−.102	−.135	−.167	−.187	−.229	−.245
	50	−.060	−.083	−.104	−.137	−.172	−.201	−.254	−.279
	60	−.062	−.083	−.105	−.140	−.177	−.214	−.280	−.302
	77	−.053	−.070	−.090	−.124	−.158	−.204	−.273	−.307
	90	−.055	−.067	−.080	−.109	−.137	−.175	−.211	−.245
	103	−.057	−.063	−.070	−.094	−.113	−.132	−.129	−.157
	120	−.055	−.050	−.050	−.053	−.055	−.067	−.084	−.109
	130	−.050	−.042	−.033	−.042	−.050	−.068	−.084	−.109
	140	−.050	−.037	−.030	−.037	−.050	−.067	−.092	−.117
	150	−.048	−.032	−.025	−.035	−.060	−.097	−.100	−.117
	167	−.047	−.030	−.017	−.030	−.033	−.080	−.132	−.154
	180	−.043	−.025	−.011	−.008	−.017	−.032	−.094	−.105
19	30	−.045	− 067	−.095	−.130	−.156	−.181	−.201	−.226
	40	−.043	−.063	−.087	−.122	−.155	−.184	−.221	−.242
	50	−.045	−.067	−.087	−.125	−.167	−.201	−.248	−.274
	60	−.048	−.065	−.083	−.124	−.163	−.201	−.258	−.280
	77	−.043	−.058	−.078	−.110	−.140	−.192	−.241	−.282
	103	−.040	−.037	−.042	−.060	−.067	−.087	−.080	−.107
	120	−.038	−.028	−.020	−.028	−.033	−.050	−.070	−.094
	130	−.033	−.018	−.013	−.020	−.030	−.047	−.062	−.099
	140	−.033	−.017	−.008	−.017	−.033	−.058	−.077	−.100
	150	−.029	−.010	.000	−.017	−.047	−.080	−.078	−.099
20	13	−.012	−.038	−.058	−.097	−.117	−.132	−.145	−.159
	30	−.016	−.033	−.063	−.104	−.135	−.162	−.186	−.213
	40	−.016	−.038	−.063	−.102	−.135	−.165	−.199	−.226
	50	−.016	−.037	−.062	−.100	−.138	−.178	−.226	−.255
	60	−.014	−.033	−.055	−.095	−.130	−.174	−.227	−.263
	77	−.014	−.027	−.040	−.075	−.100	−.150	−.182	−.226
	103	−.009	−.005	−.005	−.018	−.023	−.043	−.047	−.074
	120	−.011	.000	.003	−.001	−.010	−.030	−.050	−.074
	130	−.011	.003	.012	.001	−.013	−.035	−.053	−.084
	140	−.009	.010	.017	.001	−.015	−.042	−.058	−.084
	150	−.002	.015	.020	.001	−.030	--------	−.055	−.079
	167	−.002	.017	.027	.008	−.007	−.063	−.097	−.114
21	13	.022	−.005	−.030	−.067	−.093	−.114	−.125	−.146
	30	.012	−.013	−.040	−.083	−.120	−.152	−.177	−.206
	40	.025	.003	−.020	−.062	−.083	−.125	−.154	−.183
	50	.017	−.003	−.030	−.067	−.105	−.147	−.184	−.218
	60	.022	.003	−.017	−.053	−.092	−.145	−.193	−.232
	77	.025	.015	.000	−.027.	−.017	−.094	−.039	−.149
	90	.024	.030	.034	.019	.013	−.010	−.008	−.037
	103	.022	.033	.037	.025	.015	−.013	−.020	−.015
	120	.029	.040	.045	.030	.015	−.006	−.015	−.042
	130	.027	.040	.045	.030	.008	−.017	−.030	−.050
	140	.032	.045	.049	.022	−.015	−.020	−.023	−.045
	150	.031	.047	.054	.030	.008	−.047	−.060	.−070
	167	.032	.045	.056	.034	.007	−.027	−.053	−.074
22	7½	.053	.020	.000	−.033	−.068	−.092	−.101	−.117
	37½	.044	.022	−.001	−.035	−.077	−.114	−.134	−.164
	52½	.037	.020	−.003	−.033	−.080	−.130	−.154	−.193
	82½	.053	.054	.051	.030	.017	.000	.000	−.030
	97½	.053	.057	.061	.044	.035	.014	.022	−.003

TABLE II. 1/40-SCALE MODEL U. S. S. "AKRON"—Con.

