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REPORT NO. 4744

DATE March 13, 1942

AIR CORPS TECHNICAL REPORT

Five-Foot Wind Tunnel Test No. 277

TEST OF 1/36-SCALE MODEL OF GOODYEAR BARRAGE BALLOON, FOR BOTH DEFLATED AND ATED ENVELOPES WITH LARGE AND SMALL FINS.

TITLE

RESTRICTED

WAR DEPARTMENT
AIR CORPS, MATERIEL DIVISION
WRIGHT FIELD, DAYTON, OHIO

MDAC-361-WF-5-15-40-10M

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DATE March 13, 1942

WAR DEPARTMENT
AIR CORPS
MATERIEL DIVISION
DAYTON, OHIO

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AIR CORPS TECHNICAL REPORT

No. 474b

TEST OF 1/36-SCALE MODEL OF GOODYEAR BARRAGE BALLOON, FOR BOTH DEFLATED & DILATED ENVELOPES WITH LARGE & SMALL FINS.
The
(FIVE-FOOT WIND TUNNEL TEST NO. 277)

BY

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TEST OF 1/36-SCALE MODEL GOODYEAR BARRAGE BALLOON, FOR BOTH DEFLATED AND DILATED ENVELOPES WITH LARGE AND SMALL FINS. (FIVE-FOOT WIND TUNNEL TEST NO. 277)

SUMMARY

The Goodyear barrage balloon models which were submitted by the Goodyear Tire and Rubber Company were tested to determine their longitudinal and directional stability.

Two different envelopes were used, one to represent the low-altitude or deflated condition, while the other represented the high-altitude or dilated condition. The deflated envelope was tested with only small fins, whereas the dilated envelope was tested with both small and large fins. Finally a suspension curtain was added to the models to determine its effect on stability.

Results of these tests indicate that the dilated envelope with the large fins is directionally stable about the flying cable junction at 0, +10, and +20 degrees pitch throughout the range of yaw angles tested, namely -20 to +20 degrees. At zero degrees pitch the degree of directional stability is small for angles of yaw from -2 to +2 degrees. The model is longitudinally stable throughout the range of pitch angles tested, -20 to +20 degrees.

The dilated envelopes with the small fins is directionally stable about the flying cable junction at +20 degrees pitch for yaw angles from -20 to +20 degrees. For a pitch angle of +10 degrees there is a range of

neutral directional stability from -2 to +2 degrees yaw. At zero degrees pitch the model is unstable directionally from -2 to +3 degrees yaw. The model is longitudinally stable about the cable junction for all angles of pitch -20 to +20 degrees except for a range of pitch angles from -2 to +2 degrees, where the model is slightly unstable.

Comparison of the directional stability of the deflated envelope with that of the dilated envelope, each with small fins, shows a slight increase in stability for the deflated envelope.

The addition of suspension curtain to both the dilated and deflated envelopes with small fins, caused a slight reduction in both the directional and longitudinal stabilities.

DATES AND PLACES OF TEST

This test was conducted in the five-foot wind tunnel at Wright Field from January 1st to 10th and from March 15th to 19th, 1941.

OBJECT

The object of this test was to determine the aerodynamic characteristics of the Goodyear barrage balloon with different size fins.

DESCRIPTION OF MODEL

The envelope and fins were made of mahogany and the envelope hollowed out to a wall thickness of approximately .8 inch. The envelope representing the deflated condition had a maximum diameter of 8.57 inches and a length of 26.53 inches. The dilated envelope had a maximum diameter of 9.10 inches and a length of 25.83 inches. Four large fins and four small fins were used, with the two sets being interchangeable on the two envelopes. The seams of the fins were made to run parallel to the contour of the envelope at the point of attachment. The suspension curtain

was represented on the models by an aluminum alloy strip on either side. The details of these strips can be seen in the photographs included at the end of this report.

PROCEDURE

The models were mounted on the N.P.L. balance by a 7/16 inch diameter spindle attached at the center of buoyancy of the envelope or referred to later in this report as the "C.R." or "center of rotation." The C.R. of the dilated model was located 9.956 inches aft of nose on the centerline of the envelope and 10.520 inches aft for the deflated envelope. The cable junction about which the full scale balloon is expected to be flown, is 8.00 inches aft of the nose of the model and 10.00 inches below the centerline of the model. The test airspeed was 50 miles per hour for all tests.

For each of the conditions tested cross wind force, drag, and yawing moments about the C.R. were observed for a range of yaw angles from 0 to ±20 degrees with the model set at 0, +10, and +20 degrees pitch. The model was symmetrical in all four quadrants for the tests without the suspension curtain, hence the pitching moments were not measured but merely assumed to be equal to the corresponding yawing moments. With the suspension curtain attached, this symmetry did not exist, hence the model was also tested for pitching moments as well as lift and drag. The range of pitch angles was from 0 to ±20 degrees at zero degrees yaw.

Tests were made to determine support interference and data were corrected for these effects.

DISCUSSION OF RESULTS

The first model condition tested was the dilated envelope with large fins, graphs 1, 2, 3, 4, 29, and 30. The yawing moments about the center

of buoyancy of the envelope are given on graph 1 while graphs 29 and 30 are a plot of the yawing and pitching moments about the flying cable junction. Since this point is forward of the center of buoyancy, an increase in stability would be expected. The model is directionally stable for this condition, graph 29 for yaw angles from -20 to +20 degrees, at 0, +10, and +20 degrees pitch. The pitching moment curve on graph 30 indicated the model is longitudinally stable for the range of pitch angles tested, -20 to +20 degrees. This curve has very little slope in the region of zero degrees pitch, however the balloon is expected to be flown at approximately +13 degrees pitch, where the slope is satisfactory.

The second condition tested was the deflated envelope with small fins, graphs 5, 6, 7, and 8. No transfer of moments was made for this condition, but comparisons can be made by using the moments about the center of buoyancy, which are plotted. Sufficient data are given in this report to obtain the vectors and transfer of moments for any condition tested.

The third condition was for the dilated envelope with small fins, graphs 9, 10, 11, 12, 31, and 32. Graph 9 is a plot of the yawing moments about the center of buoyancy while graphs 31 and 32 are moments about the flying cable junction. Inspection of graph 31 shows the model is directionally stable at +20 degrees pitch for all yaw angles. At 10 degrees pitch it is stable except for a range of yaw angles from -2 to +2 degrees, where the stability is about neutral. At 0 degrees pitch the model is unstable for yaw angles from -2 to +2 degrees but satisfactory for the larger angles. The pitching moment curve on graph 32 indicates satisfactory longitudinal stability for all pitch angles tested, except those from -2 to +2 degrees. A comparison of graphs 9 and 5 shows

a slight increase in directional stability for the deflated envelope.

The fourth condition was the same as condition three, dilated envelope with small fins, but a suspension curtain was placed on the sides of the model, graphs 13 through 20. Comparison of graphs 9, 13, and 17 indicates a slight reduction in both directional and longitudinal stabilities due to the addition of the suspension curtain.

The last condition was the deflated envelope, with small fins and suspension curtain, graphs 21 through 25. As in the previous condition the suspension curtain caused a slight reduction in directional and longitudinal stability. This is shown by a comparison of graphs 5, 21, and 25.

CONCLUSIONS

(1) Both directional and longitudinal stabilities are definitely improved by the larger fins, however the small fins should provide sufficient stability about the flying cable junction, if the balloon is flown at a pitch angle of approximately +13 degrees or more.

(2) A slight increase in directional and longitudinal stabilities should exist for the deflated envelope over the dilated envelope provided the pitch angle does not decrease as the balloon is lowered.

(3) Addition of the suspension curtain to the model tends to reduce both directional and longitudinal stabilities slightly.

WIND TUNNEL NOMENCLATURE

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d	= diameter of wind tunnel at test section = 5 ft.
S	= wing area — sq. ft.
b	= wing span—ft.
c	= mean aerodynamic chord—ft. (m. a. c.)
E. M. A. R.	= equivalent monoplane aspect ratio
α	= angle of attack of longitudinal reference axis to wind—deg.
Ψ	= angle of yaw relative to wind—deg.
δ_R	= angle of rudder relative to neutral position—deg.
δ_E	= angle of elevator relative to stabilizer—deg.
i_t	= angle of stabilizer relative to longitudinal reference axis—deg.
v	= airspeed—ft per sec.
V	= airspeed—m. p. h.
W	= weight of full scale airplane—lb.
M	= pitching moment—lb.-ft.
N	= yawing moment—lb.-ft.
L	= rolling moment—lb.-ft.
ρ	= mass density of air—slugs per cu. ft. = .002378 (standard air)
q	= $\rho v^2/2$ — lb. per sq. ft.
C_L	= lift coefficient = Lift/qS
C_D	= drag coefficient = Drag/qS
C_C	= cross-wind force coefficient = Cross-wind force /qS
$\Delta\alpha$	= Prandtl's wall correction for angle of attack $= \frac{57.3\, S\, C_L}{2\pi d^2}\left[1+\frac{3}{16}\left(\frac{b}{d}\right)^2+\ldots\right]$
ΔC_D	= Prandtl's wall correction for drag coefficient $= \frac{S\, C_L^2}{2\pi d^2}\left[1+\frac{3}{16}\left(\frac{b}{d}\right)^2+\ldots\right]$
L/D	= lift/drag ratio = C_L/C_D
C_m	= pitching moment coefficient = M/qcS
C_n	= yawing moment coefficient = N/qbS
C_l	= rolling moment coefficient = L/qbS
$\Delta C_m/\Delta\alpha$	= slope of "pitching moment versus angle of attack" curve at trim
$\Delta C_n/\Delta\Psi$	= slope of "yawing moment versus angle of yaw" curve at zero yaw
$\Delta C_n/\Delta\delta_R$	= slope of "yawing moment due to rudder versus rudder angle" curve at zero rudder angle
C_{D_i}	= induced drag coefficient $= \frac{C_L^2}{\pi \times E.M.A.R.}$
C_{D_o}	= profile drag coefficient
C_{D_p}	= parasite drag coefficient = $C_D - (C_{D_i} + C_{D_o})$
A_e	= equivalent flat plate area = C_{D_p} S/1.279

Postive distances are upstream, upward and to right viewed from the rear
Positive forces are downstream, upward and to right viewed from the rear
Positive pitching moment is a stalling moment
Positive yawing moment is clockwise viewed from above
Positive rolling moment is clockwise viewed from the rear
Positive angles are in the same direction as moments
Positive stabilizer setting is with leading edge up referred to longitudinal reference axis
Positive elevator setting is with trailing edge down referred to stabilizer
Positive rudder setting is with trailing edge left referred to neutral position and viewed from the rear
Angle of attack of thrust line is referred to wind

TABLE I

GOODYEAR BARRAGE BALLOON

DILATED CONDITION - 4 LARGE FINS

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, January 6, 1941
Plotted on Graphs 1, 2, 3, and 4.

Angle of Yaw	0° Pitch				+10° Pitch				+20° Pitch			
	Cross Wind Force Lb.	Drag Lb.	C/D	Yaw Moment About C.R. Lb.- In.	Cross Wind Force Lb.	Drag Lb.	C/D	Yaw Moment About C.R. Lb. - In.	Cross Wind Force Lb.	Drag Lb.	C/D	Yaw Moment About C.R. Lb. - In.
0°	-.073	.309	-.22	+.47	-.099	.417	-.24	+.59	-.134	1.169	-.11	+1.08
+2	+.149	.309	+.48	.75	+.161	.420	+.38	.41	+.164	1.174	+.14	.14
4	.460	.326	1.41	.24	.446	.432	1.03	.11	.483	1.198	.36	-.89
6	.821	.354	2.32	-.69	.738	.460	1.60	-.36	.842	1.241	.68	-2.24
10	1.508	.450	3.35	-2.57	1.438	.545	2.64	-2.57	1.533	1.351	1.14	-4.81
15	2.362	.678	3.43	-6.05	2.294	.789	2.91	-6.17	2.397	1.602	1.50	-9.26
20	3.526	1.177	3.00	-13.04	3.348	1.344	2.49	-12.69	3.090	2.187	1.41	-13.27
-2	-.337	.320	-1.05	+.58	-.362	.428	-.85	+1.07	-.418	1.184	-.35	+1.94
-4	-.677	.339	-2.00	1.38	-.662	.445	-1.49	1.58	-.769	1.220	-.63	3.09
-6	-1.002	.369	-2.72	2.21	-.950	.472	-2.01	2.08	-1.098	1.276	-.86	4.30
-10	-1.648	.471	-3.50	4.00	-1.624	.571	-2.84	4.39	-1.752	1.398	-1.25	6.87
-15	-2.549	.706	-3.61	7.56	-2.540	.832	-3.05	8.30	-2.687	1.663	-1.61	11.56
-20	-3.092	1.300	-2.84	14.91	-3.544	1.450	-2.44	14.88	-3.241	2.250	-1.44	14.78

TABLE II
GOODYEAR BARRAGE BALLOON
DEFLATED CONDITION - 4 SMALL FINS

50 M.P.H (St'd-Air)
Test No. 277

Wright Field, January 9, 1941
Plotted on Graphs 5,6,7, and 8.

Angle of Yaw	0° Pitch				±10° Pitch				+20° Pitch			
	Cross Wind Force Lb.	Drag Lb.	C_D	Yaw Moment About C.R. Lb.- In.	Cross Wind Force Lb.	Drag Lb.	C_D	Yaw Moment About C.R. Lb.- In.	Cross Wind Force Lb.	Drag Lb.	C_D	Yaw Moment About C. R. Lb. - In.
°												
0	+.010	.273	+.04	-.47	+.038	.377	+.10	-.68	+.061	.893	+.07	-.92
+2	.218	.285	.76	-.29	.208	.382	.54	-.34	.253	.908	.28	-.82
4	.442	.294	1.50	-.33	.412	.398	1.04	-.21	.464	.932	.50	-.89
6	.688	.324	2.12	-.45	.645	.428	1.51	-.28	.706	.962	.73	-1.11
10	1.220	.413	2.95	-1.27	1.179	.522	2.26	-1.23	1.197	1.052	1.14	-1.93
15	2.062	.641	3.22	-4.19	1.894	.732	2.59	-3.14	1.898	1.854	1.51	-3.97
20	2.878	.992	2.90	-7.68	2.814	1.124	2.50	-7.99	2.638	1.595	1.65	-7.45
-2	-.200	.278	- .72	-.60	-.162	.379	-.43	-.88	-.147	.902	-.16	-.55
-4	-.447	.292	-1.53	-.56	-.378	.393	-.96	-1.00	-.397	.921	-.43	-.56
-6	-.703	.324	-2.17	-.26	-.632	.427	-1.48	-.60	-.646	.952	-.68	-.22
-10	-1.259	.421	-2.99	+.86	-1.187	.518	-2.29	+.56	-1.152	1.038	-1.11	+.81
-15	-2.059	.646	-3.19	3.43	-1.910	.726	-2.63	2.55	-1.809	1.238	-1.46	2.56
-20	-2.909	1.006	-2.89	7.22	-2.814	1.121	-2.51	7.10	-2.593	1.586	-1.64	6.43

TABLE III

GOODYEAR BARRAGE BALLOON

DILATED CONDITION - 4 SMALL FINS

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, January 10, 1941
Plotted on Graphs 9,10,11, and 12.

Angle of Yaw	0° Pitch				+10° Pitch				+20° Pitch			
	Cross Wind Force Lb.	Drag Lb.	$C_{/D}$	Yaw Moment About C.R. Lb. - In	Cross Wind Force Lb.	Drag Lb.	$C_{/D}$	Yaw Moment About C.R. Lb. - In	Cross Wind Force Lb.	Drag Lb.	$C_{/D}$	Yaw Moment About C.R. Lb. - In.
0°												
0	-.033	+.306	-.11	-.19	-.023	+.414	-.06	-.23	-.019	.935	-.02	-.43
+2	+.135	.310	+.44	+.47	+.152	.418	+.36	+.20	+.173	.942	+.18	-.15
4	.368	.322	1.14	.49	.353	.432	.82	.41	.368	.958	.38	-.15
6	.641	.350	1.83	.21	.588	.461	1.28	.47	.600	.979	.61	-.21
10	1.210	.440	2.75	-.73	1.157	.550	2.10	-.75	1.106	1.070	1.03	-1.10
15	1.971	.639	3.07	-2.78	1.941	.751	2.71	-3.18	1.860	1.273	1.46	-3.88
20	2.807	.982	2.86	-6.63	2.797	1.103	2.54	-7.48	2.682	1.625	1.65	-8.21
-2	-.214	.312	-.69	-.42	-.234	.426	-.55	-.44	-.220	.943	-.23	-.35
-4	-.529	.333	-1.59	-.02	-.479	.439	-1.09	-.29	-.450	.959	-.47	-.27
-6	-.803	.367	-2.19	+.36	-.734	.472	-1.55	-.14	-.688	.989	-.70	+.01
-10	-1.378	.461	-2.99	1.45	-1.320	.575	-2.30	+1.30	-1.205	1.083	-1.11	1.05
-15	-2.121	.663	-3.35	3.52	-2.071	.795	-2.60	3.74	-1.949	1.301	-1.50	3.84
-20	-2.992	1.054	-2.84	7.90	-2.959	1.171	-2.53	8.59	-2.776	1.659	-1.67	8.27

TABLE IV

GOODYEAR BARRAGE BALLOON

DILATED CONDITION - 4 SMALL FINS WITH SUSPENSION CURTAIN

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, March 18, 1941
Plotted on Graphs 13, 14, 15, and 16.

Angle of Yaw	0° Pitch				+10° Pitch				+20° Pitch			
	Cross Wind Force Lb.	Drag Lb. (Net)	C/D	Yaw Moment About C. R. Lb.-In.	Cross Wind Force Lb.	Net Drag Lb.	C/D	Yaw Moment About C. R. Lb. In.	Cross Wind Force Lb.	Net Drag Lb.	C/D	Yaw Moment About C. R. Lb. - In
0°	-.003	.323	-.01	+.10	-.008	.468	-.02	-.27	-.008	1.049	-.01	-.41
+2	+.187	.331	+.56	.66	+.168	.473	+.35	+.28	+.166	1.058	+.16	-.18
4	.415	.349	1.19	.62	.363	.490	.74	.51	.329	1.071	.31	+.12
6	.719	.382	1.88	.23	.605	.511	1.18	.54	.558	1.101	.51	.13
10	1.300	.480	2.71	-.75	1.172	.601	1.95	-.44	1.014	1.173	.87	-.44
15	2.104	.697	3.02	-2.98	1.951	.811	2.41	-2.79	1.754	1.364	1.29	-3.05
20	2.999	1.070	2.80	-7.34	2.828	1.189	2.38	-7.36	2.545	1.701	1.50	-2.00
-2	-.201	.333	-.60	-.40	-.211	.477	-.44	-.44	-.199	1.053	-.19	-.52
-4	-.500	.357	-1.40	-.16	-.470	.494	-.95	-.26	-.408	1.062	-.38	-.53
-6	-.757	.385	-1.97	+.29	-.709	.522	-1.36	-.21	-.626	1.093	-.57	-.41
-10	-1.346	.487	-2.77	1.32	-1.275	.621	-2.05	+.99	-1.140	1.183	-.96	+.66
-15	-2.089	.692	-3.02	3.22	-2.052	.841	-2.44	3.30	-1.831	1.382	-1.32	3.17
-20	-3.016	1.079	-2.79	7.63	-2.950	1.235	-2.39	7.91	-2.682	1.751	-1.53	7.51

TABLE V

GOODYEAR BARRAGE BALLOON

DIRATED CONDITION - 4 SMALL FINS

WITH SUSPENSION CURTAIN

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field March 18, 1941
Plotted on Graphs 17,18,19, and 20

Angle of Pitch	0° YAW			
	Lift Lb.	Net Drag Lb.	L/D	Pitching Moment About C.R.
0°	+.011	.336	+.03	-.02
+2	.224	.338	.66	+.37
4	.448	.356	1.26	.47
6	.706	.382	1.85	.34
10	1.286	.483	2.66	-.57
15	2.021	.698	2.90	-1.95
20	2.937	1.085	2.71	-6.43
-2	-.198	.336	-.59	-.53
-4	-.452	.353	-1.28	-.49
-6	-.745	.391	-1.91	-.19
-10	-1.345	.501	-2.68	+.94
-15	-2.116	.738	-2.87	2.86
-20	-3.019	1.122	-2.47	7.03

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TABLE VI

GOODYEAR BARRAGE BALLOON

DEFLATED CONDITION - 4 SMALL FINS

WITH SUSPENSION CURTAIN

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, March 19, 1941
Plotted on Graphs 21,22,23, and 24.

Angle of Yaw	0° Pitch				+10° Pitch				+20° Pitch			
	Cross Wind Force Lb.	Net Drag Lb.	C/D	Yaw Moment About C.R. Lb.-In.	Cross Wind Force Lb.	Net Drag Lb.	C/D	Yaw Moment About C.R. Lb. - In.	Cross Wind Force Lb.	Net Drag Lb.	C/D	Yaw Moment About C.R. Lb.- In.
0°	+.006	.308	+.02	-.46	+.033	.436	+.08	-.60	+.041	1.016	+.04	-.69
+2	.232	.317	.73	-.31	.205	.443	.46	-.12	.225	1.020	.22	-.52
4	.466	.331	1.41	-.31	.406	.457	.89	+.10	.438	1.040	.42	-.47
6	.721	.363	1.99	-.41	.646	.490	1.32	.07	.657	1.064	.62	-.48
10	1.289	.465	2.76	-1.22	1.186	.588	2.02	-.38	1.102	1.149	.96	-.63
15	2.117	.685	3.09	-3.78	1.972	.809	2.44	-3.23	1.833	1.353	1.35	-3.14
20	2.984	1.062	2.81	-7.30	2.876	1.191	2.41	-7.58	2.592	1.690	1.53	-6.68
-2	-.217	.312	-.70	-.51	-.162	.441	-.37	-.87	-.148	1.019	-.15	-.90
-4	-.471	.331	-1.42	-.46	-.381	.455	-.84	-1.12	-.367	1.028	-.36	-.91
-6	-.726	.371	-1.96	-.42	-.667	.490	-1.36	-.66	-.583	1.050	-.56	-.83
-10	-1.313	.467	-2.81	+.73	-1.204	.585	-2.06	+.28	-1.044	1.124	-.93	-.52
-15	-2.089	.685	-3.05	2.80	-1.973	.802	-2.46	2.47	-1.791	1.318	-1.36	+1.09
-20	-2.980	1.059	-2.81	6.60	-2.888	1.197	-2.41	6.98	-2.557	1.656	-1.54	5.62

TABLE VII

GOODYEAR BARRAGE BALLOON

DEFLATED CONDITION - 4 SMALL FINS

WITH SUSPENSION CURTAIN

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, March 19, 1941
Plotted on Graphs 25,26,27, and 28.

Angle of Pitch	0° YAW			
	Lift Lb.	Net Drag Lb.	L/D	Pitching Moment About C.R.
0°	+.030	.303	+.1	-.17
+2	+.222	.311	.72	+.22
4	+.451	.329	1.36	+.21
6	+.706	.360	1.96	+.13
10	+1.265	.447	2.83	-.71
15	+2.066	.676	3.06	-3.09
20	+2.990	1.081	2.76	-7.09
-2	-.178	.309	-.58	-.57
-4	-.416	.325	-1.28	-.73
-6	-.699	.360	-1.94	-.46
-10	-1.271	.461	-2.76	+.50
-15	-2.051	.701	-2.92	+2.43
-20	-2.944	1.087	-2.71	+6.20

TABLE VIII

GOODYEAR BARRAGE BALLOON

DILATED CONDITION - 4 LARGE FINS

MOMENTS ABOUT CABLE JUNCTION

50 M.P.H. (St'd-Air)
Test No. 277

Wright Field, January 6, 1941
Plotted on Graphs 29 and 30.

Angle of Yaw Degrees	0° Pitch Yawing Moment Lb.-In.	+10° Pitch Yawing Moment Lb.-In.	+20° Pitch Yawing Moment Lb.-In.
0	.00	.00	.00
+2	-.17	-.71	-1.10
4	-1.32	-1.60	-3.35
6	-2.97	-2.68	-5.49
10	-6.22	-6.33	-9.61
15	-12.50	-11.70	-16.03
20	-20.96	-20.56	-21.62
-2	+.66	+1.03	+1.56
-4	2.16	2.16	3.44
-6	3.63	3.27	5.37
-10	6.76	7.06	9.43
-15	12.64	12.74	16.22
-20	22.07	21.58	20.94

Angle of Pitch Degrees	0° Yaw Pitching Moment Lb.-In.
0	+3.70
+2	+3.43
4	2.29
6	.31
10	-3.82
15	-10.23
20	-21.00
-2	+4.35
-4	5.59
-6	6.87
-10	9.12
-15	12.98
-20	21.82

TABLE IX

GOODYEAR BARRAGE BALLOON

DILATED CONDITION - 4 SMALL FINS

MOMENTS ABOUT CABLE JUNCTION

50 M.P.H. (St'd-Air)
Test No. 277

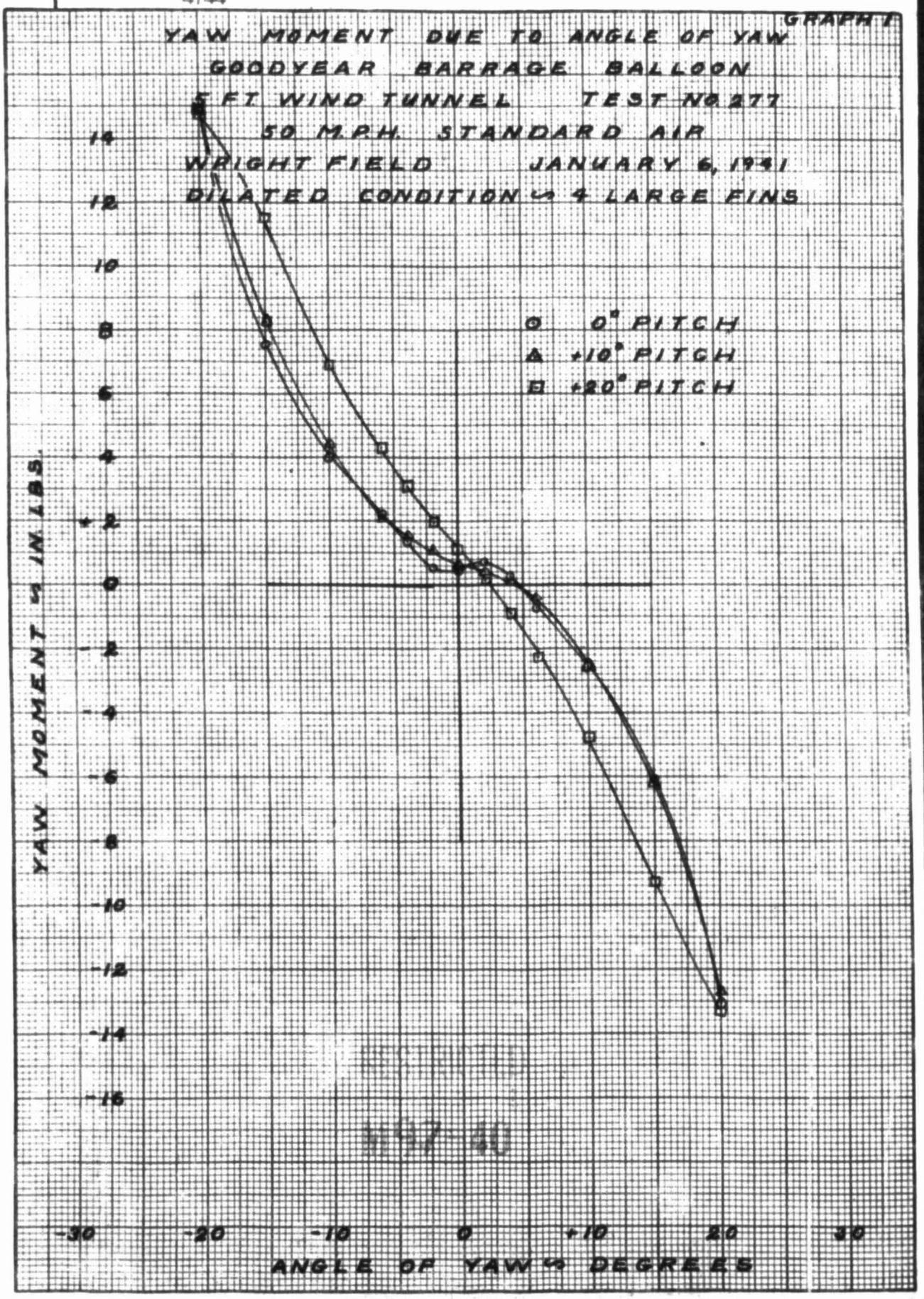
Wright Field, January 10, 1941
Plotted on Graphs 31 and 32.

Angle of Yaw Degrees	0° Pitch Yawing Moment Lb.-In.	+10° Pitch Yawing Moment Lb.-In.	+20° Pitch Yawing Moment Lb.-In.
0	.00	.00	.00
+2	+.31	+.06	-.16
4	-.15	-.15	-.61
6	-.97	-.58	-1.19
10	-3.01	-2.98	-3.19
15	-6.72	-7.02	-7.68
20	-12.33	-13.29	-13.84
-2	+.14	+.23	+.55
-4	1.18	.89	1.15
-6	2.13	1.57	1.97
-10	4.36	4.23	4.17
-15	8.01	8.28	8.62
-20	14.21	15.02	15.01

Angle of Pitch Degrees	0° Yaw Pitching Moment Lb.-In.
0	+3.00
+2	3.16
4	2.69
6	1.68
10	-2.14
15	-5.88
20	-12.79
-2	+3.09
-4	4.05
-6	4.97
-10	6.53
-15	8.58
-20	13.97

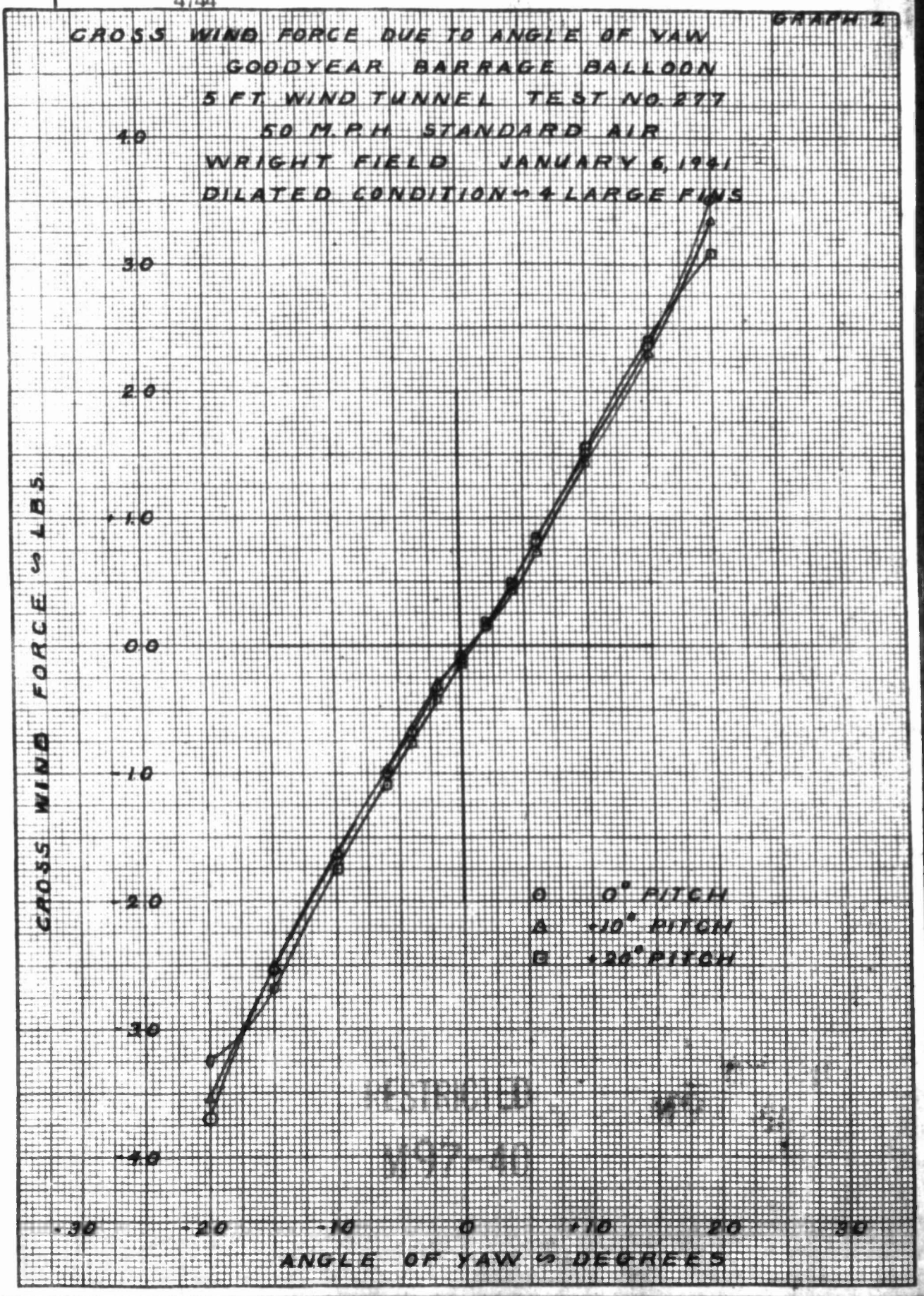
GRAPH 1

YAW MOMENT DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1931
DILATED CONDITION - 4 LARGE FINS



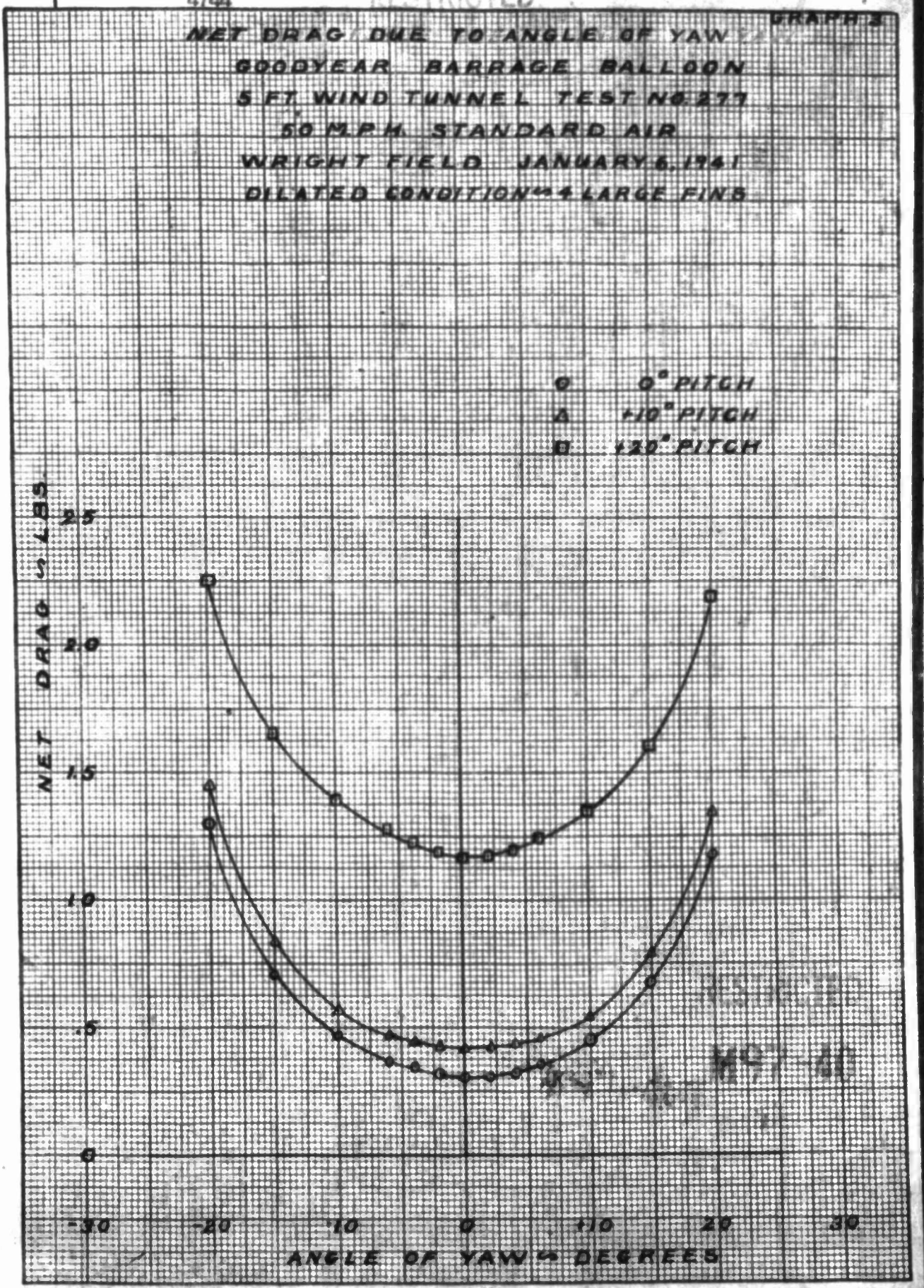
GRAPH 2

GROSS WIND FORCE DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1941
DILATED CONDITION - 4 LARGE FINS



GRAPH 2

NET DRAG DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1941
DILATED CONDITION + 4 LARGE FINS