OBSERVED PRESSURES p/q

BARE HULL

[100 m. p. h. approximately]

Station No.	ω	Angle of pitch, θ							
		0°	3°	6°	9°	12°	15°	18°	20°
22	127½	.053	.063	.067	.050	.030	.009	.002	−.018
	142½	.053	.063	.066	.042	.015	−.001	−.010	−.032
	172½	.053	.063	.066	.032	.000	−.037	−.053	−.062
23	7½	.095	.073	.050	.009	−.018	−.044	−.054	−.073
	37½	.096	.076	.063	.021	−.013	−.049	.068	−.101
	52½	.096	.081	.066	.036	.012	−.038	.051	−.090
	82½	.096	.096	.098	.080	.069	.046	.056	.030
	97½	.096	.099	.100	.083	.066	.050	.061	.036
	127½	.098	.099	.100	.080	.062	.048	.050	.031
	142½	.089	.094	.095	.066	.046	.029	.028	.009
	172½	.089	.094	.088	.046	.012	−.018	−.012	−.014
24	7½	.127	.109	.091	.053	.016	−.014	−.036	−.054
	37½	.127	.114	.101	.070	.045	−.008	−.021	−.054
	52½	.127	.117	.113	.086	.072	.019	.019	−.019
	82½	.127	.129	.130	.115	.101	.085	.095	.075
	97½	.127	.133	.133	.116	.101	.085	.093	.075
	127½	.127	.129	.128	.103	.084	.066	.066	.055
	142½	.127	.123	.116	.096	.076	.070	.068	.056
	172½	.127	.119	.113	.066	.036	.029	.063	.053
25	7½	.172	.168	.166	.142	.108	.072	.042	.022
	37½	.172	.170	.170	.156	.143	.104	.095	.064
	52½	.172	.170	.177	.164	.149	.145	.134	.116
	82½	.172	.172	.177	.164	.148	.147	.140	.136
	97½	.172	.172	.171	.162	.148	.142	.136	.131
	127½	.172	.165	.166	.152	.136	.131	.120	.120
	142½	.172	.163	.159	.149	.135	.132	.132	.126
	172½	.172	.160	.146	.115	.111	.132	.146	.136
26	7½	.215	.216	.216	.210	.199	.198	.190	.174
	37½	.215	.214	.213	.196	.174	.196	.203	.197
	52½	.215	.212	.206	.190	.174	.190	.203	.194
	82½	.215	.209	.201	.185	.169	.181	.197	.196
	97½	.215	.206	.198	.183	.167	.185	.195	.192
	127½	.215	.206	.198	.186	.177	.195	.197	.196
	142½	.215	.206	.198	.186	.182	.198	.203	.196
	172½	.215	.202	.201	.201	.202	.206	.211	.197

TABLE III-A

1/40-SCALE MODEL U. S. S. "AKRON"

AVERAGE PRESSURES—p'/q [1]

BARE HULL

$\theta = 0°$

Station No.	Cross-sectional area	q, lb./sq. ft.				
		8.0	12.7	18.2	21.4	24.7
	Sq. ft.					
1	0	1.001	1.005	1.003	----------	----------
2	.05	.848	.853	.849	0.852	0.842
3	.27	.631	.678	.687	.638	.673
4	.75	.390	.378	.391	.390	.387
5	1.51	.130	.122	.134	.128	.127
6	2.22	.013	.015	.018	.014	.017
7	3.40	−.053	−.041	−.035	−.036	−.036
8	4.83	−.155	−.150	−.146	−.153	−.155
9	6.11	−.148	−.140	−.146	−.152	−.150
10	7.06	−.127	−.128	−.130	−.131	−.128
11	7.87	−.125	−.125	−.130	−.127	−.130
12	8.36	−.105	−.100	−.105	−.103	−.104
13	8.60	−.068	−.066	−.073	−.070	−.072
14	8.60	−.057	−.058	−.061	−.060	−.063
15	8.40	−.065	−.075	−.075	−.073	−.076
16	7.76	−.072	−.077	−.076	−.073	−.079
17	6.54	−.076	−.078	−.077	−.071	−.073
18	5.50	−.051	−.052	−.052	−.049	−.052
19	4.55	−.031	−.033	−.033	−.030	−.037
20	3.68	.000	−.001	−.005	−.003	−.010
21	2.85	.029	.033	.024	.032	.024
22	2.07	.055	.058	.050	.057	.048
23	1.45	.087	.094	.087	.097	.091
24	.98	.119	.122	.120	.130	.125
25	.47	.163	.166	.166	.176	.169
26	.18	.205	.208	.207	.214	.212

[1] Values in each column are a mean of two independent observations.

TABLE III-B

AVERAGE PRESSURES $-p'/q$

BARE HULL

[$q = 25.2$ lb./sq. ft.]

Station No.	Angle of pitch—θ						
	3°	6°	9°	12°	15°	18°	20°
1	----------	0.942	0.840	0.682	0.434	0.098	−0.132
2	0.830	.793	.717	.656	.544	.455	.332
3	.671	.649	.609	.553	.490	.409	.340
4	.376	.353	.337	.238	.240	.193	.138
5	.127	.111	.096	.058	.028	−.024	−.059
6	.024	.014	−.003	−.039	−.061	−.103	−.137
7	−.031	−.034	−.055	−.077	−.098	−.137	−.157
8	−.150	−.160	−.178	−.199	−.221	−.261	−.286
9	−.150	−.157	−.170	−.189	−.202	−.236	−.254
10	−.131	−.138	−.160	−.173	−.192	−.211	−.232
11	−.132	−.133	−.150	−.178	−.184	−.212	−.229
12	−.101	−.104	−.129	−.156	−.171	−.217	−.233
13	−.078	−.075	−.097	−.114	−.132	−.172	−.195
14	−.076	−.075	−.087	−.108	−.123	−.170	−.189
15	−.090	−.087	−.100	−.120	−.144	−.176	−.197
16	−.090	−.092	−.103	−.125	−.149	−.185	−.198
17	−.087	−.090	−.113	−.131	−.153	−.188	−.210
18	−.060	−.069	−.092	−.113	−.140	−.170	−.190
19	−.042	−.049	−.075	−.101	−.129	−.147	−.180
20	−.016	−.018	−.048	−.070	−.098	−.123	−.149
21	.022	.018	−.013	−.034	−.065	−.088	−.114
22	.048	.039	.011	−.016	−.046	−.054	−.075
23	.088	.083	.055	.032	.004	.000	−.025
24	.125	.114	.088	.068	.045	.041	.025
25	.169	.165	.153	.137	.128	.115	.100
26	.210	.205	.192	.180	.196	.202	.196

TABLE IV

1/40-SCALE MODEL U. S. S. "AKRON"

LONGITUDINAL FORCE—P''/q

θ degs.	Pressure distribution [1]	Force tests	θ degs.	Pressure distribution [1]	Force tests
3	0.007	0.459	15	0.047	0.346
6	.064	.443	18	----------	.256
9	.001	.430	20	----------	.158
12	.025	.398			

[1] Mean of two speeds.

TABLE V

1/40-SCALE MODEL U. S. S. "AKRON"

TRANSVERSE FORCE PER FOOT LENGTH—f/q

BARE HULL

[$q = 25.2$ lb./sq. ft.]