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GRAPH 4

C/D VS. ANGLE OF YAW

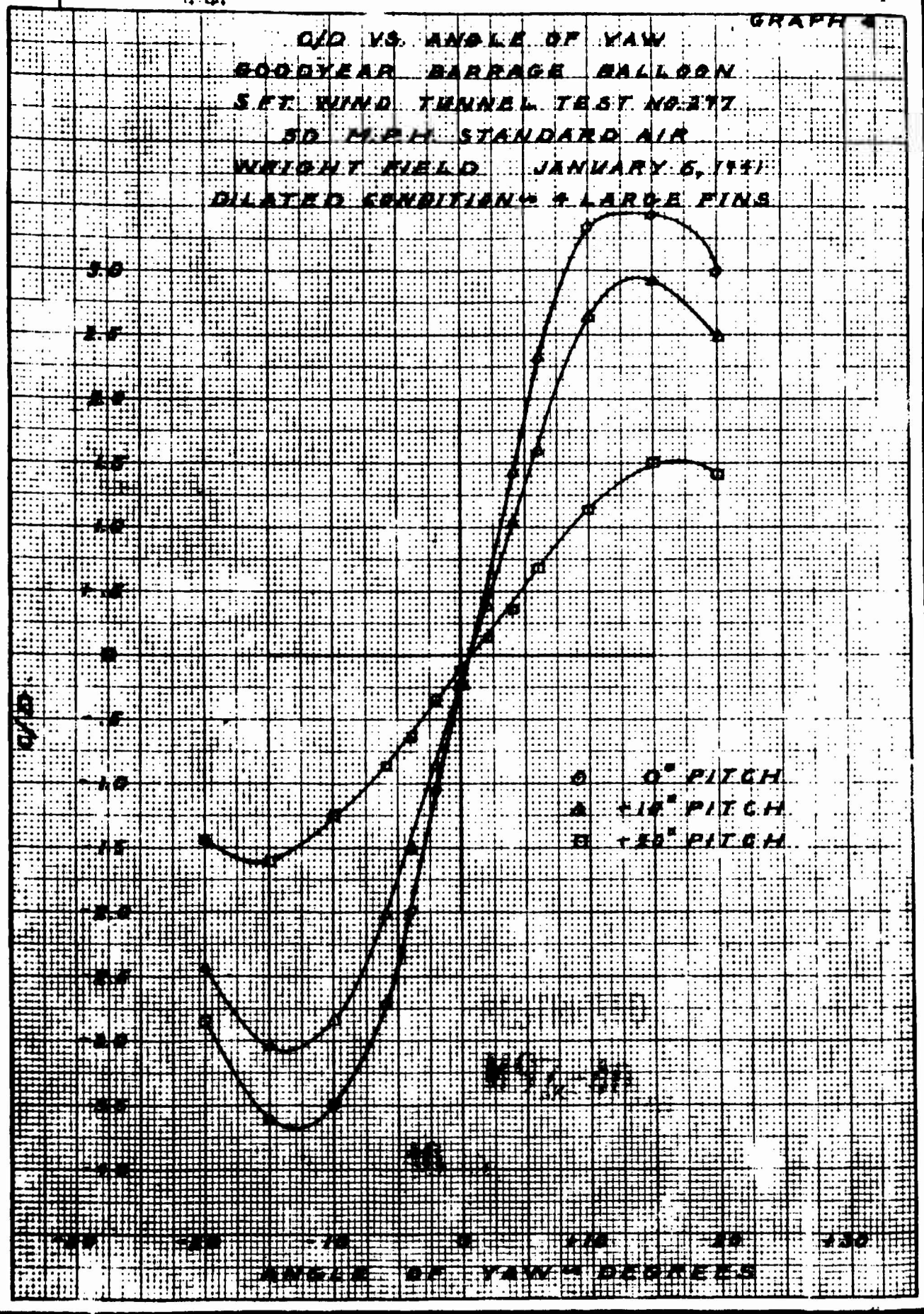
GOODYEAR BARRAGE BALLOON

5 FT. WIND TUNNEL TEST NO. 277

50 M.P.H. STANDARD AIR

WRIGHT FIELD JANUARY 6, 1941

DILATED CONDITION + LARGE FINS



SFI. L NO

GRAPH 5

YAW MOMENT DUE TO ANGLE OF YAW

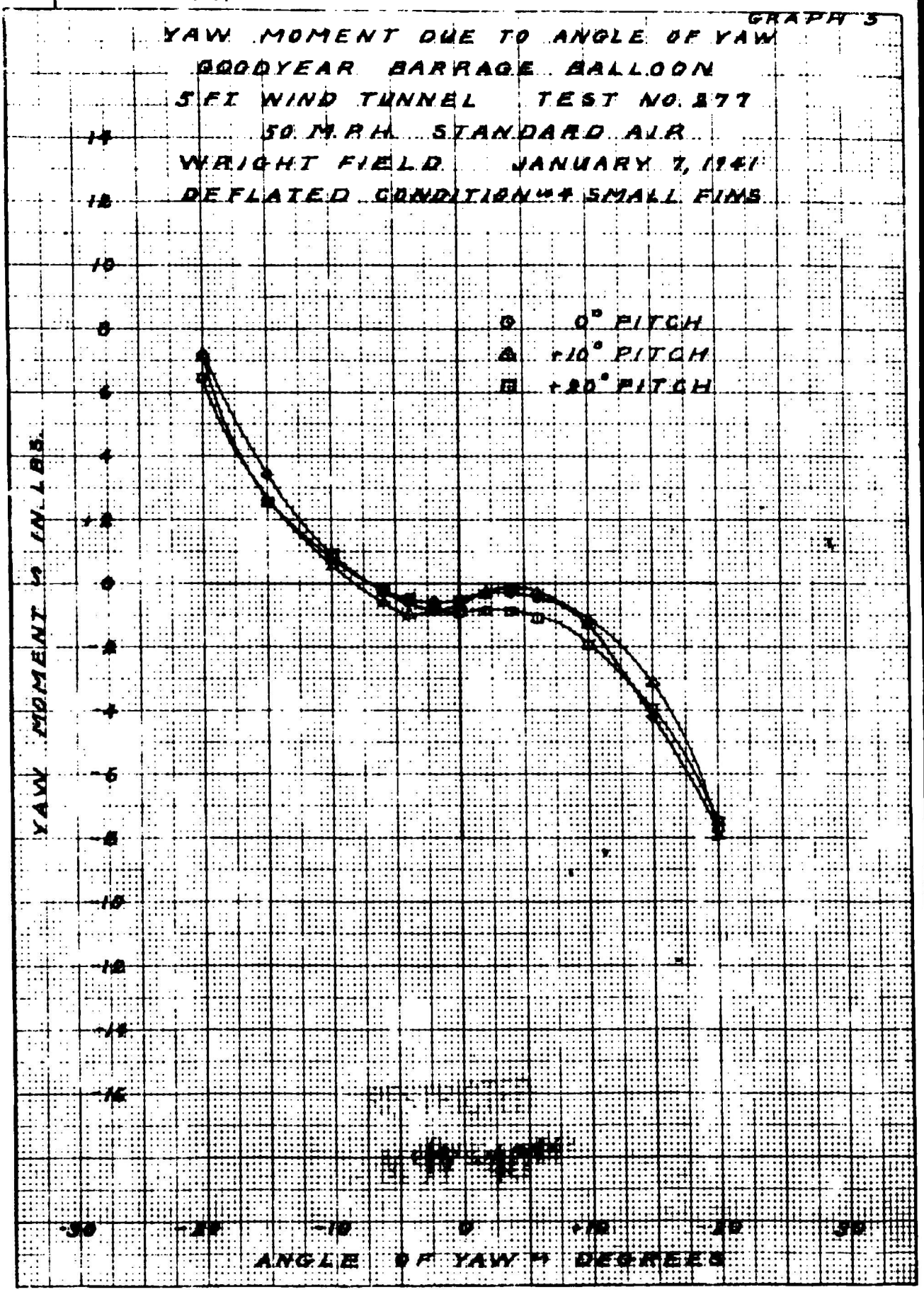
GOODYEAR BARRAGE BALLOON

SFI WIND TUNNEL TEST NO. 177

50 M.P.H. STANDARD AIR

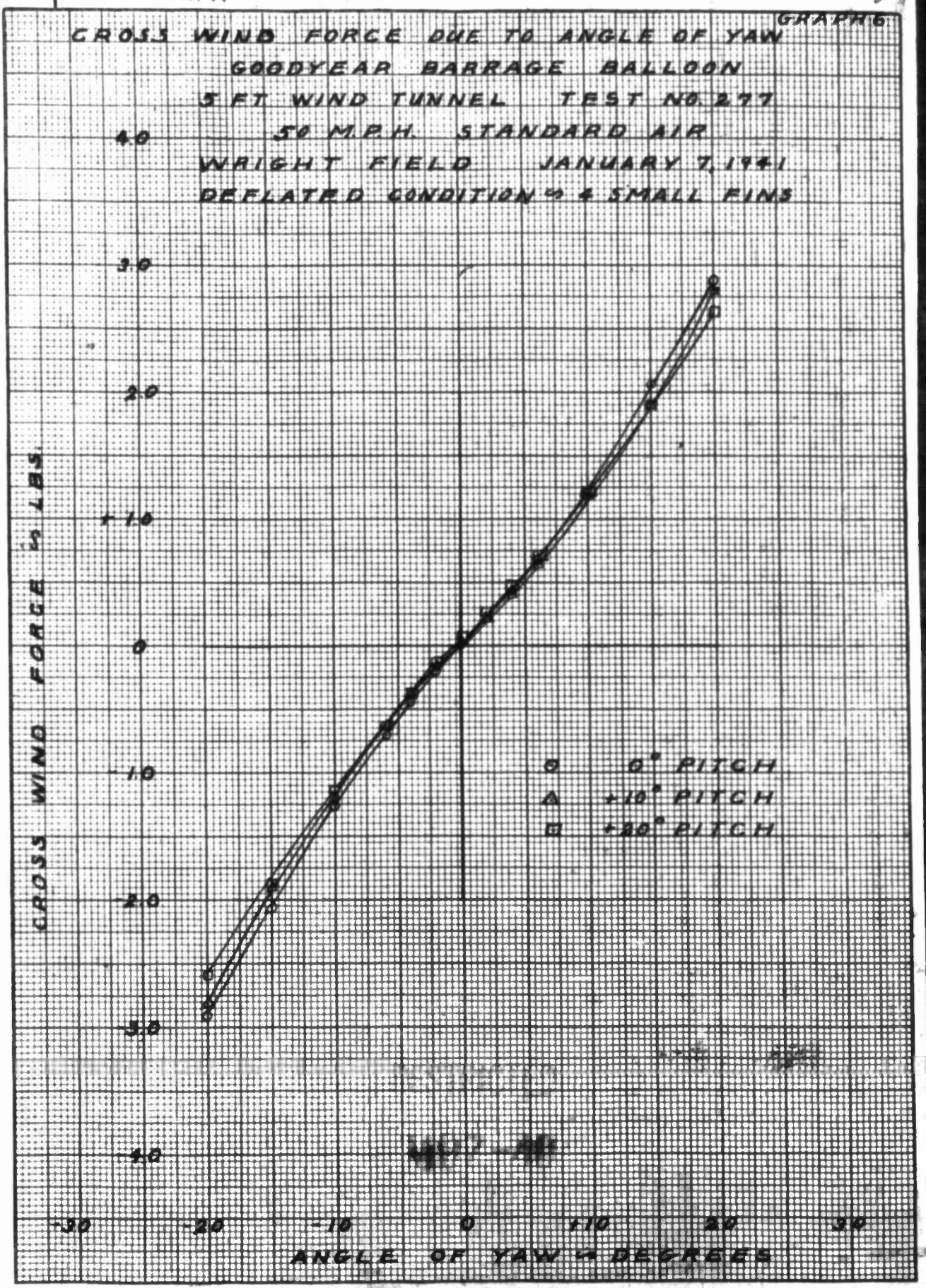
WRIGHT FIELD JANUARY 7, 1941

DEFLATED CONDITION "A" SMALL FINS



GRAPH 6

CROSS WIND FORCE DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 7, 1941
DEFLATED CONDITION ⇔ 4 SMALL FINS



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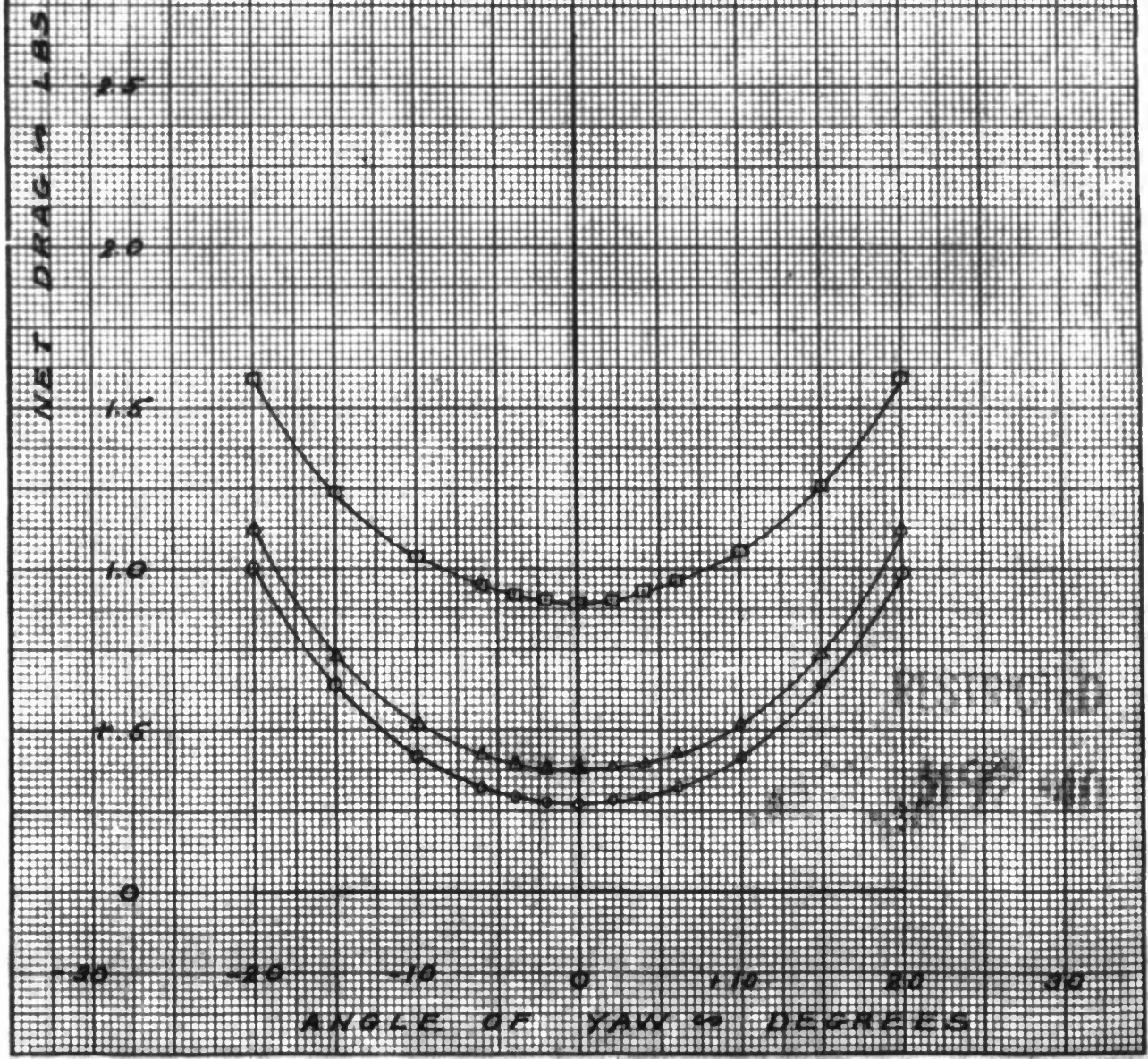
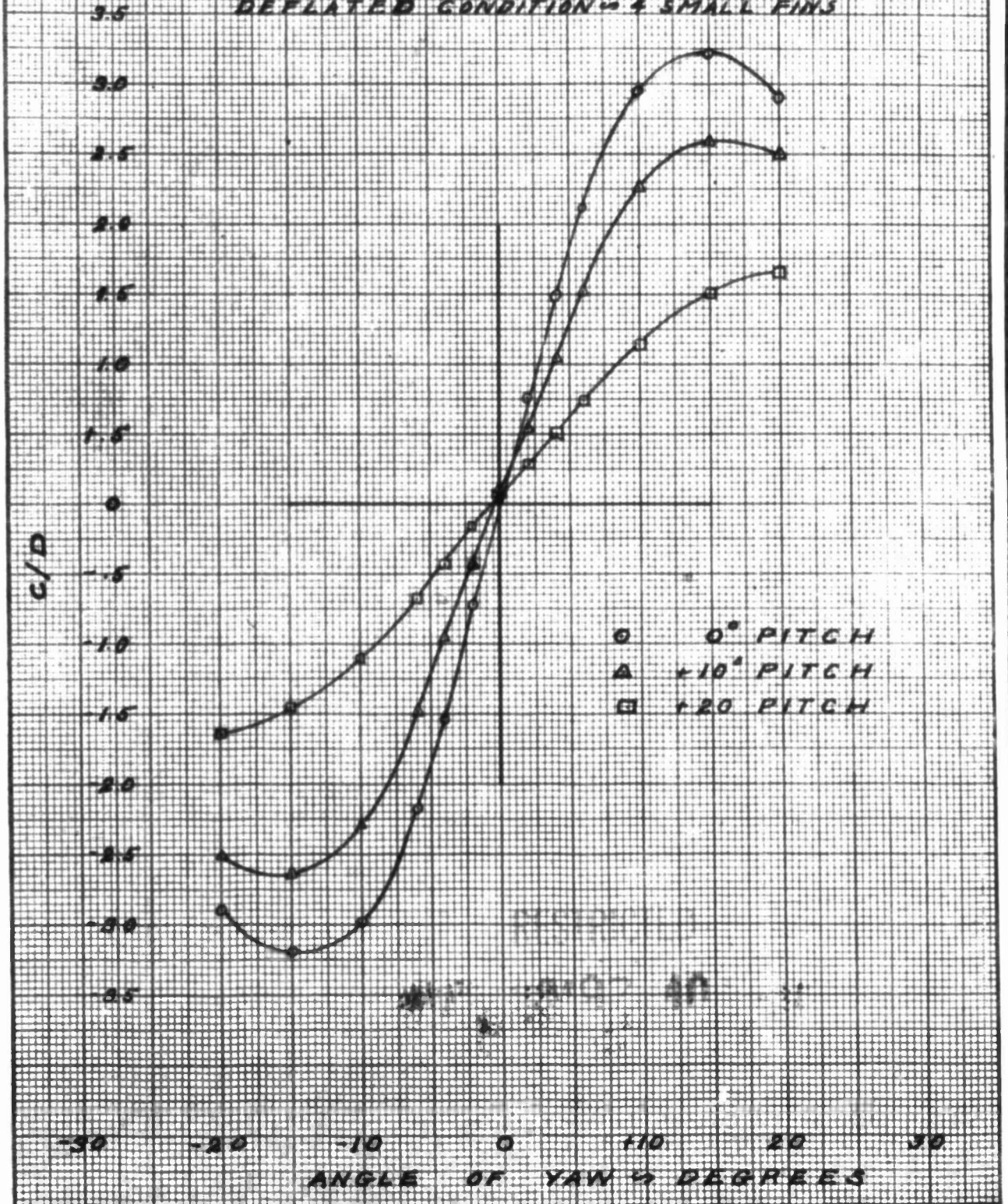
GRAPH 7

NET DRAG DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 7, 1941
DEFLATED CONDITION No. 4 SMALL FINS



GRAPH 8

C/D VS. ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST No. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 7, 1941
DEFLATED CONDITION — 4 SMALL FINS