Station No.	Angle of pitch—θ						
	3°	6°	9°	12°	15°	18°	20°
1	0	0	0	0	0	0	0
2	.014	.027	.047	.062	.076	.073	.000
3	.078	.146	.220	.255	.331	.404	.435
4	.184	.319	.470	.537	.666	.835	.918
5	.287	.461	.665	.770	.966	1.177	1.307
6	.305	.498	.735	.879	1.088	1.290	1.443
7	.280	.475	.715	.844	1.051	1.242	1.366
8	.269	.426	.650	.771	.913	1.104	1.239
9	.144	.317	.477	.585	.730	.858	.957
10	.162	.285	.390	.481	.570	.694	.720
11	.093	.189	.290	.340	.371	.528	.544
12	.078	.096	.165	.211	.206	.293	.298
13	.067	.031	.070	.107	.144	.160	.232
14	−.005	.028	.030	.046	.058	.065	.128
15	−.091	−.066	−.094	−.103	−.069	−.066	−.037
16	−.090	−.106	−.125	−.180	−.187	−.154	−.123
17	−.103	−.174	−.259	−.279	−.301	−.268	−.234
18	−.100	−.181	−.265	−.268	−.254	−.266	−.203
19	−.120	−.184	−.262	−.254	−.254	−.209	−.304
20	−.101	−.158	−.209	−.221	−.216	−.245	−.239
21	−.077	−.137	−.178	−.187	−.175	−.209	−.250
22	−.046	−.087	−.105	−.137	−.137	−.149	−.174
23	−.027	−.046	−.046	−.051	−.088	−.101	−.116
24	−.014	−.018	−.001	−.026	−.049	−.090	−.100
25	.001	.016	.006	.004	−.017	−.038	−.035
26	.006	.008	.007	.005	−.001	−.003	−.001

TABLE V—Continued

1/40-SCALE MODEL U. S. S. "AKRON"—Con.

[q=12.5 lb./sq. ft.]

Station No.	Angle of pitch—θ						
	3°	6°	9°	12°	15°	18°	20°
1	0	0	0	0	--------	--------	0
2	.018	.044	.043	.061	--------	--------	.095
3	.074	.150	.191	.266	--------	--------	.437
4	.183	.326	.413	.571	--------	--------	.895
5	.274	.459	.615	.822	--------	--------	1.309
6	.300	.496	.677	.898	--------	--------	1.423
7	.308	.475	.650	.869	--------	--------	1.379
8	.272	.447	.596	.806	--------	--------	1.296
9	.159	.344	.440	.606	--------	--------	1.031
10	.156	.274	.386	.456	--------	--------	.848
11	.071	.162	.224	.306	--------	--------	.662
12	.066	.103	.117	.227	--------	--------	.367
13	.060	.093	.084	.169	--------	--------	.276
14	−.002	.023	.021	.032	--------	--------	.151
15	−.090	−.066	−.110	−.105	--------	--------	−.009
16	−.106	−.110	−.132	−.158	--------	--------	−.112
17	−.111	−.182	−.265	−.244	--------	--------	−.184
18	−.122	−.178	−.261	−.291	--------	--------	−.211
19	−.145	−.211	−.254	−.222	--------	--------	−.281
20	−.097	−.175	−.204	−.206	--------	--------	−.251
21	−.084	−.141	−.176	−.159	--------	--------	−.222
22	−.038	−.101	−.103	−.114	--------	--------	−.164
23	−.015	−.035	−.028	−.029	--------	--------	−.136
24	−.003	−.009	.006	.002	--------	--------	−.110
25	.021	.025	.031	.018	--------	--------	−.055
26	.005	.014	.014	.008	--------	--------	−.009

TABLE VI

1/40-SCALE MODEL U. S. S. "AKRON"

TRANSVERSE FORCE PER FOOT LENGTH—f/q ON HULL WITH TAIL SURFACES AND CONTROL CAR

[Elevators neutral; q=25.2 lb./sq. ft.]

Station No.	Angle of pitch—θ						
	3°	6°	9°	12°	15°	18°	20°
1	0	0	0	0	0	0	0
2	.012	.031	.048	.066	.079	.077	.096
3	.055	.123	.204	.268	.333	.354	.432
4	.144	.269	.428	.571	.702	.783	.916
5	.164	.377	.625	.831	1.033	1.127	1.330
6	.217	.440	.716	.885	1.104	1.232	1.470
7	.251	.416	.686	.871	1.077	1.198	1.360
8	.211	.367	.568	.759	.909	1.008	1.232
9	.301	.360	.574	.654	.829	.937	.995
10	.078	.194	.363	.490	.587	.650	.823
11	.182	.231	.262	.327	.484	.493	.630
12	.039	.071	.160	.165	.245	.339	.389
13	.028	.015	.046	.107	.107	.183	.286
14	.007	−.009	−.012	−.009	.051	.109	.139
15	−.055	−.105	−.111	−.139	−.080	−.039	.046
16	−.070	−.147	−.180	−.156	−.077	−.086	.000
17	−.079	−.141	−.141	−.208	−.168	−.135	−.069
18	−.043	−.069	−.068	−.046	.000	.115	.164
19	−.085	−.057	−.005	.083	.198	.287	.299
20	−.037	−.018	.021	.133	.221	.361	.412
21	−.024	−.036	.005	.097	.136	.252	.299
22	−.009	−.002	.024	.101	.120	.194	.227
23	−.010	−.017	.014	.069	.058	.103	.124
24	.006	.021	.057	.055	.082	.072	.090
25	.006	.017	.050	.054	.043	.028	.023
26	−.001	.007	.021	.015	−.006	.000	−.006

[Elevators neutral; q=12.5 lb./sq. ft.]

Station No.	Angle of pitch—θ						
	3°	6°	9°	12°	15°	18°	20°
1	0	0	0	0	0	0	0
2	.016	.037	.044	.068	.078	.086	.094
3	.075	.154	.195	.268	.346	.378	.417
4	.177	.338	.424	.582	.703	.788	.874
5	.231	.469	.613	.841	1.025	1.133	1.258
6	.268	.488	.692	.906	1.150	1.230	1.377
7	.288	.472	.660	.872	1.065	1.217	1.310
8	.206	.409	.575	.765	.891	1.013	1.150
9	.288	.373	.571	.655	.819	.889	.922
10	.068	.236	.333	.470	.597	.610	.739
11	.169	.211	.222	.338	.460	.495	.561
12	.027	.114	.156	.229	.232	.339	.291
13	.000	.021	.053	.095	.114	.146	.186
14	.007	.011	−.019	.035	.081	.086	.137
15	−.053	−.110	−.101	−.114	−.039	−.032	.046
16	−.077	−.110	−.145	−.154	−.066	−.092	−.029
17	−.071	−.141	−.135	−.180	−.157	−.101	−.075
18	−.053	−.096	−.056	−.039	.024	.081	.144
19	−.085	−.081	.005	.071	.179	.304	.316
20	−.026	−.023	.006	.102	.224	.332	.377
21	−.036	−.027	.001	.099	.154	.236	.300
22	.000	−.015	.031	.082	.113	.178	.214
23	−.013	−.002	.028	.057	.070	.094	.106
24	.005	.021	.058	.062	.070	.066	.079
25	.005	.022	.050	.054	.037	.028	.013
26	.000	.008	.015	.013	−.001	−.002	−.009

TABLE VIII

1/40-SCALE MODEL U. S. S. "AKRON"

TRANSVERSE FORCE PER FOOT LENGTH-f/q ON HULL WITH TAIL SURFACES AND CONTROL CAR

[Elevators 20° up]