GRAPH 9

YAW MOMENT DUE TO ANGLE OF YAW

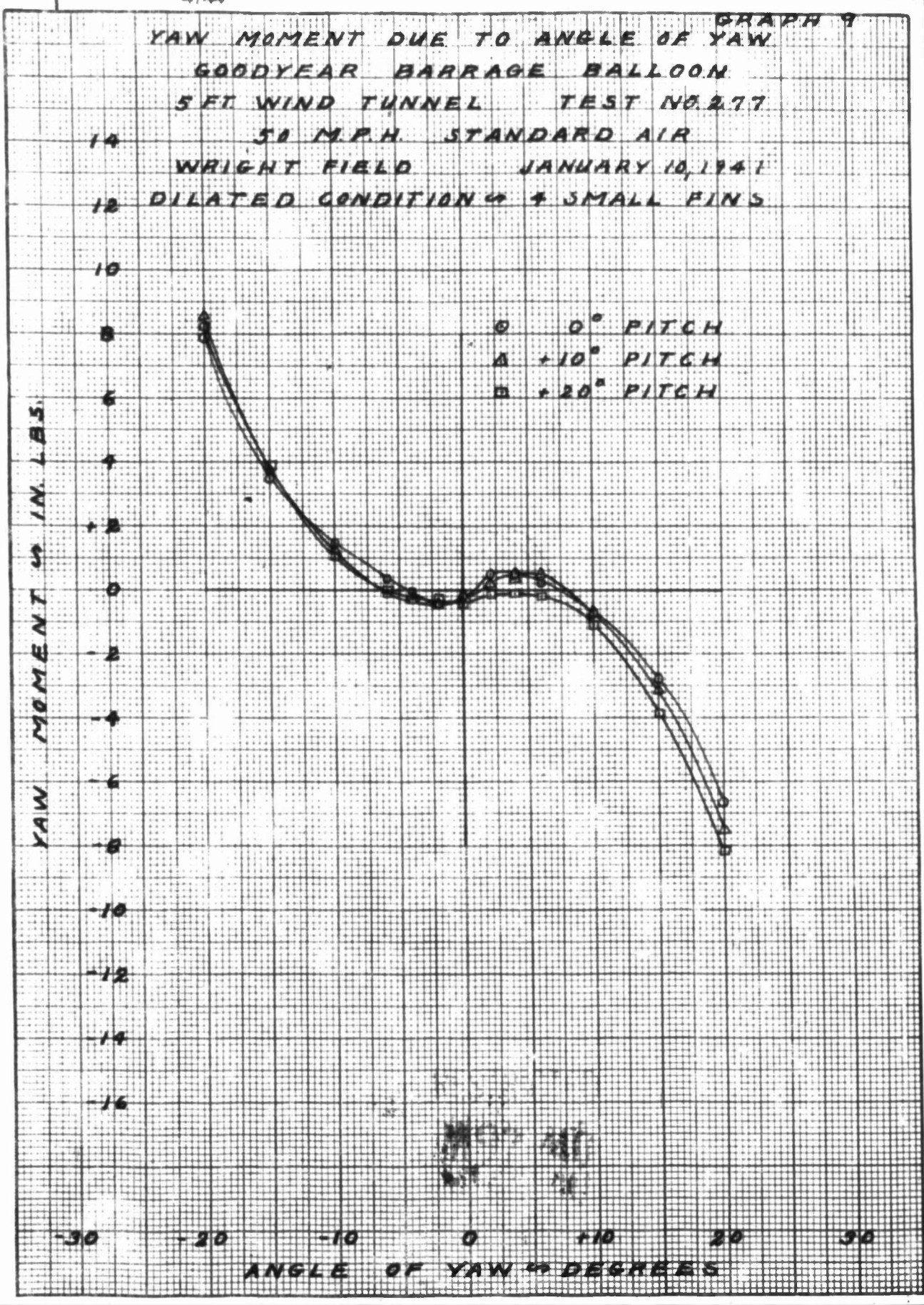
GOODYEAR BARRAGE BALLOON

5 FT WIND TUNNEL TEST NO. 277

50 M.P.H. STANDARD AIR

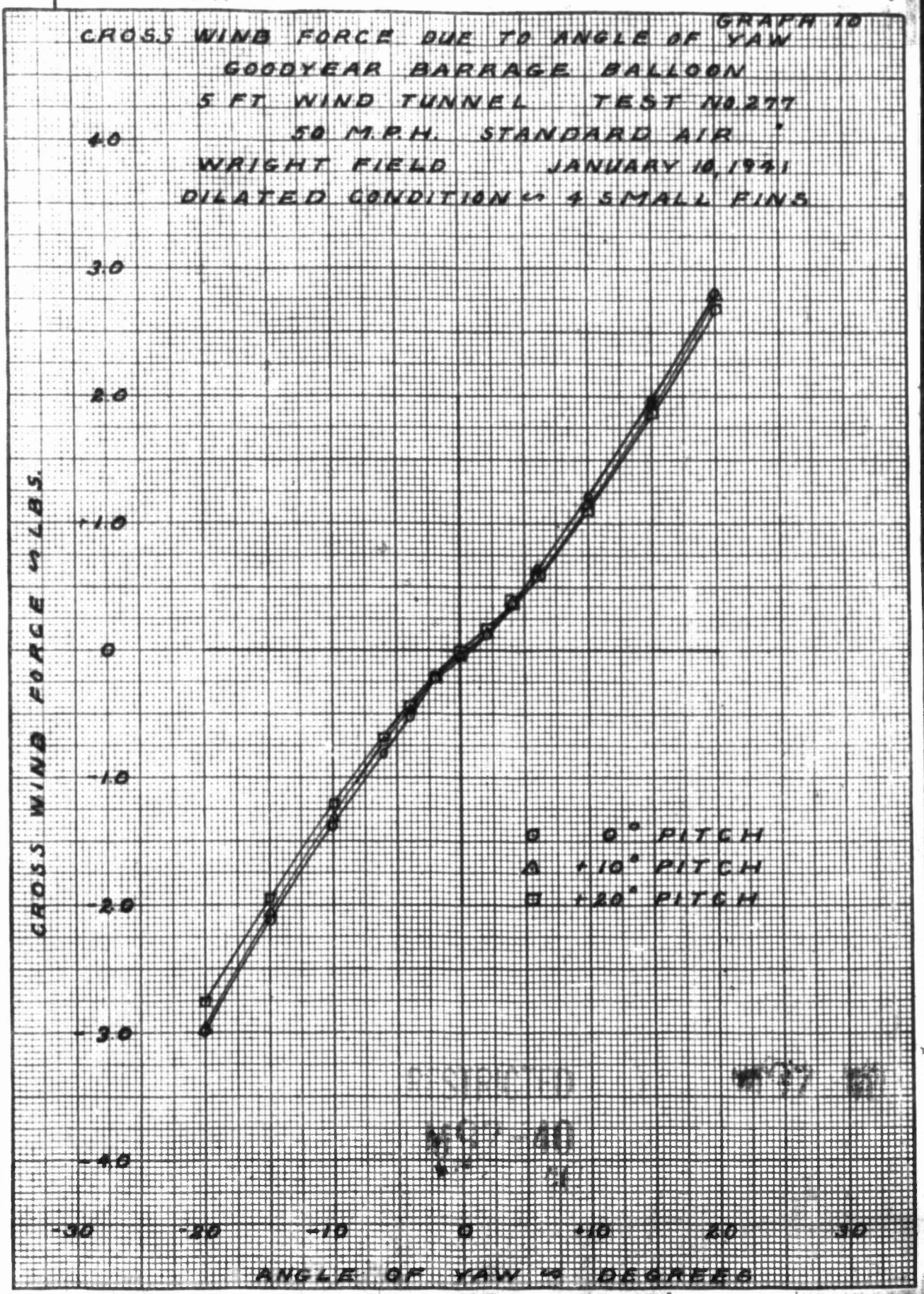
WRIGHT FIELD JANUARY 10, 1941

DILATED CONDITION + 4 SMALL FINS



GRAPH 10

CROSS WIND FORCE DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 10, 1941
DILATED CONDITION + 4 SMALL FINS



GRAPH 11

NET DRAG DUE TO ANGLE OF YAW

GOODYEAR BARRAGE BALLOON

5 FT. WIND TUNNEL TEST No. 277

50 M.P.H. STANDARD AIR

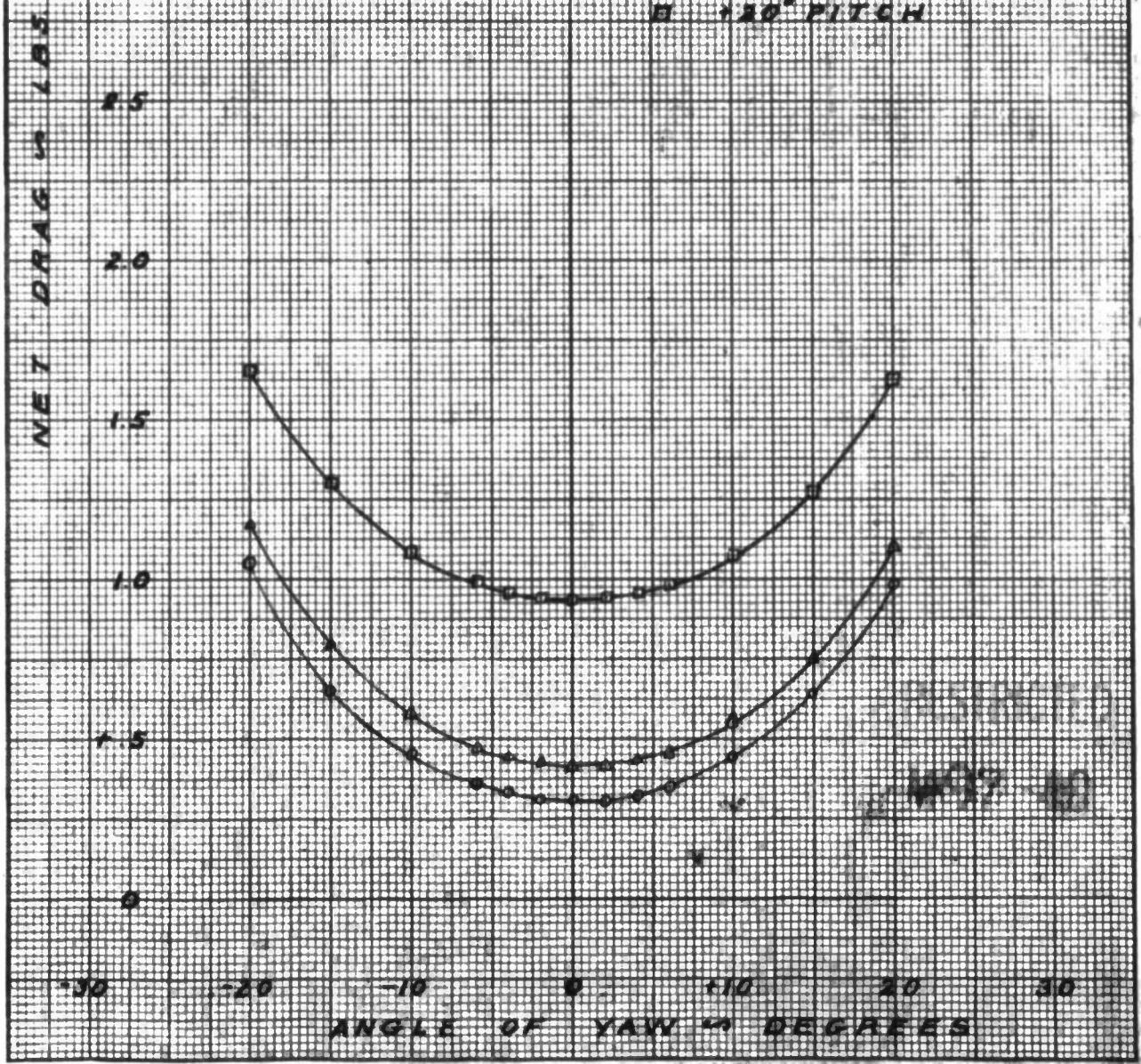
WRIGHT FIELD JANUARY 10, 1941

DILATED CONDITION + 4 SMALL FINS

○ 0° PITCH

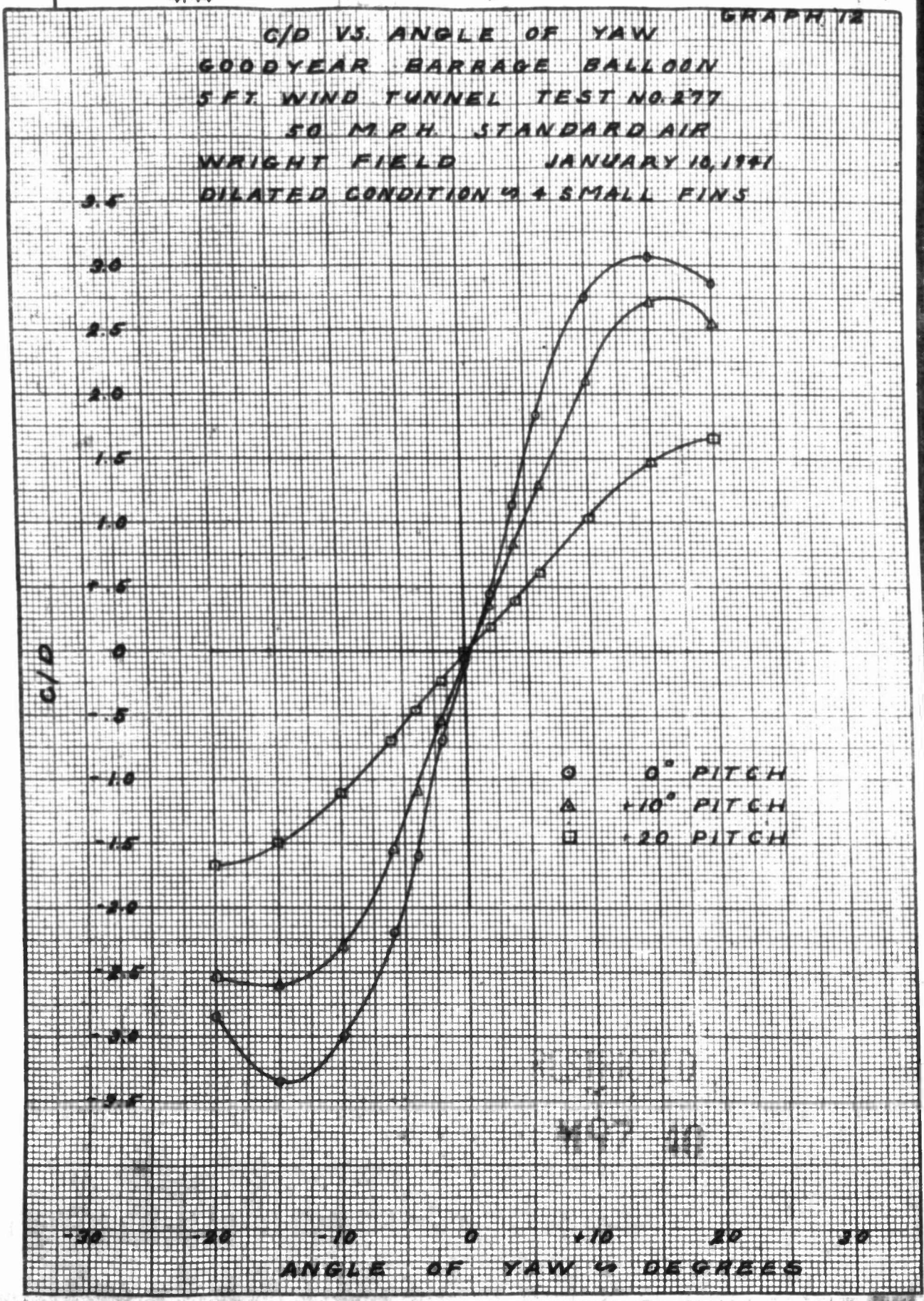
△ +10° PITCH

□ +20° PITCH



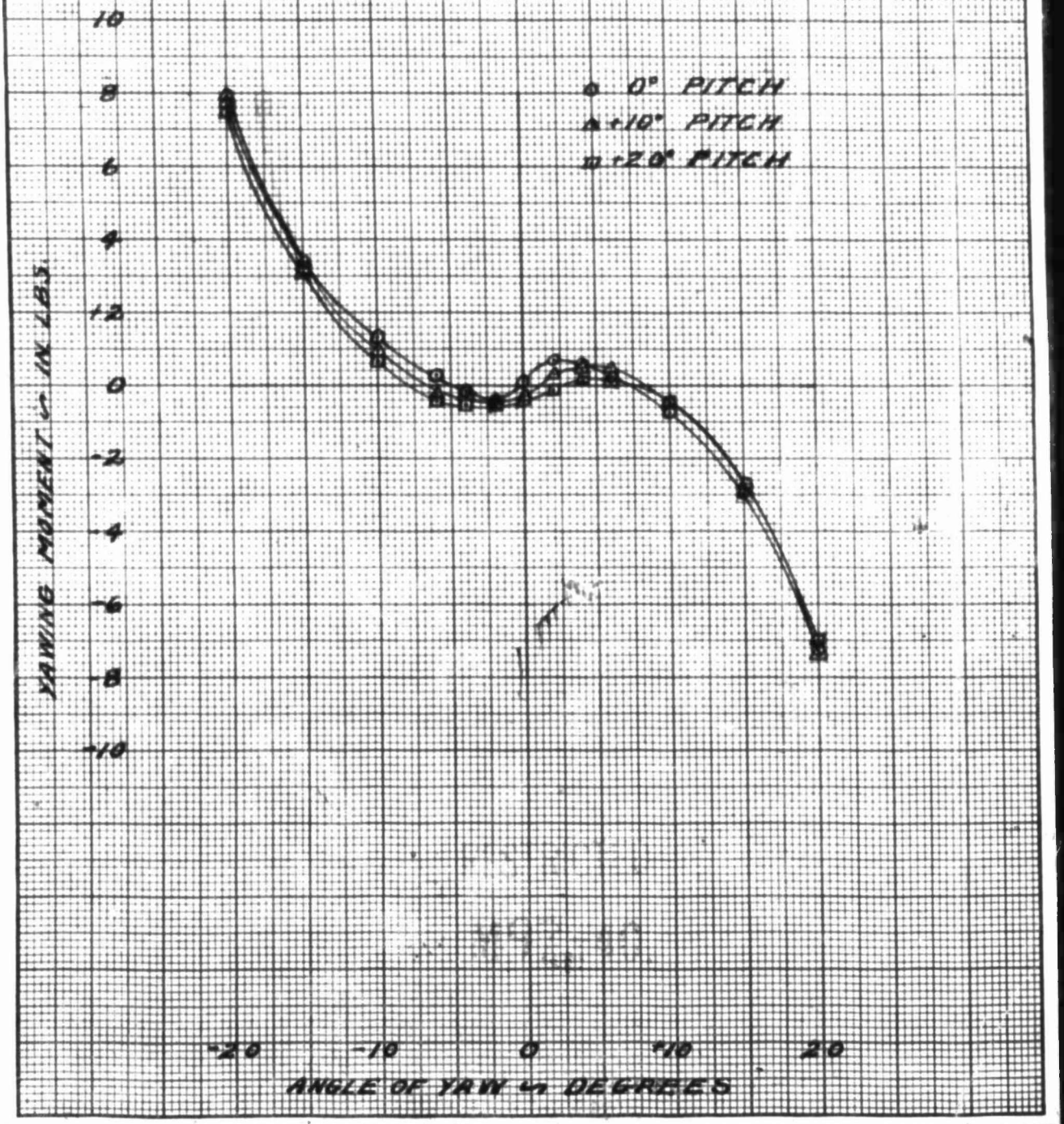
GRAPH 12

C/D VS. ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 10, 1941
DILATED CONDITION 4 4 SMALL FINS



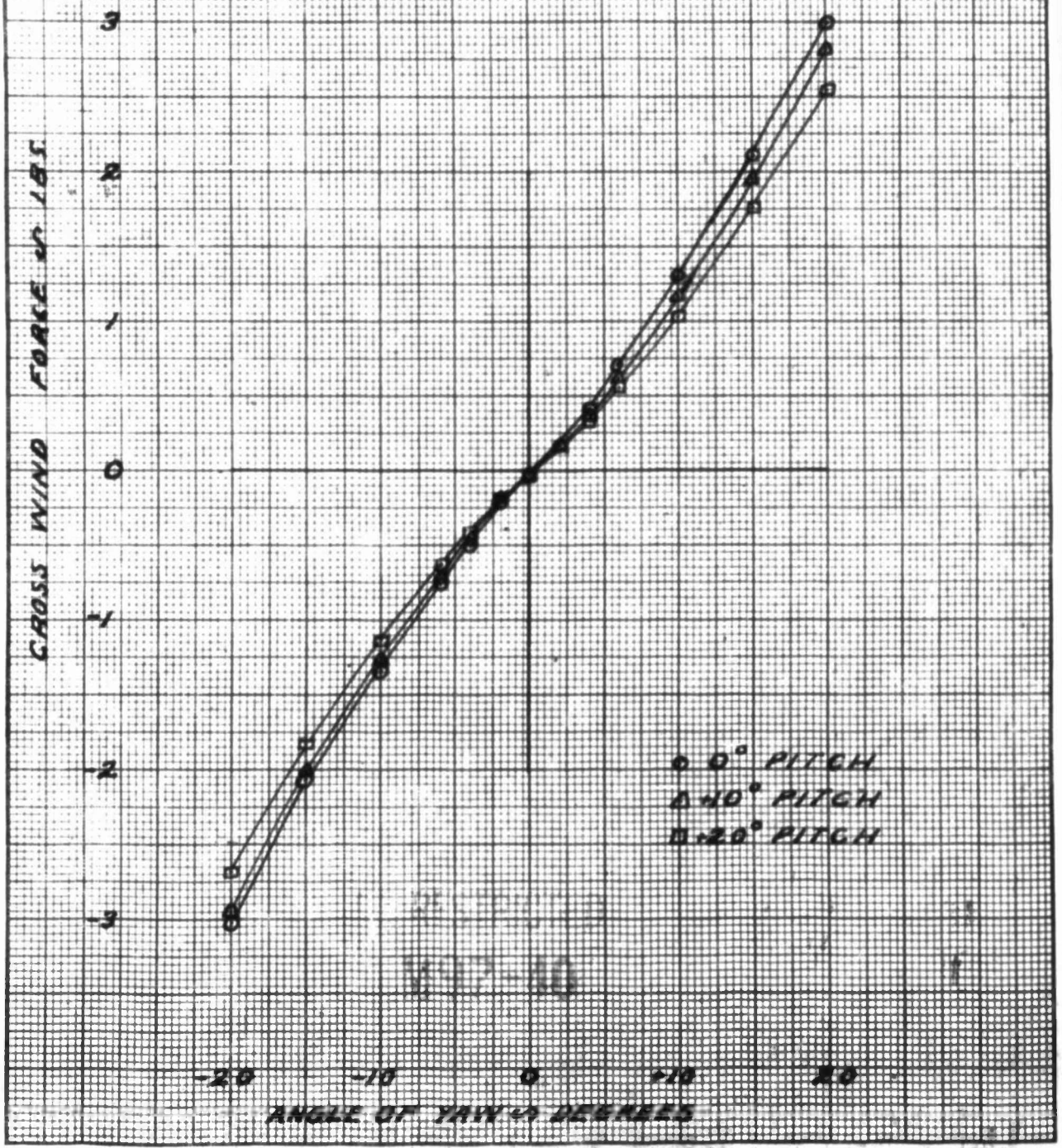
GRAPH 13

YAW MOMENT DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION 4 SMALL FINS
WITH SUSPENSION CURTAIN



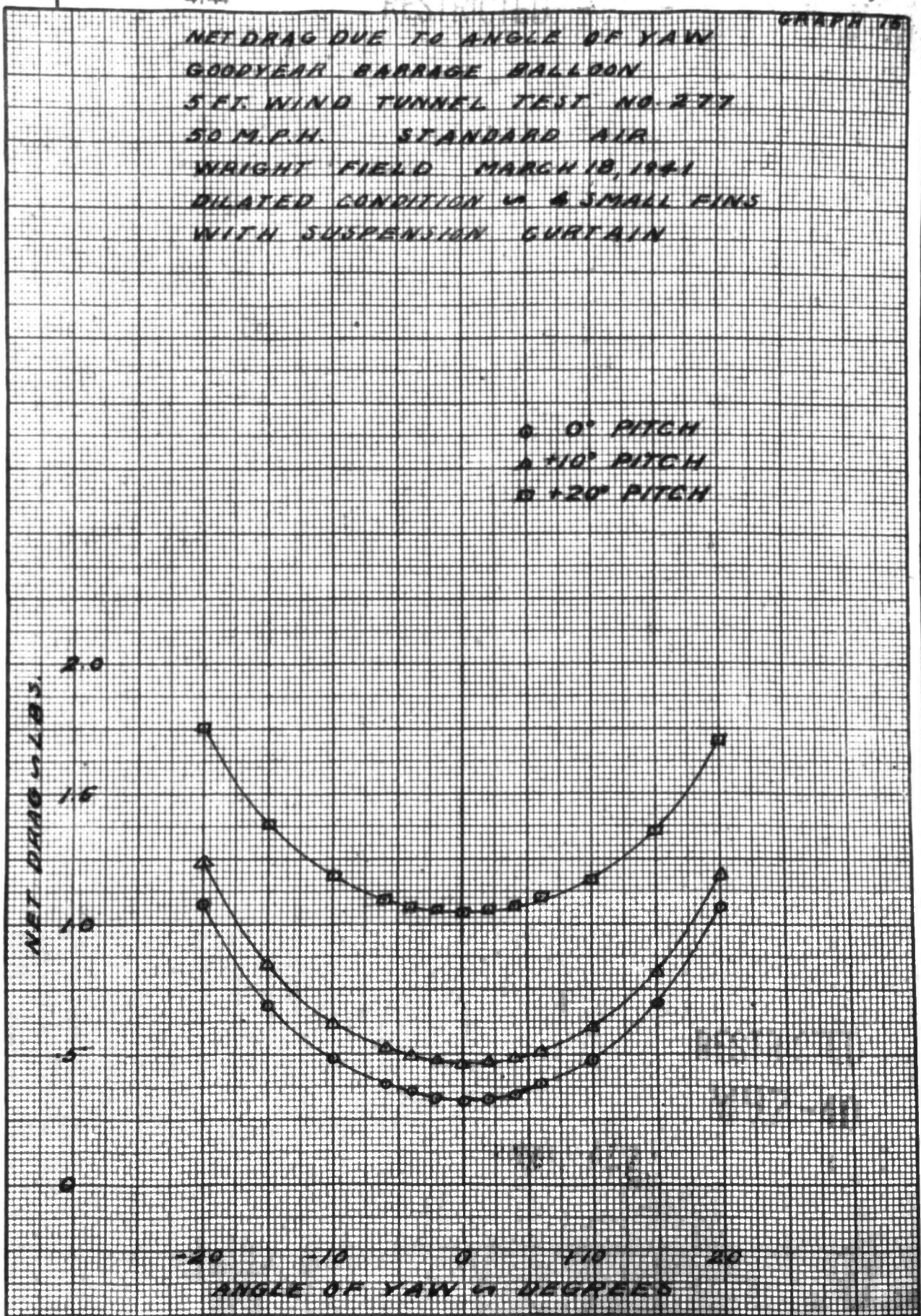
GRAPH 16

CROSS WIND FORCE DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DEFLATED CONDITION w 4 SMALL FINS
WITH SUSPENSION CURTAIN