Station No.	q=12.8 lb./sq. ft.				q=22.8 lb./sq. ft.			
	θ				θ			
	0°	6°	15°	20°	0°	6°	15°	20°
1	0	0	0	0	0	0	0	0
2	−.003	.035	.077	.098	−.001	.031	.068	.090
3	−.003	.137	.350	.422	−.007	.135	.314	.421
4	.012	.303	.740	.903	.008	.305	.671	.924
5	.014	.468	1.068	1.296	.029	.454	.963	1.320
6	.015	.505	1.177	1.391	.039	.503	1.042	1.383
7	.051	.506	1.111	1.337	.022	.518	1.010	1.299
8	.026	.416	.955	1.128	.016	.433	.851	1.143
9	.114	.411	.834	.958	.123	.434	.734	.900
10	−.027	.211	.555	.715	−.023	.228	.477	.682
11	.036	.169	.442	.542	.055	.173	.362	.513
12	.023	.099	.280	321	.032	.064	.149	.293
13	.023	.053	.097	.197	.039	.060	.046	.172
14	.000	.005	.012	.174	.002	.002	.007	.148
15	−.039	−.059	−.048	.069	−.023	−.091	−.119	.064
16	−.011	−.112	−.165	.018	−.024	−.159	−.165	−.004
17	−.055	−.152	−.166	−.036	−.069	−.164	−.212	−.109
18	−.020	−.074	.000	.206	−.028	−.087	−.030	.148
19	−.112	−.110	.178	.338	−.086	−.071	.152	.270
20	−.111	−.085	.152	.320	−.067	−.070	.140	.318
21	−.149	−.109	.088	.212	−.080	−.108	.083	.259
22	−.134	−.138	−.025	.066	−.164	−.125	−.016	.084
23	−.089	−.066	−.028	.021	−.081	−.029	−.040	.062
24	−.035	−.008	.028	.028	−.032	−.020	−.053	.026
25	.001	.016	.048	.024	−.009	.033	.047	.015
26	.003	.012	.008	−.002	−.010	.018	.011	−.003

TABLE VII

1/40-SCALE MODEL U. S. S. "AKRON"

TRANSVERSE FORCE PER FOOT LENGTH-f/q ON HULL WITH TAIL SURFACES AND CONTROL CAR

[Elevators 20° down]

Station No.	q=12.8 lb./sq. ft.				q=22.8 lb./sq. ft.			
	θ				θ			
	0°	6°	15°	20°	0°	6°	15°	20°
1	0	0	0	0	0	0	0	0
2	−.001	.035	.084	.093	.001	.037	.079	.094
3	−.003	.142	.348	.421	.000	.150	.333	.433
4	.008	.303	.717	.897	.017	.309	.709	.906
5	.022	.441	1.000	1.297	.023	.445	1.000	1.293
6	.048	.496	1.104	1.432	.047	.518	1.112	1.418
7	.058	.477	1.096	1.379	.076	.480	1.075	1.346
8	.043	.412	.902	1.199	.057	.422	.921	1.176
9	.143	.442	.829	1.080	.164	.461	.842	1.023
10	−.021	.196	.567	.770	.002	.224	.565	.770
11	.029	.204	.417	.573	.060	.220	.441	.561
12	.023	.101	.206	.353	.028	.094	.245	.312
13	.018	.067	.116	.155	.028	.060	.146	.234
14	−.007	.032	.065	.123	.007	.035	.095	.142
15	−.034	−.073	−.062	.032	−.018	−.057	−.075	.014
16	−.031	−.174	−.090	−.009	−.022	−.079	−.088	.013
17	−.034	−.091	−.143	−.061	−.012	−.125	−.135	−.061
18	.052	.013	.092	.252	.041	.000	.102	.227
19	.008	.064	.308	.431	.024	.042	.279	.426
20	.064	.113	.434	.650	.096	.118	.410	.610
21	.120	.131	.393	.516	.133	.145	.373	.514
22	.155	.192	.38[illegible]	.512	.168	.190	.395	.503
23	.087	.122	.275	.317	.096	.122	.265	.313
24	.050	.075	.164	.167	.046	.075	.163	.151
25	.005	.044	.049	.044	.005	.046	.058	.033
26	−.006	.011	.001	−.005	−.007	.011	.000	−.003