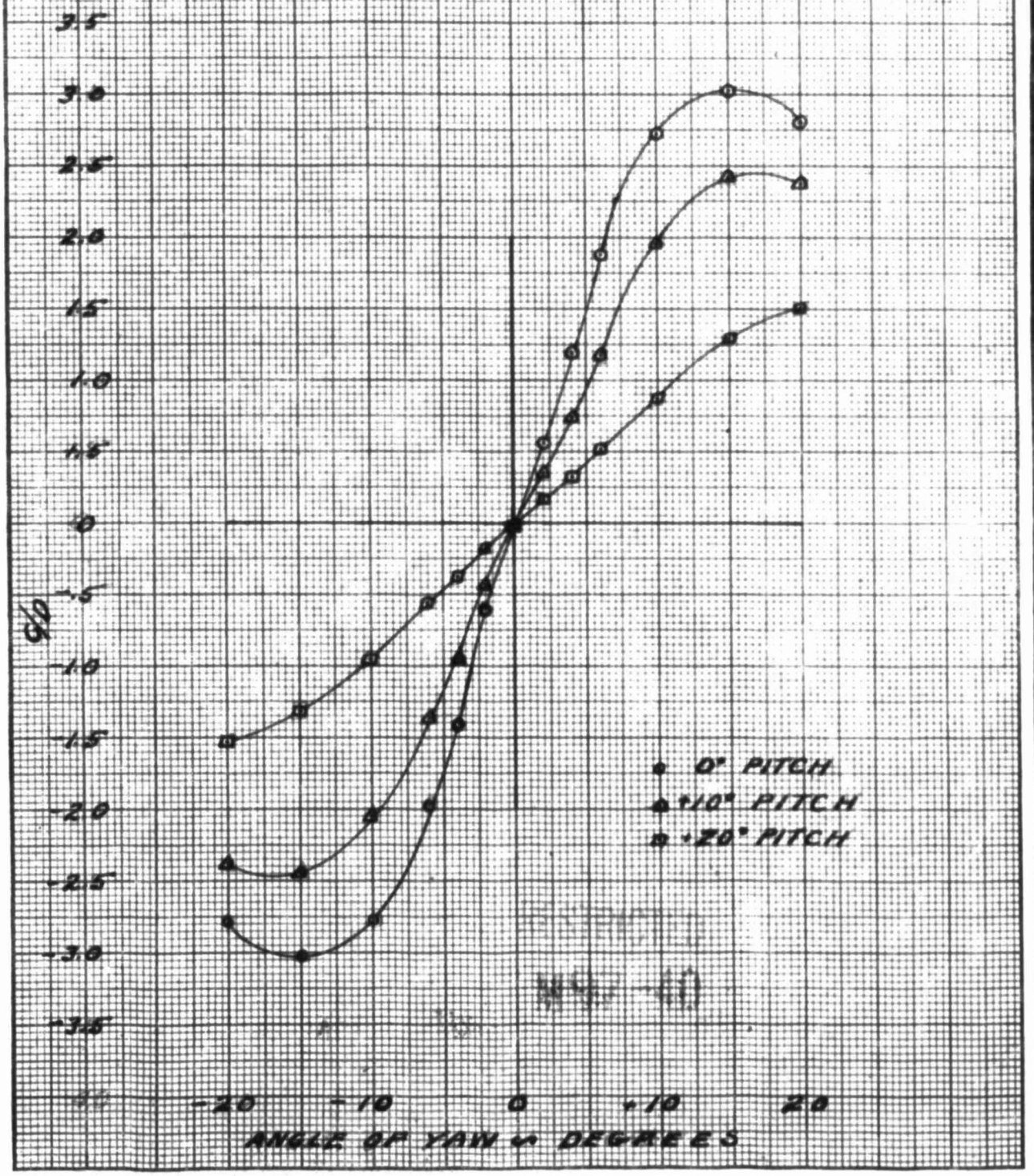
GRAPH 15

NET DRAG DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION w/ 4 SMALL FINS
WITH SUSPENSION CURTAIN



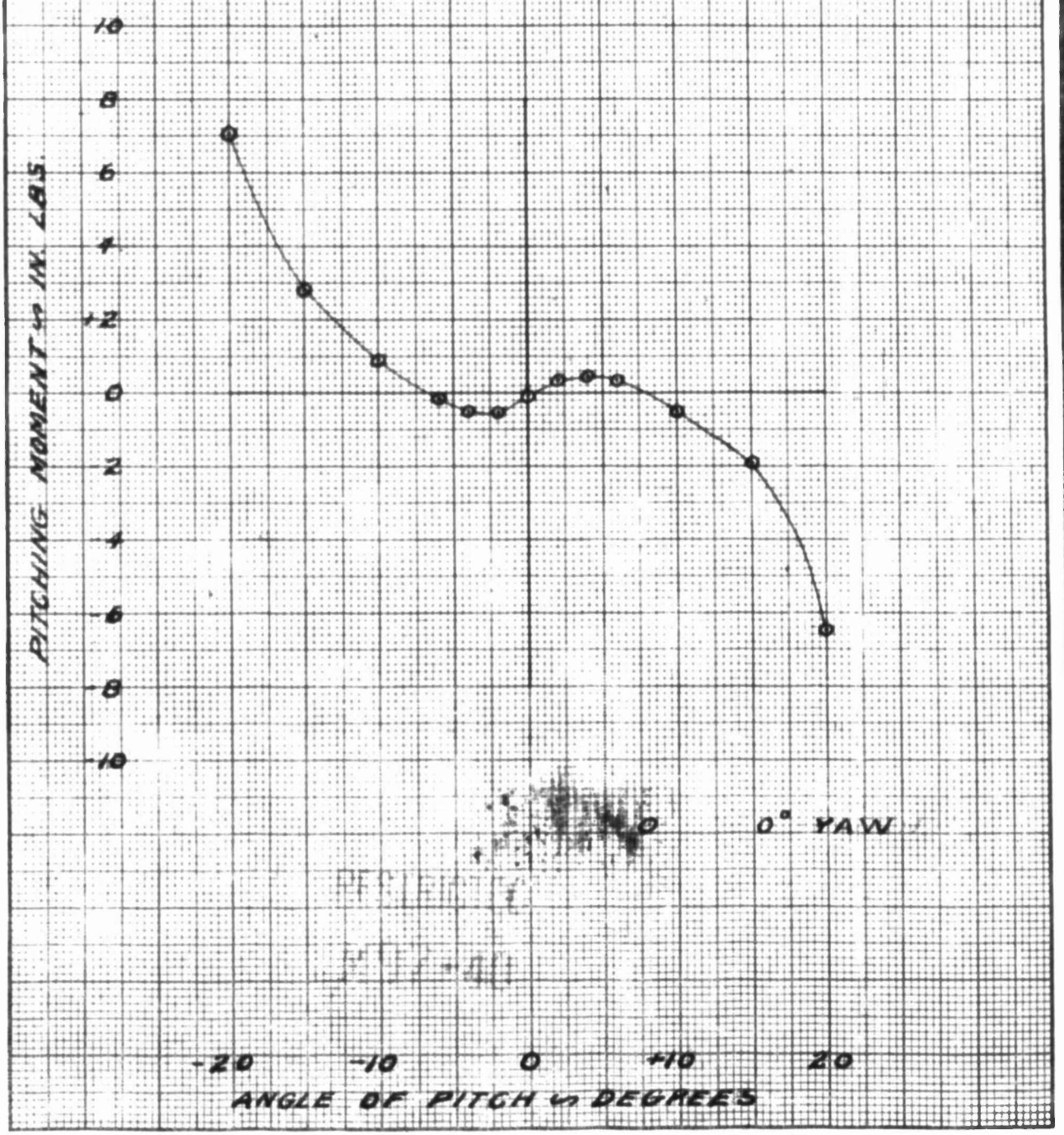
GRAPH 16

C_D VS. ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION + 4 SMALL FINS
WITH SUSPENSION CURTAIN



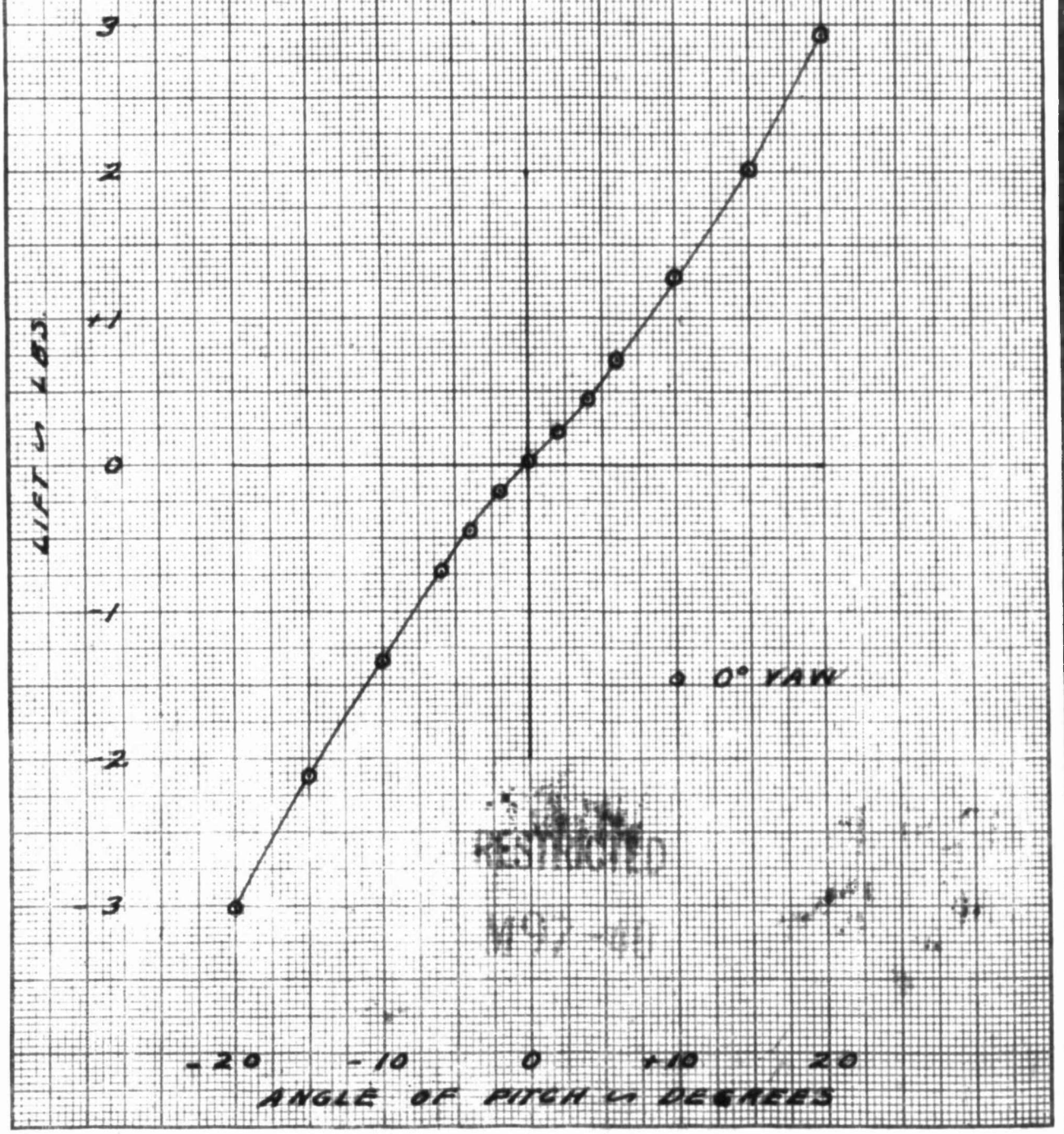
GRAPH 17

PITCHING MOMENT DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION ⇒ 4 SMALL FINS
WITH SUSPENSION CURTAIN



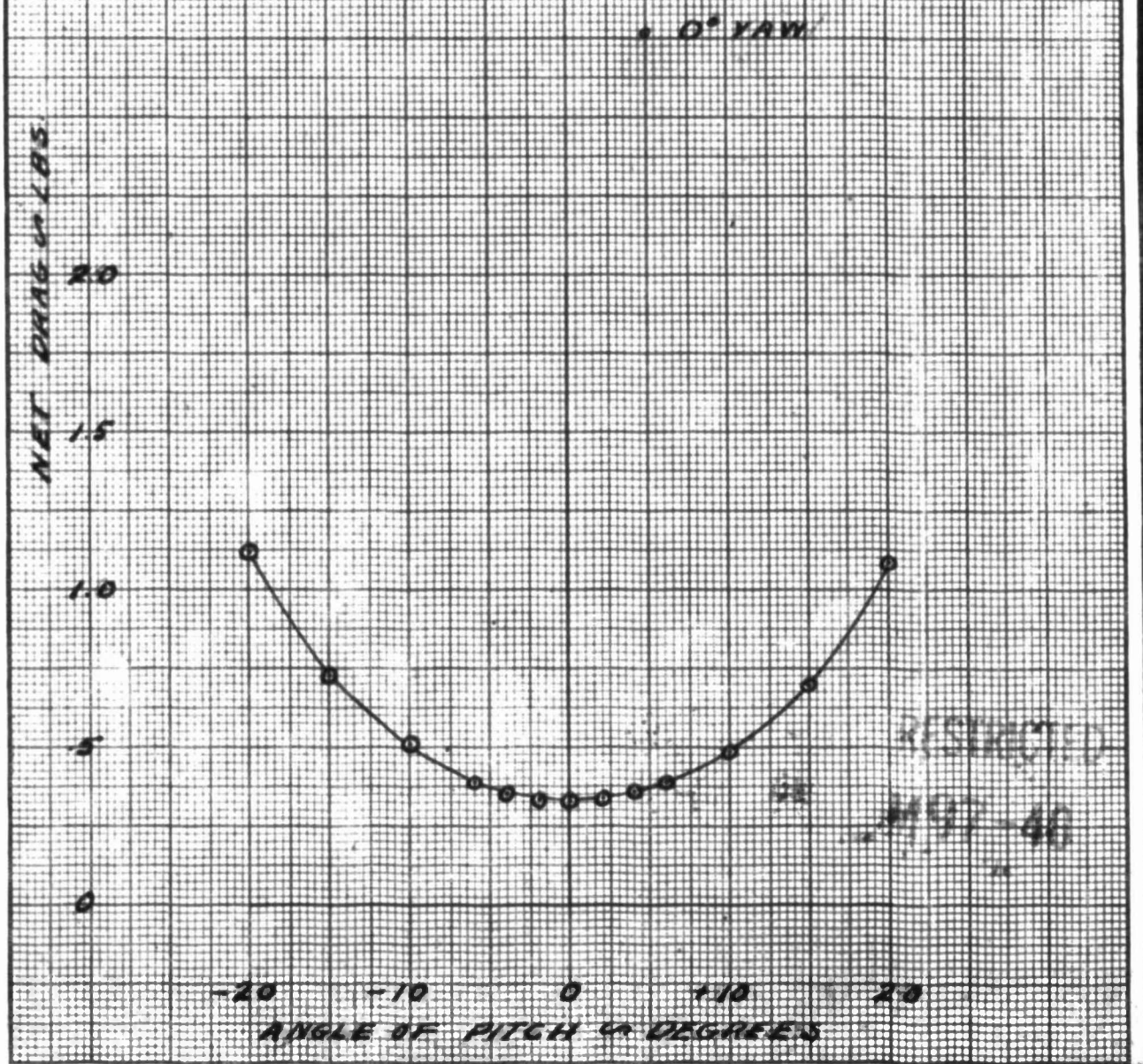
GRAPH 18

LIFT DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION w 4 SMALL FINS
WITH SUSPENSION CURTAIN



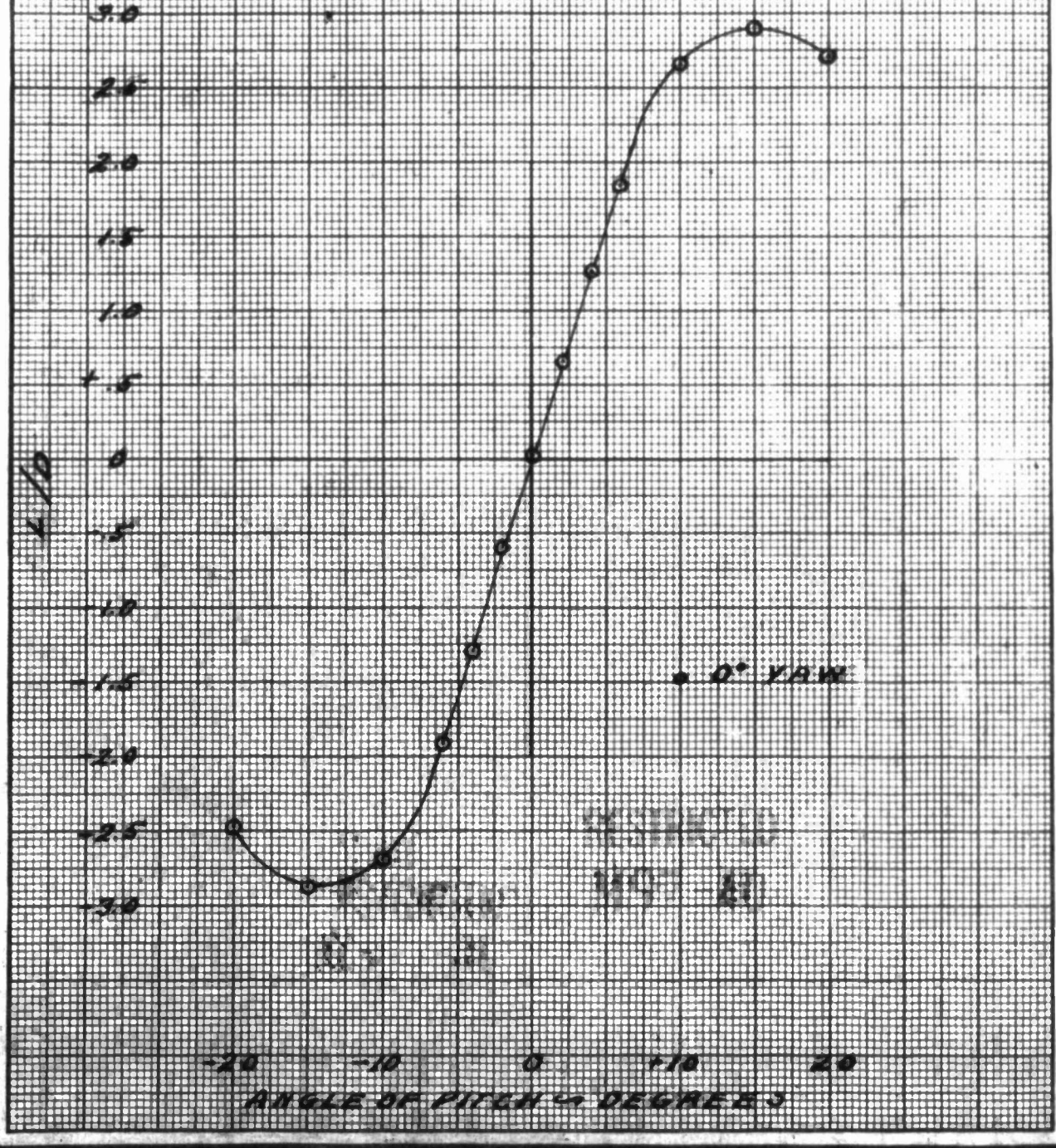
GRAPH 17

NET DRAG DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION w 4 SMALL FINS
WITH SUSPENSION CURTAIN



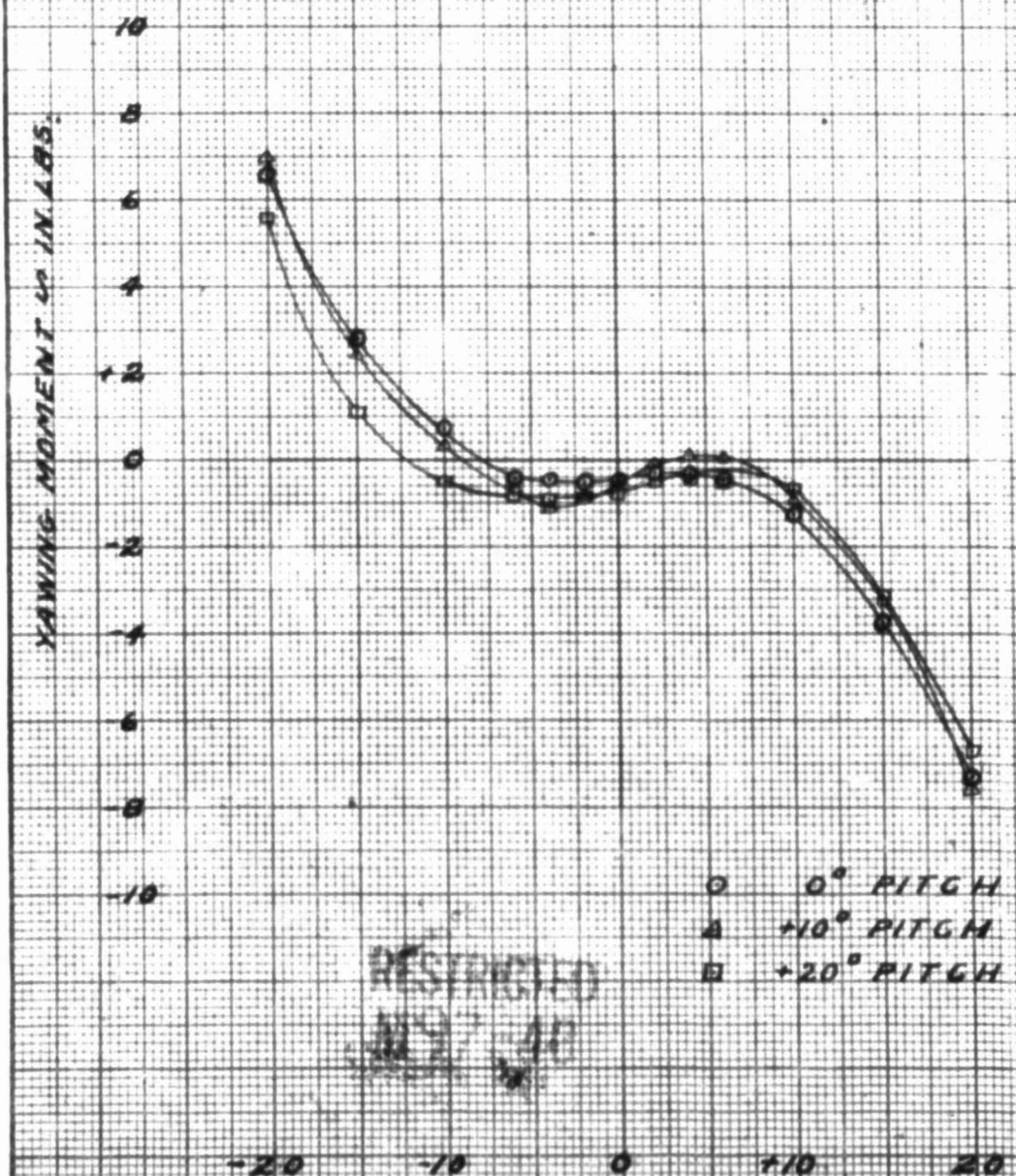
GRAPH 20

L/D VS. ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DILATED CONDITION & 4 SMALL FINS
WITH SUSPENSION CURTAIN



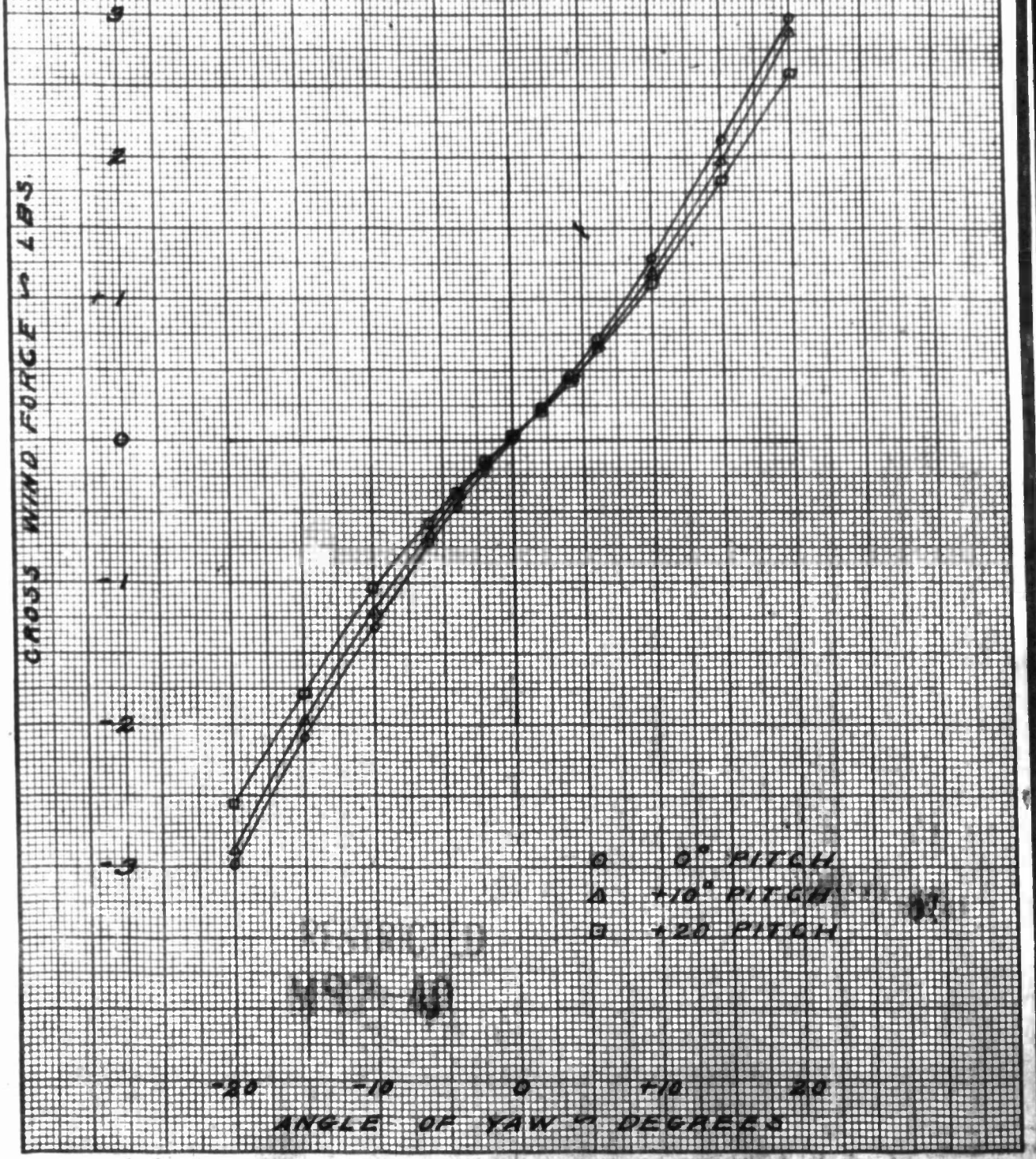
GRAPH 21

YAW MOMENT DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DEFLATED CONDITION + 4 SMALL FINS
WITH SUSPENSION CURTAIN



GRAPH 22

CROSS WIND FORCE DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 19, 1941
DEFLATED CONDITION W/ 4 SMALL FINS WITH SUSPENSION CURTAIN



SERIAL No. 1744

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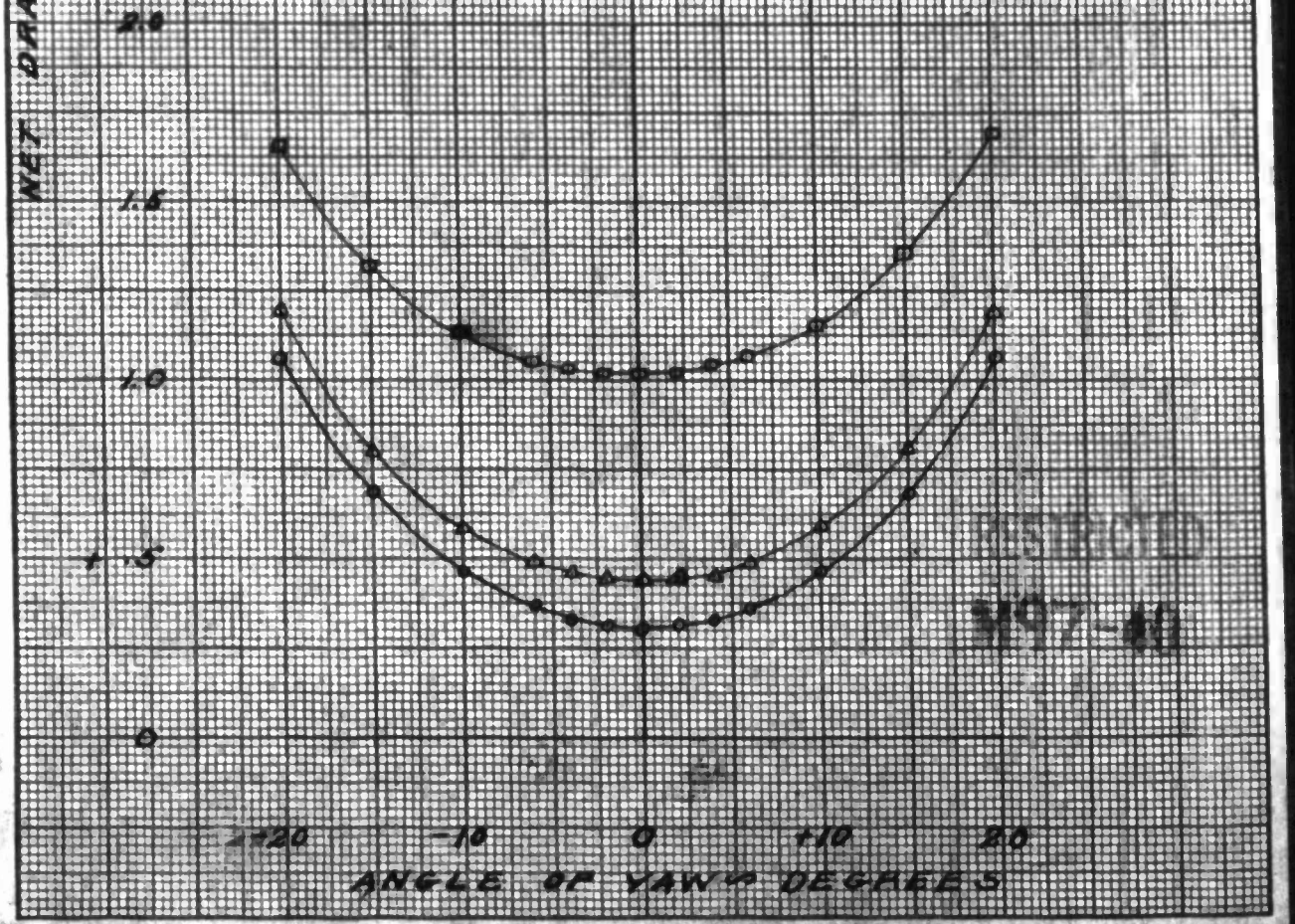
GRAPH 28

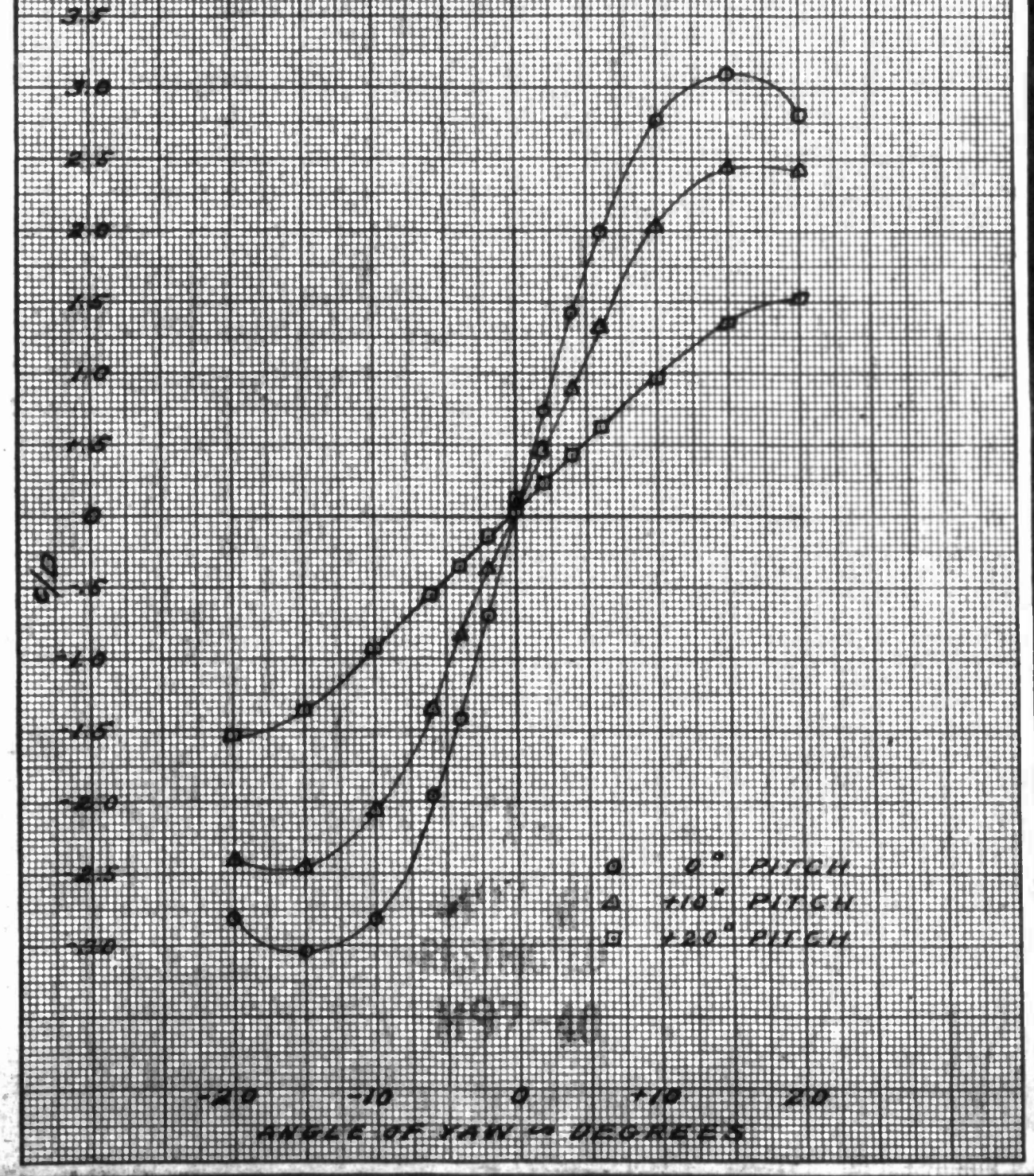
NET DRAG DUE TO ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 19, 1941
DEFLATED CONDITION — 4 SMALL FINS
WITH SUSPENSION CURTAIN

○ 0° PITCH
△ +10° PITCH
□ +20° PITCH



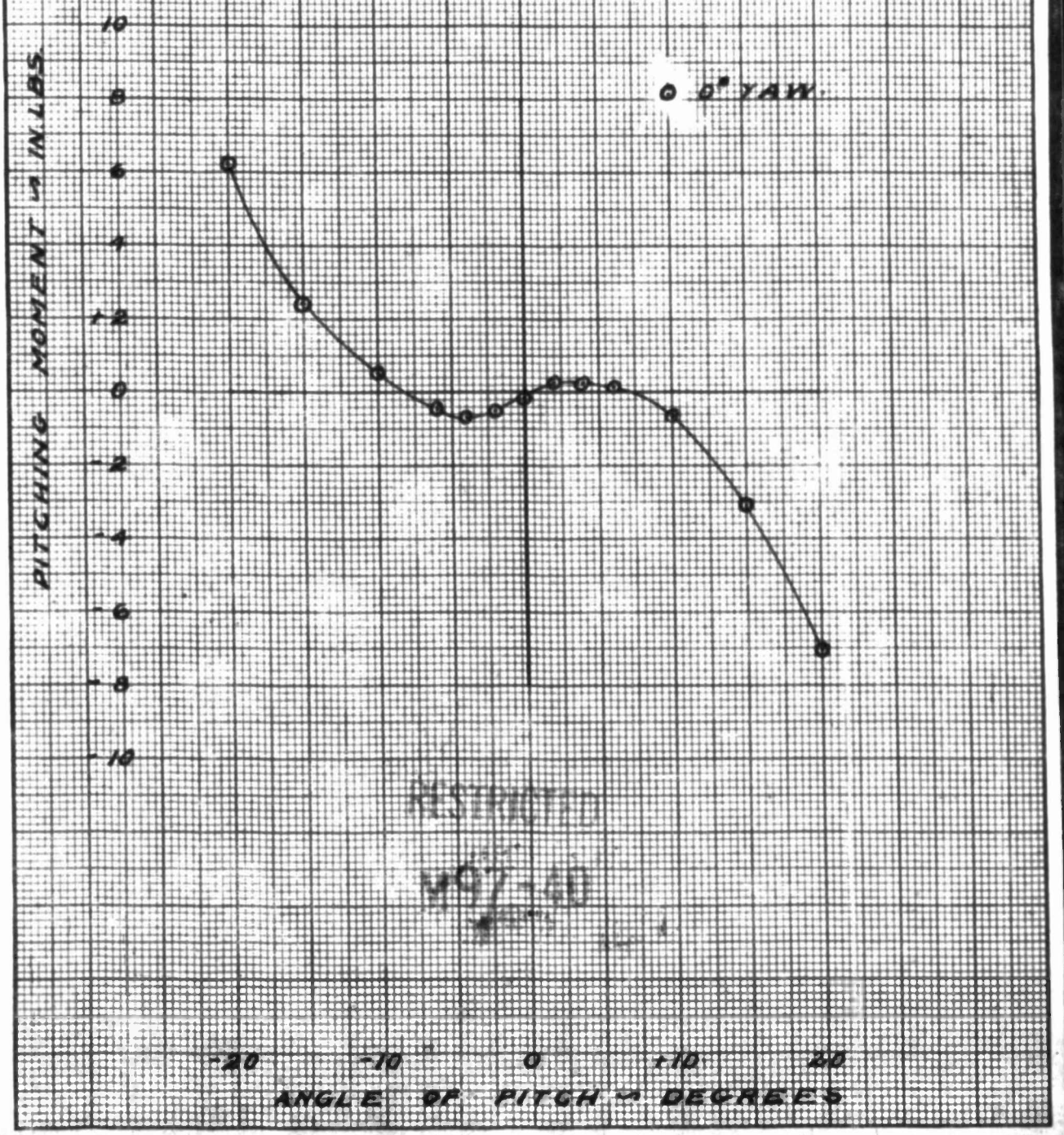
GRAPH 23
CR...

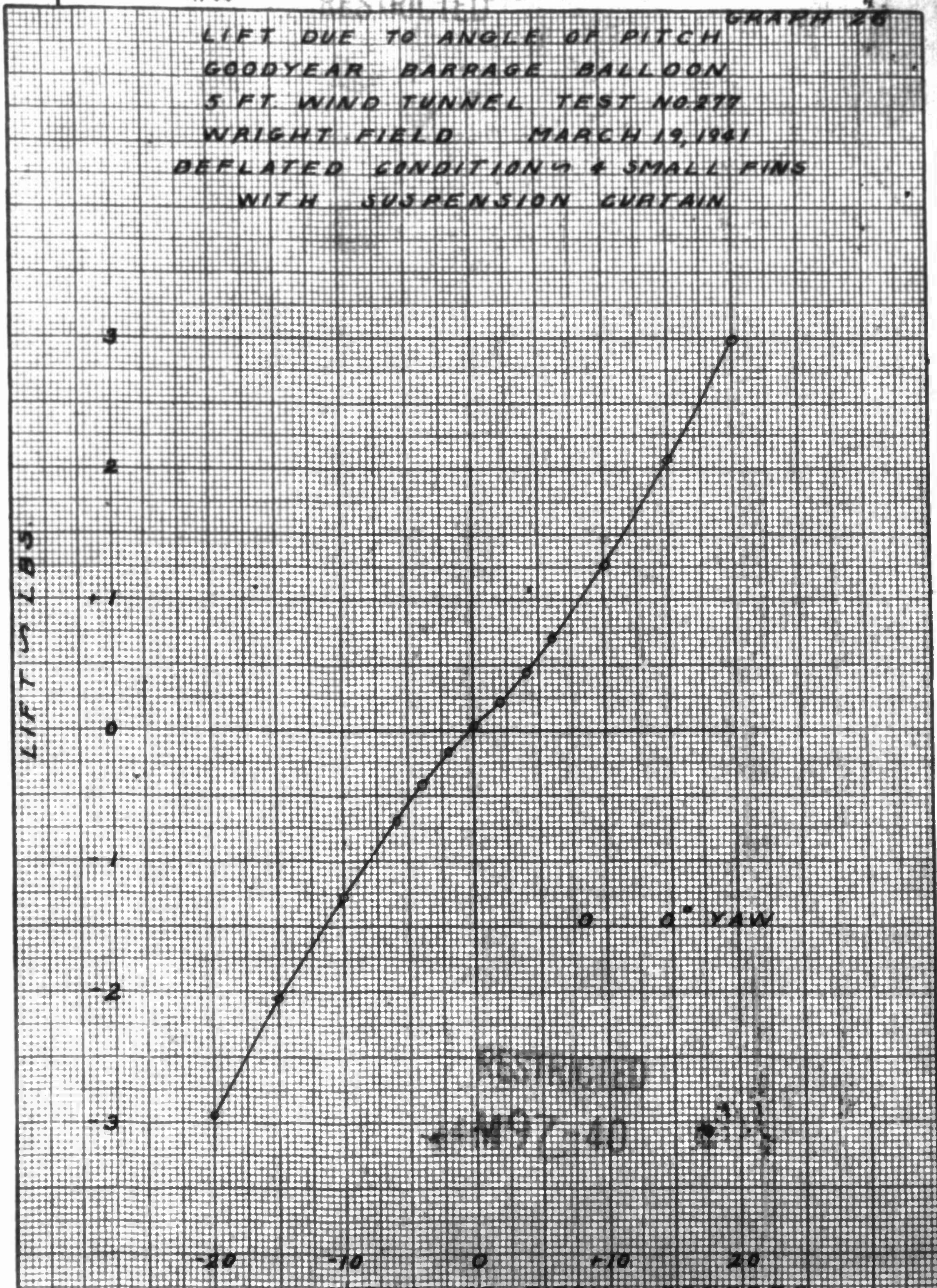
C/D VS ANGLE OF YAW
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DEFLATED CONDITION + 4 SMALL FINS
WITH SUSPENSION CURTAIN



GRAPH 25

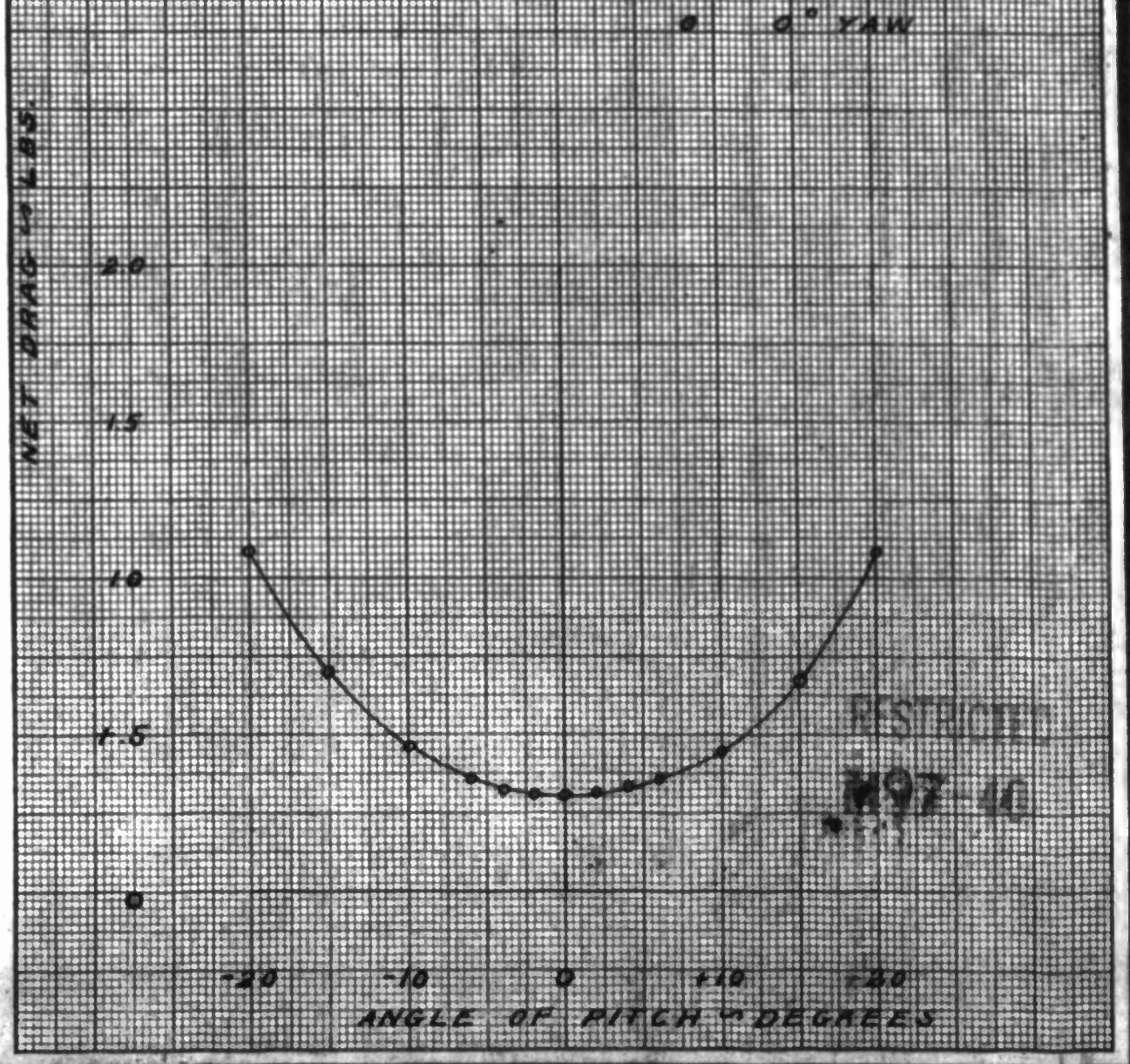
PITCHING MOMENT DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 18, 1941
DEFLATED CONDITION - 4 SMALL FINS
WITH SUSPENSION CURTAIN




GRAPH 26
LIFT DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO.277
WRIGHT FIELD MARCH 19, 1941
DEFLATED CONDITION ~ 4 SMALL FINS
WITH SUSPENSION CURTAIN
LIFT ~ LBS
3
2
+1
0
-1
-2
-3
o 0° YAW
-20
-10
0
+10
20
ANGLE OF PITCH ~ DEGREES
RESTRICTED

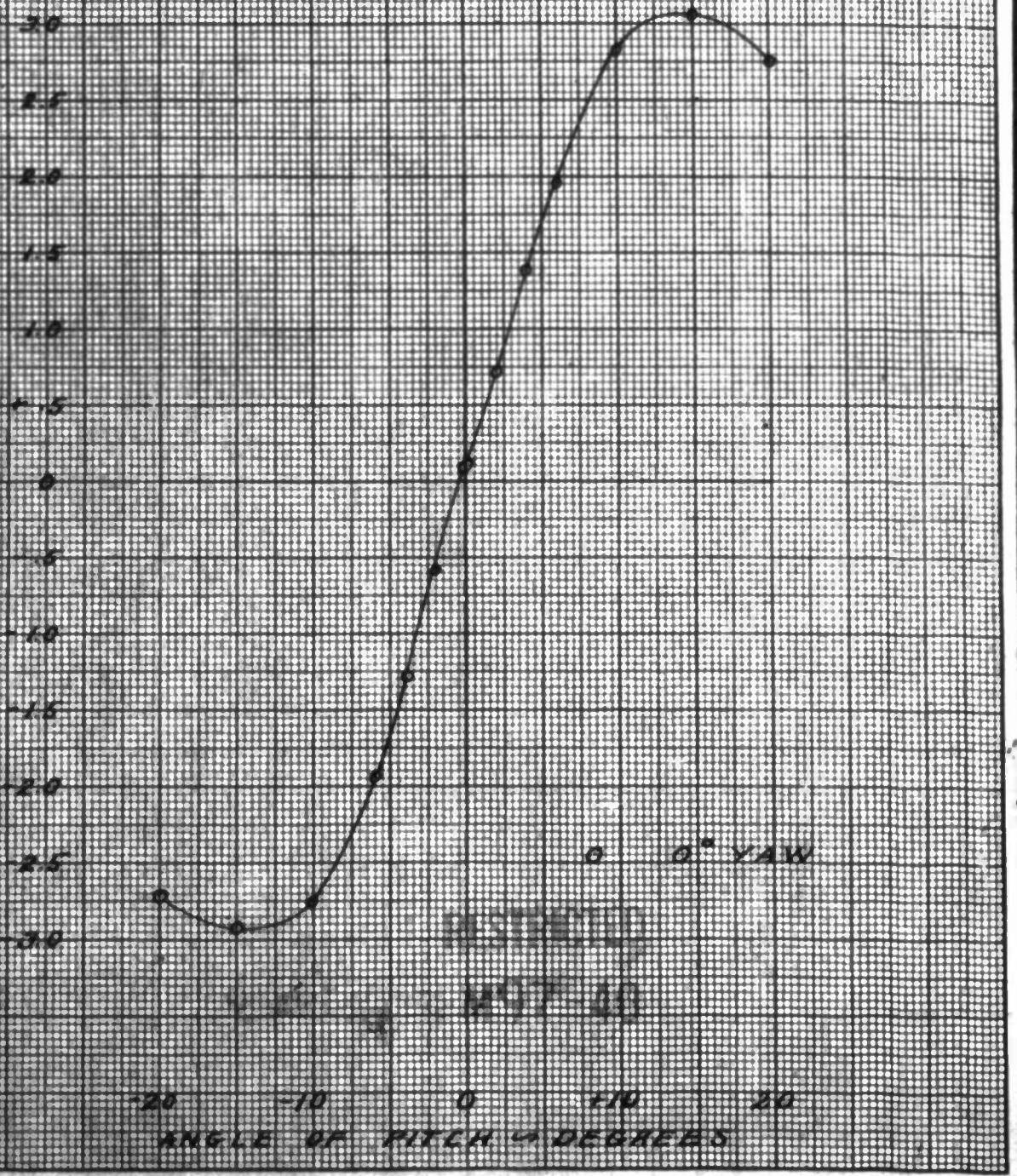
GRAPH 27

NET DRAG DUE TO ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 19, 1941
DEFLATED CONDITION + 4 SMALL FINS
WITH SUSPENSION CURTAIN



GRAPH 28

L/D VS ANGLE OF PITCH
GOODYEAR BARRAGE BALLOON
5 FT. WIND TUNNEL TEST NO. 877
30 M.P.H. STANDARD AIR
WRIGHT FIELD MARCH 19, 1941
DEFLATED CONDITION W/ 4 SMALL FINS
WITH SUSPENSION CURTAIN



YAWING MOMENT ABOUT CABLE JUNCTION GRAPH 29

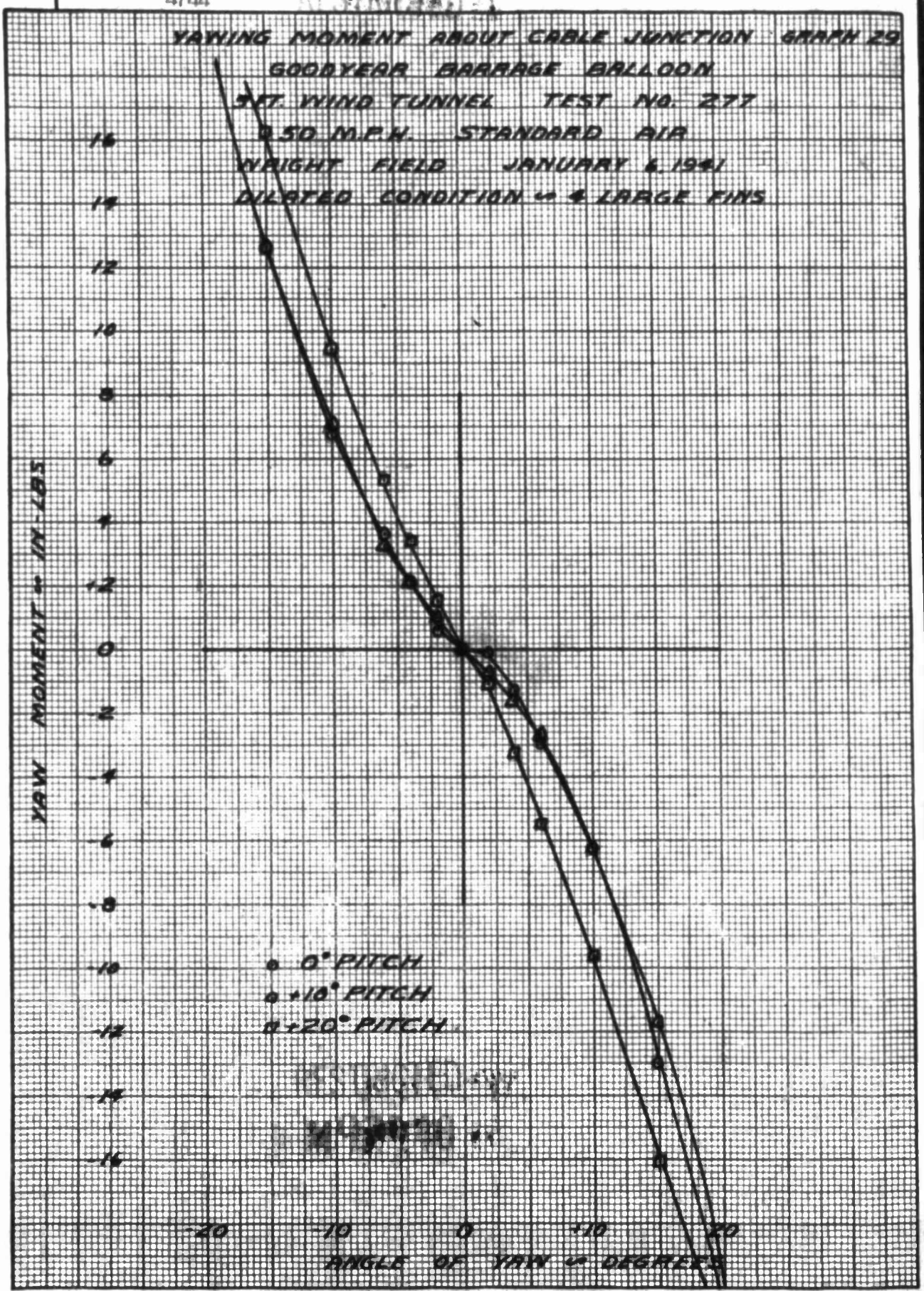
GOODYEAR BARRAGE BALLOON

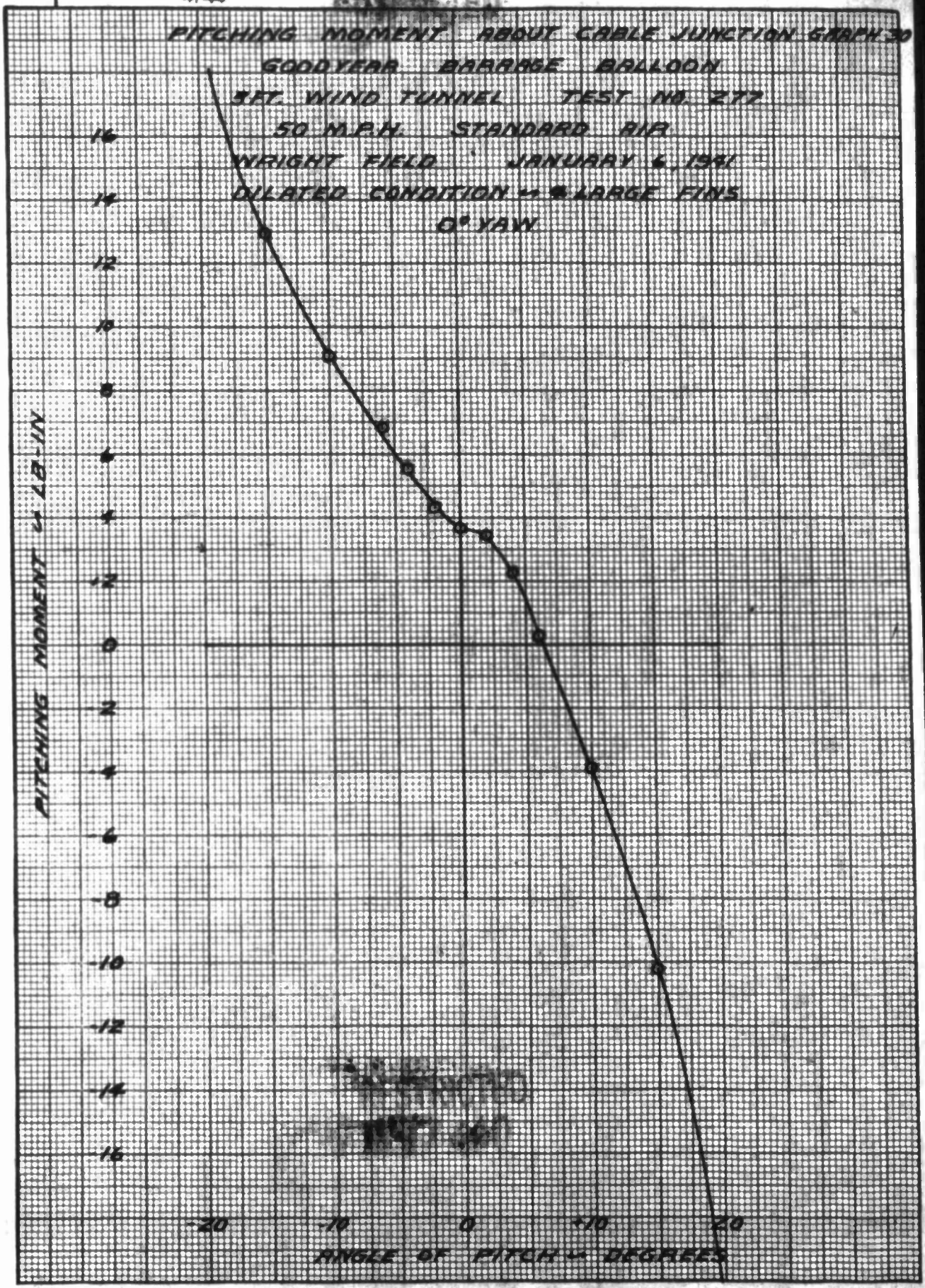
5FT. WIND TUNNEL TEST NO. 277

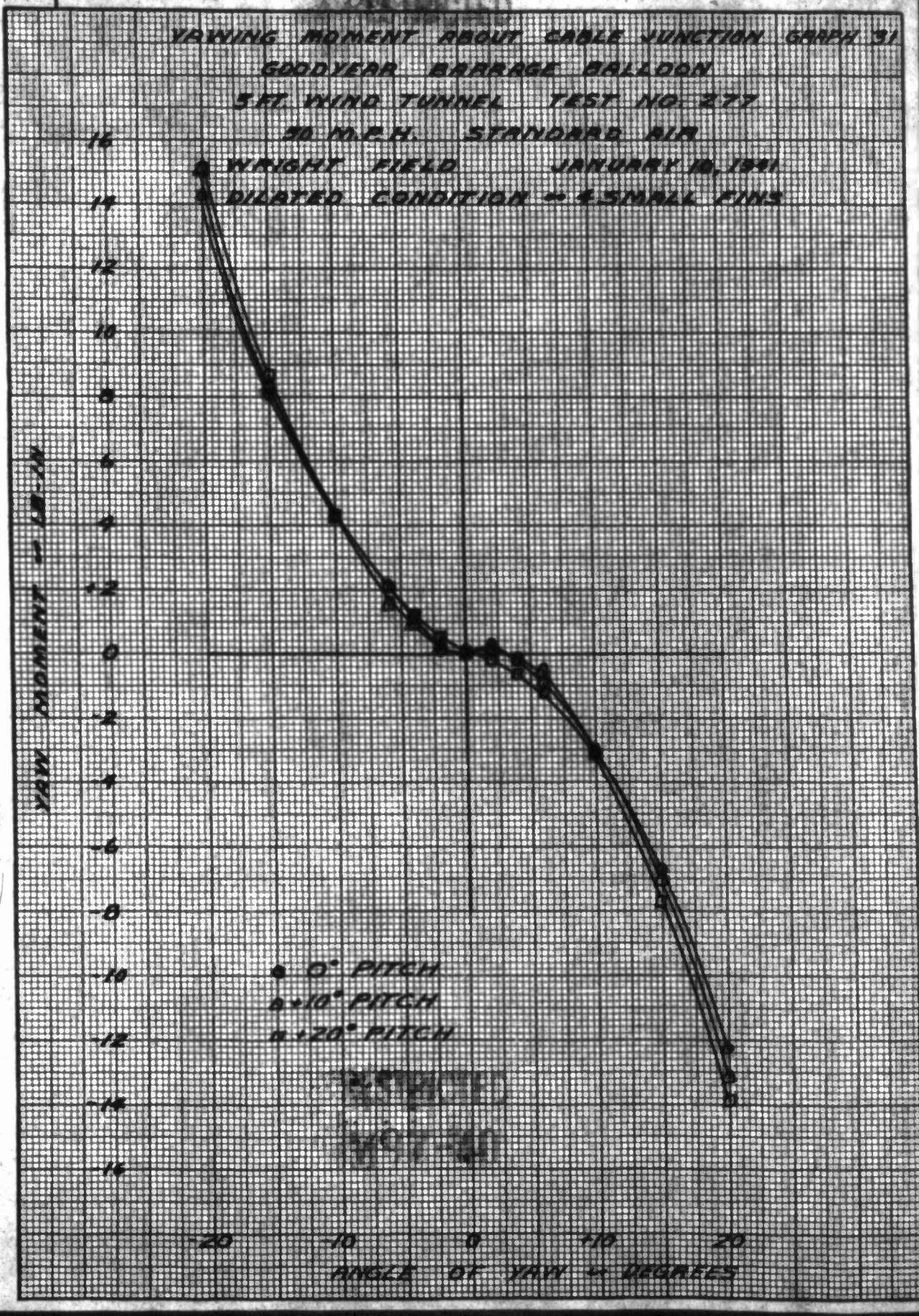
@ 50 M.P.H. STANDARD AIR

WRIGHT FIELD JANUARY 6, 1941

DILATED CONDITION w/ 4 LARGE FINS

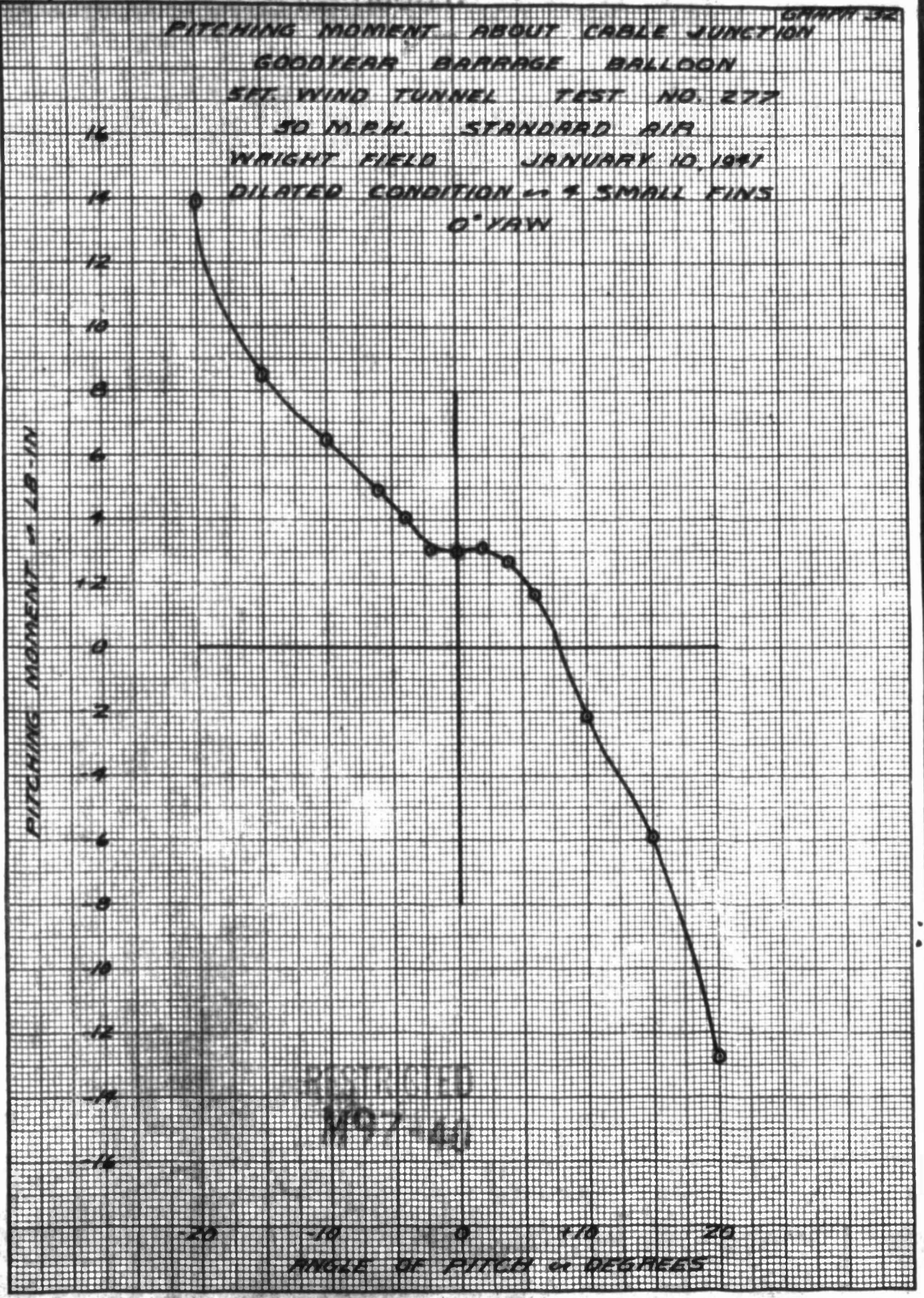



PITCHING MOMENT ABOUT CABLE JUNCTION EACH 30
GOODYEAR BARRAGE BALLOON
7FT. WIND TUNNEL TEST NO. 272
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1941
DILATED CONDITION - LARGE FINS
0° YAW
PITCHING MOMENT - LB-IN
16
14
12
10
8
6
4
2
0
2
4
6
8
10
12
14
16
-20
-10
0
+10
20
ANGLE OF PITCH - DEGREES

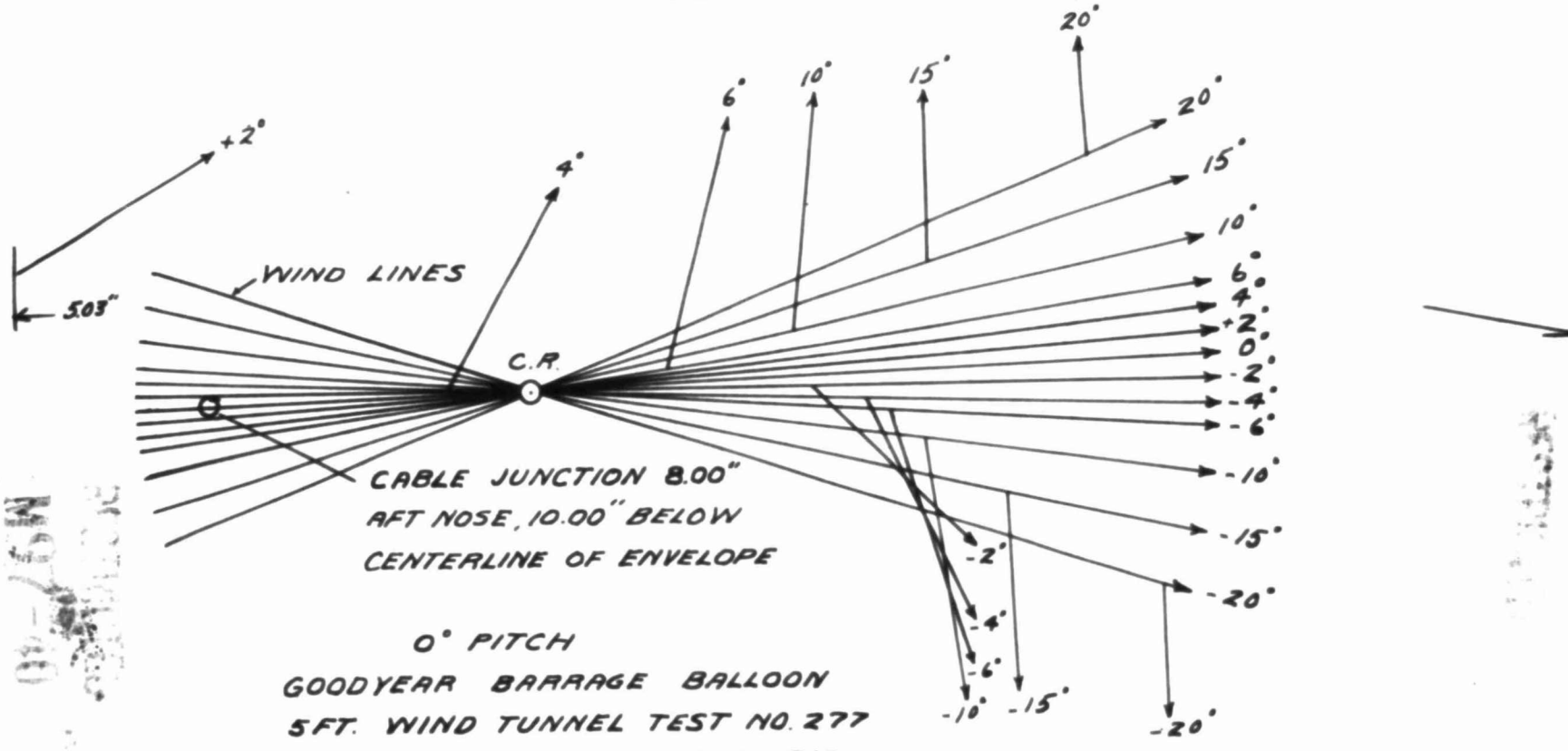


GRAPH 32

PITCHING MOMENT ABOUT CABLE JUNCTION
GOODYEAR BARRAGE BALLOON
5FT. WIND TUNNEL TEST NO. 277
30 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 10, 1941
DILATED CONDITION -- 4 SMALL FINS
0° YAW



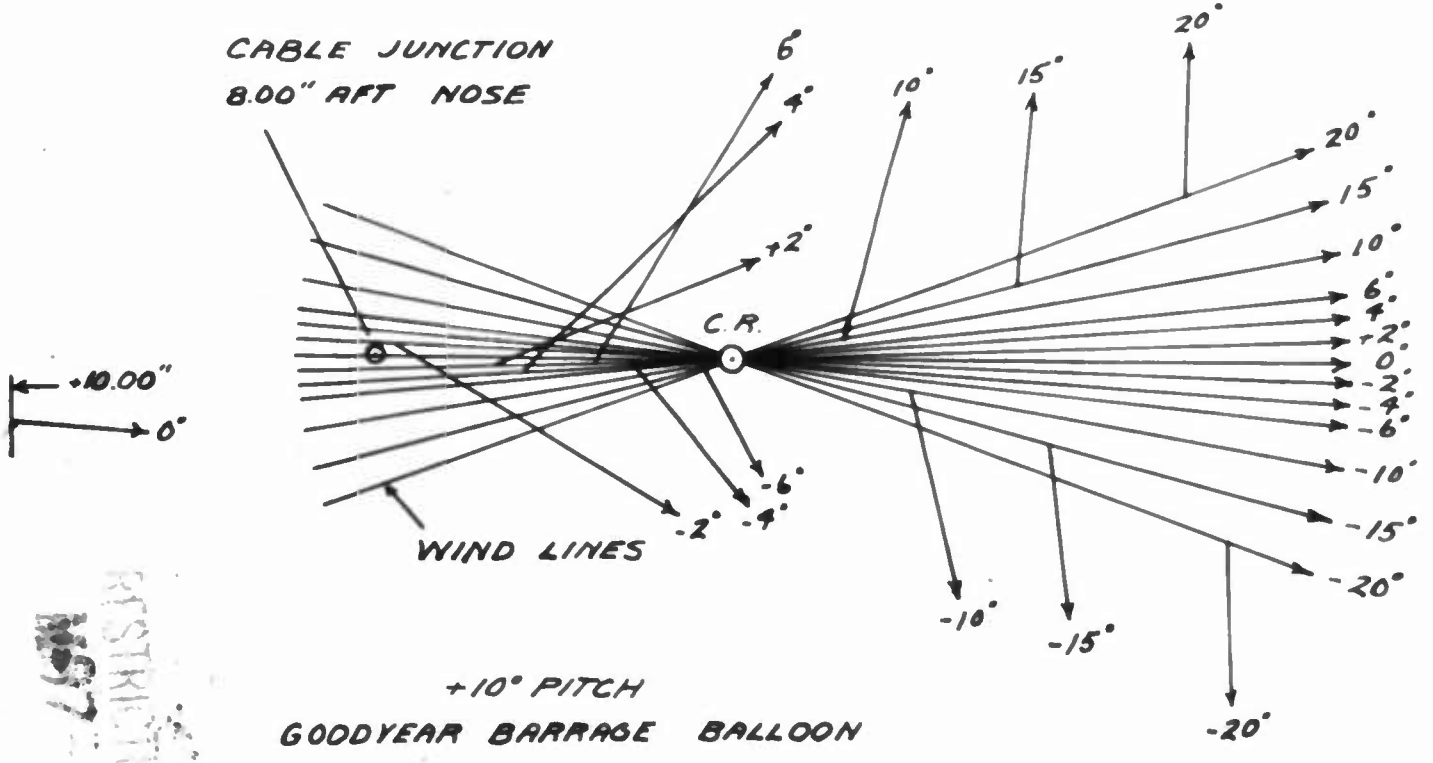
PLAN VIEW



0° PITCH
GOODYEAR BARRAGE BALLOON
5FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1941
DILATED CONDITION - 4 LARGE FINS
VECTORS NOT DRAWN TO SCALE

C.R. 9.956" AFT NOSE ON
CENTERLINE OF ENVELOPE

PLAN VIEW

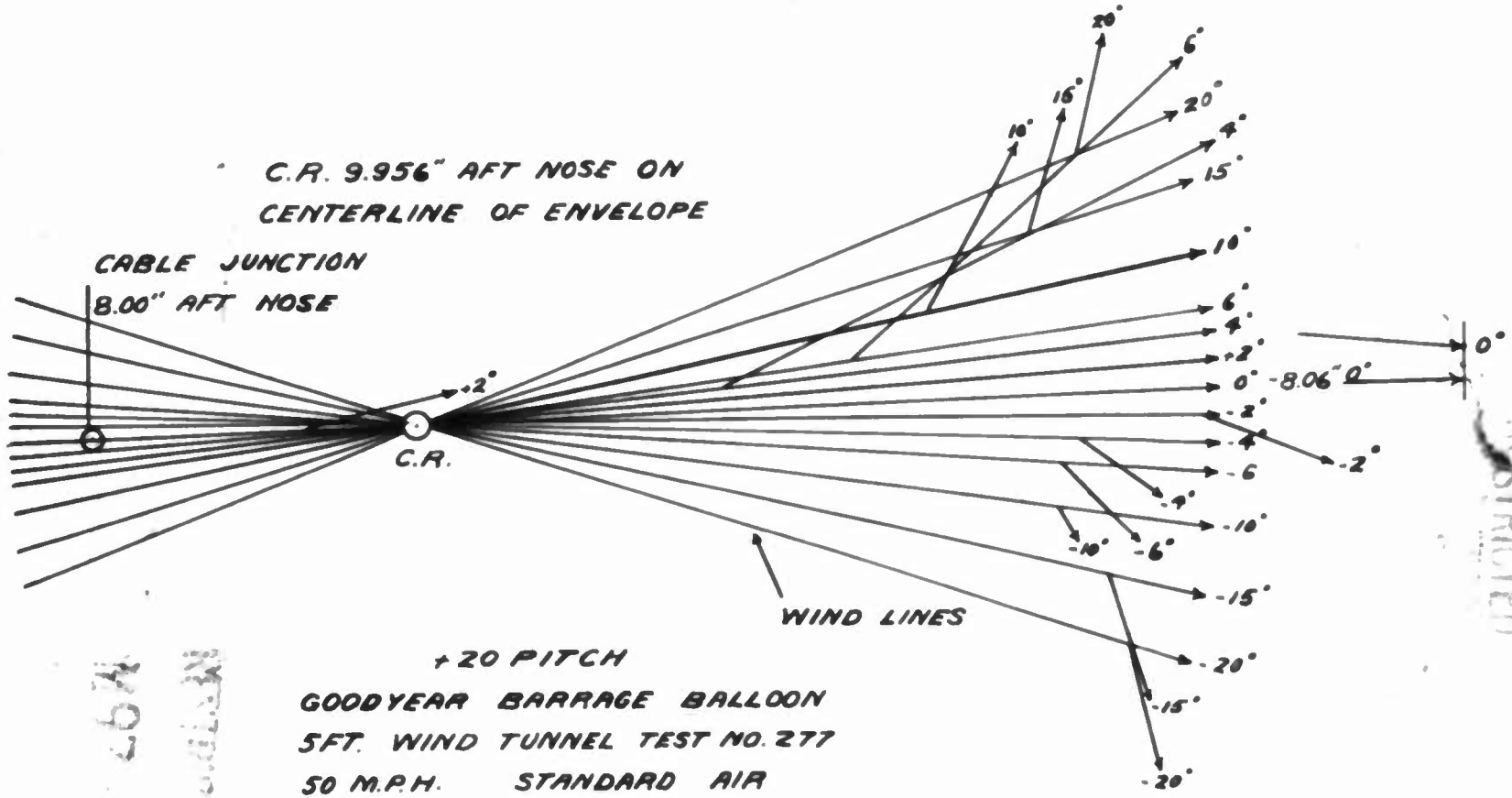


+10° PITCH

GOODYEAR BARRAGE BALLOON
5 FT. WIND-TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 10, 1941
DILATED CONDITION - 4 SMALL FINS
VECTORS NOT DRAWN TO SCALE

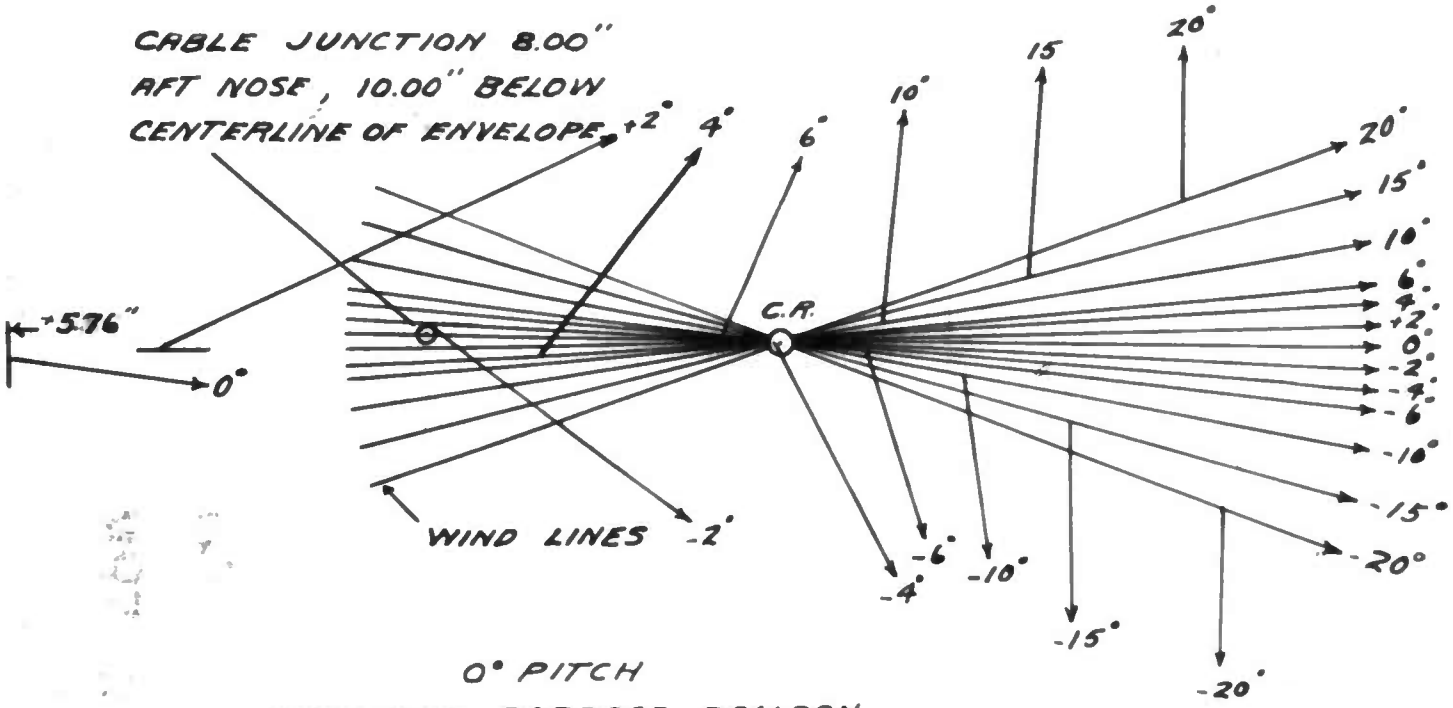
C.R. 9.956" AFT NOSE ON
CENTERLINE OF ENVELOPE

PLAN VIEW



+20 PITCH
GOODYEAR BARRAGE BALLOON
5FT. WIND TUNNEL TEST NO. 277
50 M.P.H. STANDARD AIR
WRIGHT FIELD JANUARY 6, 1941
DILATED CONDITION - 4 LARGE FINS
VECTORS NOT DRAWN TO SCALE

PLAN VIEW



0° PITCH

GOODYEAR BARRAGE BALLOON

5 FT. WIND TUNNEL TEST NO. 277

50 M.P.H. STANDARD AIR

WRIGHT FIELD JANUARY 10, 1941

DILATED CONDITION ~ 4 SMALL FINS

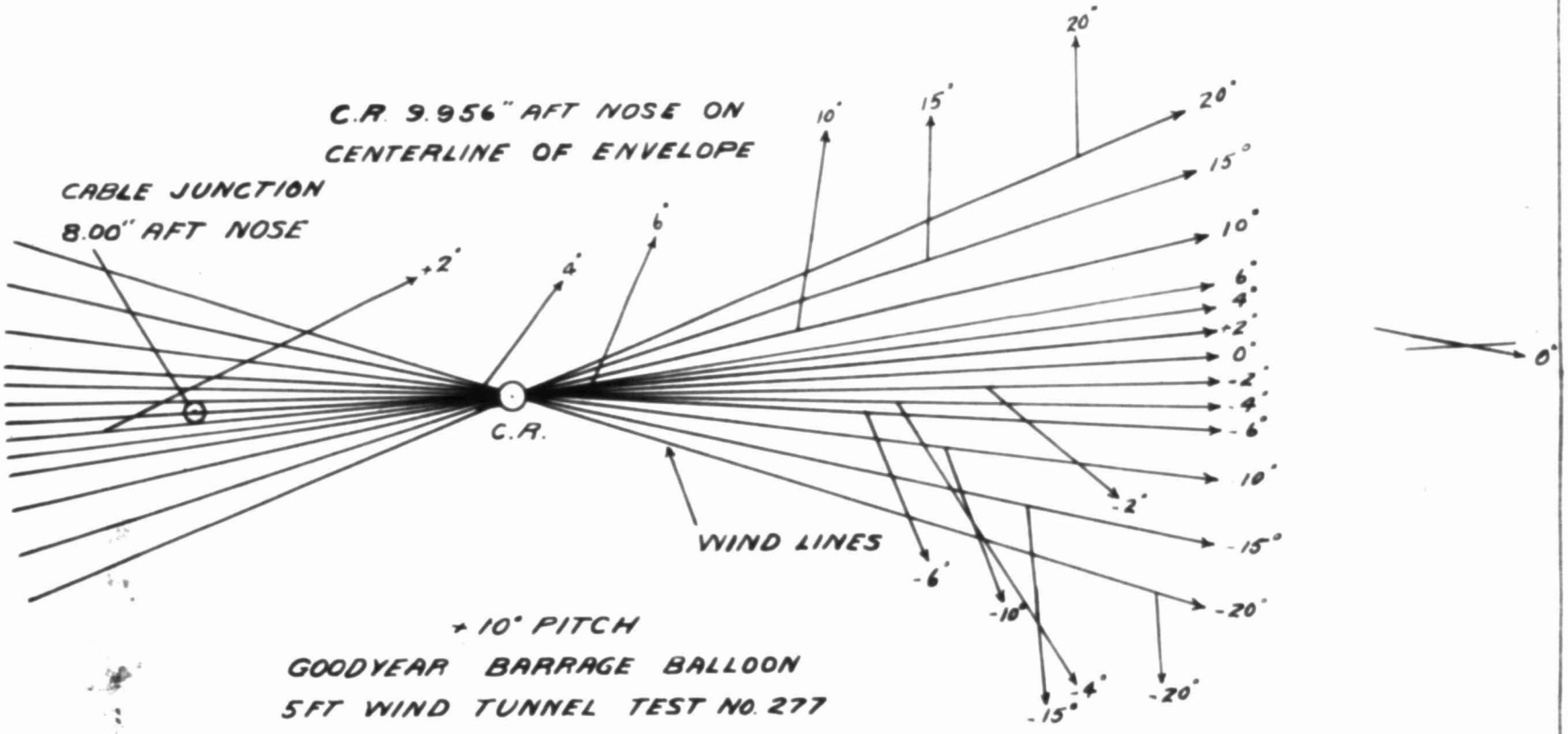
VECTORS NOT DRAWN TO SCALE

C.R. 9.956" AFT NOSE ON CENTERLINE OF ENVELOPE

SERIAL NO. 47144

PAGE 53

PLAN VIEW



+ 10° PITCH

GOODYEAR BARRAGE BALLOON

5FT WIND TUNNEL TEST NO. 277

50 M.P.H. STANDARD AIR

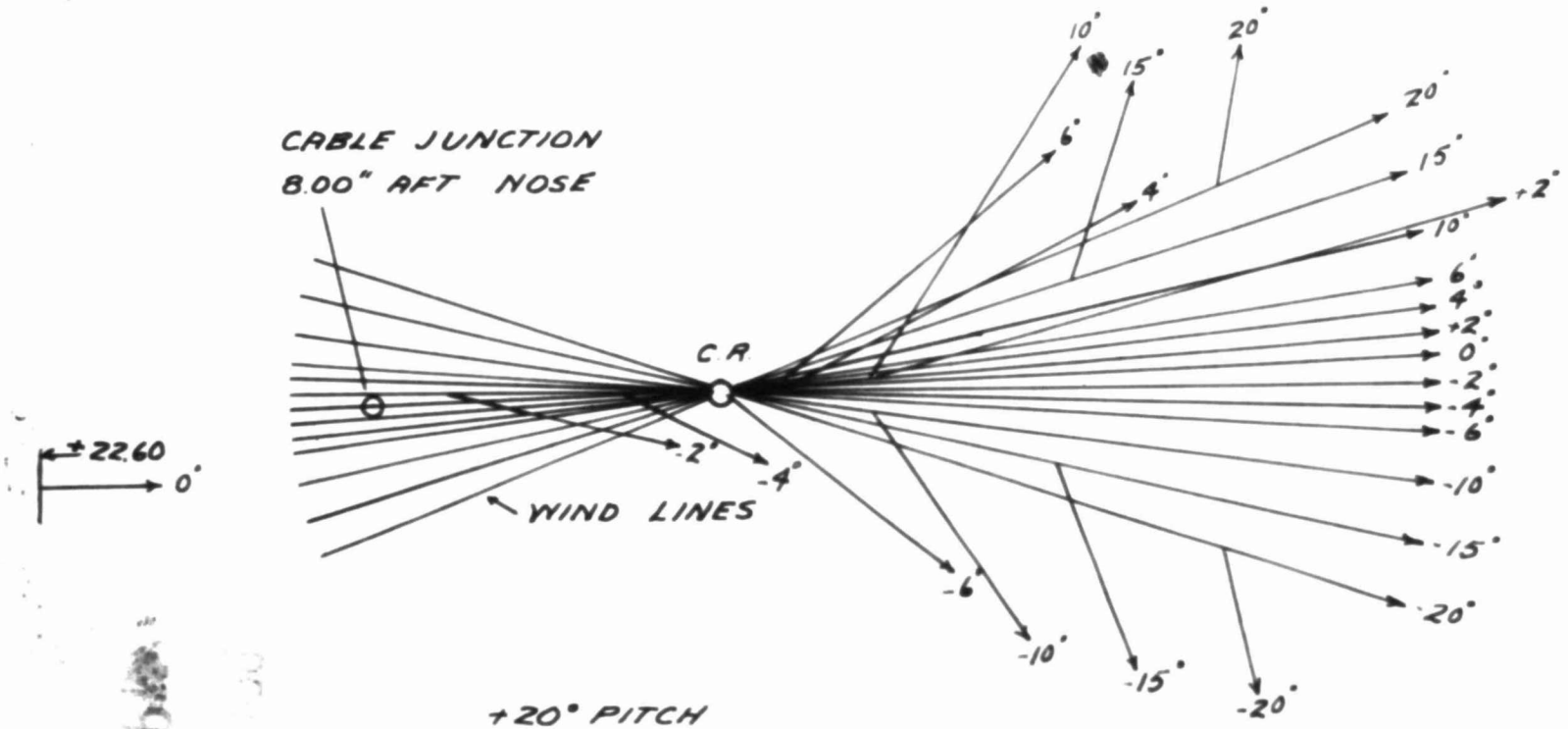
WRIGHT FIELD JANUARY 6, 1941

DILATED CONDITION, 4 LARGE FINS

VECTORS NOT DRAWN TO SCALE

SERIAL NO. 47144

PLAN VIEW



+20° PITCH

GOODYEAR BARRAGE BALLOON

5 FT. WIND TUNNEL TEST NO. 277

50 M.P.H. STANDARD AIR

WRIGHT FIELD JANUARY 10, 1941

DILATED CONDITION - 4 SMALL FINS

VECTORS NOT DRAWN TO SCALE

C.R. 9.956" AFT NOSE ON CENTERLINE OF ENVELOPE

SERIAL NO. 1714

LIST OF PHOTOGRAPHS

NO.	TITLE
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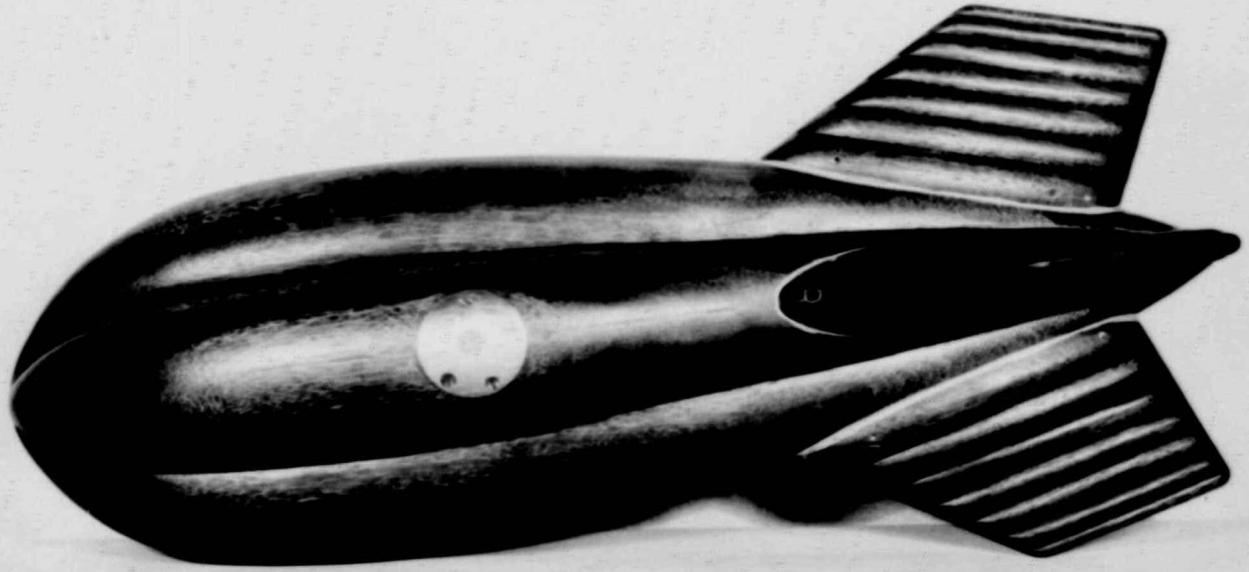
73312	Top View of Goodyear Barrage Balloon, Deflated, Small Fins.
73313	Top View of Goodyear Barrage Balloon, Dilated, Small Fins.
80263	Front View of Goodyear Barrage Balloon Model, Deflated, Small Fins, with Suspension Curtain.
80264	Side View of Goodyear Barrage Balloon Model Deflated, Small Fins, with Suspension Curtain.
80265	Front View of Goodyear Barrage Balloon Model, Dilated, Small Fins, with Suspension Curtain.
80266	Side View of Goodyear Barrage Balloon Model Dilated, Small Fins, with Suspension Curtain.

73311

73312



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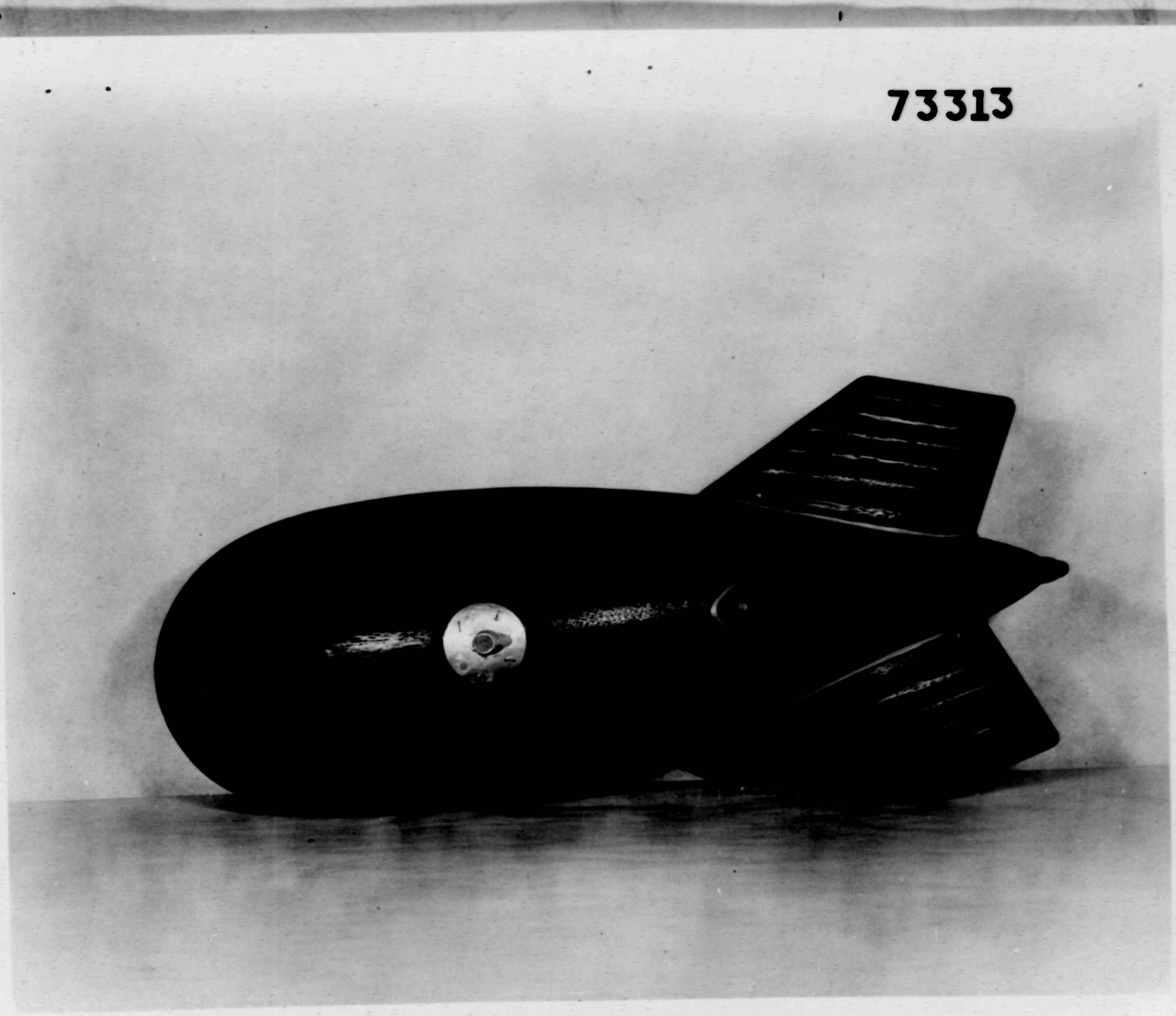


80263

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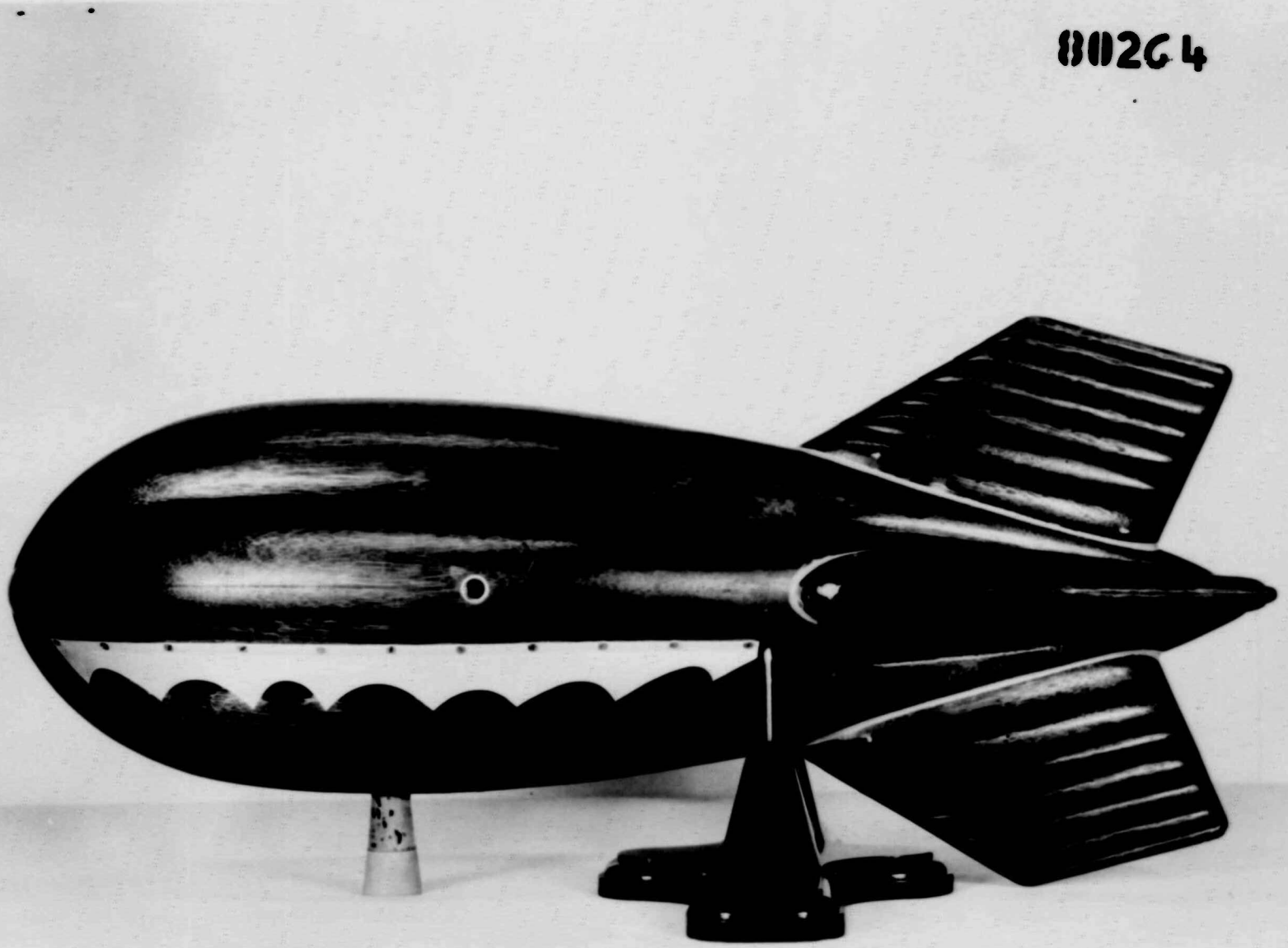

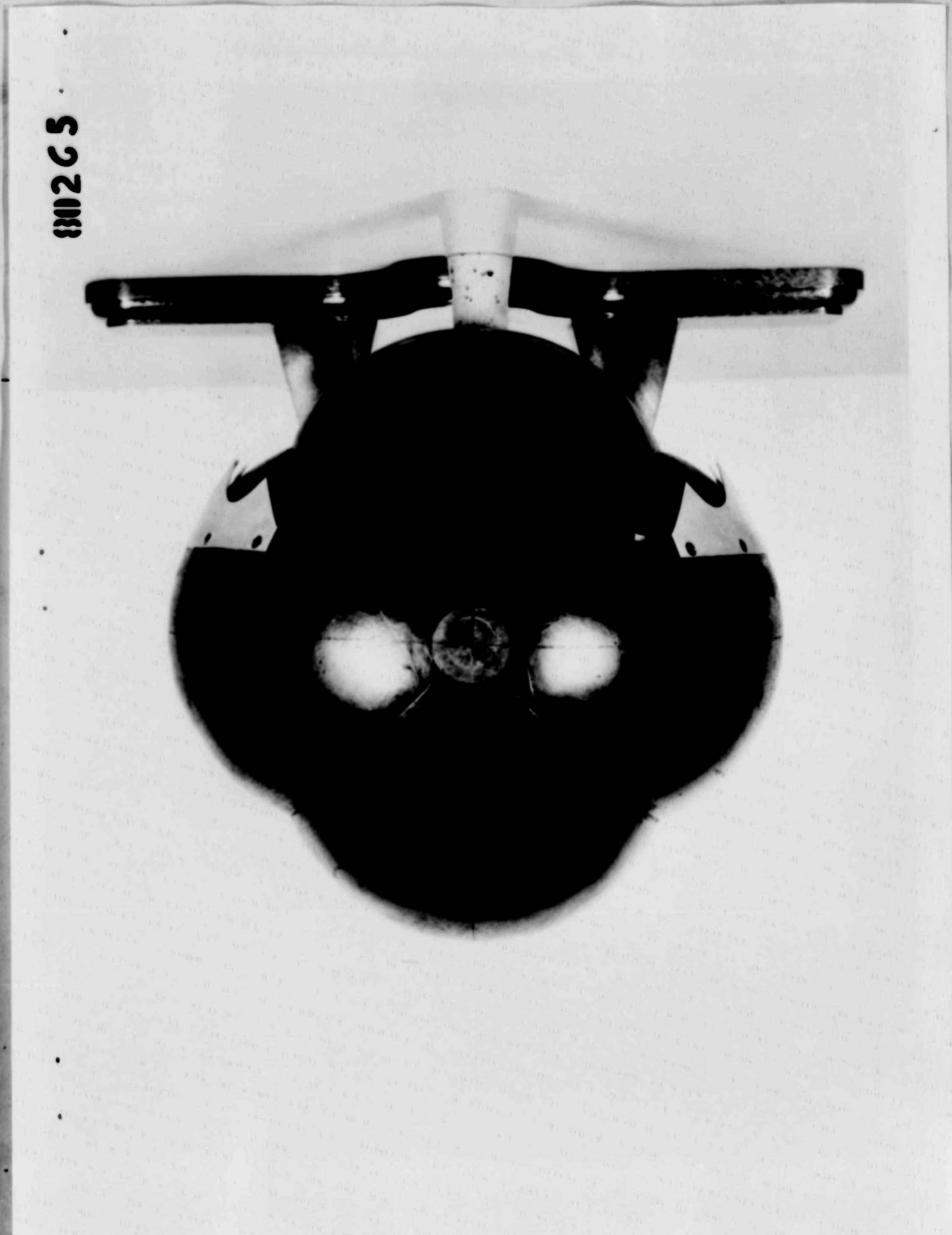
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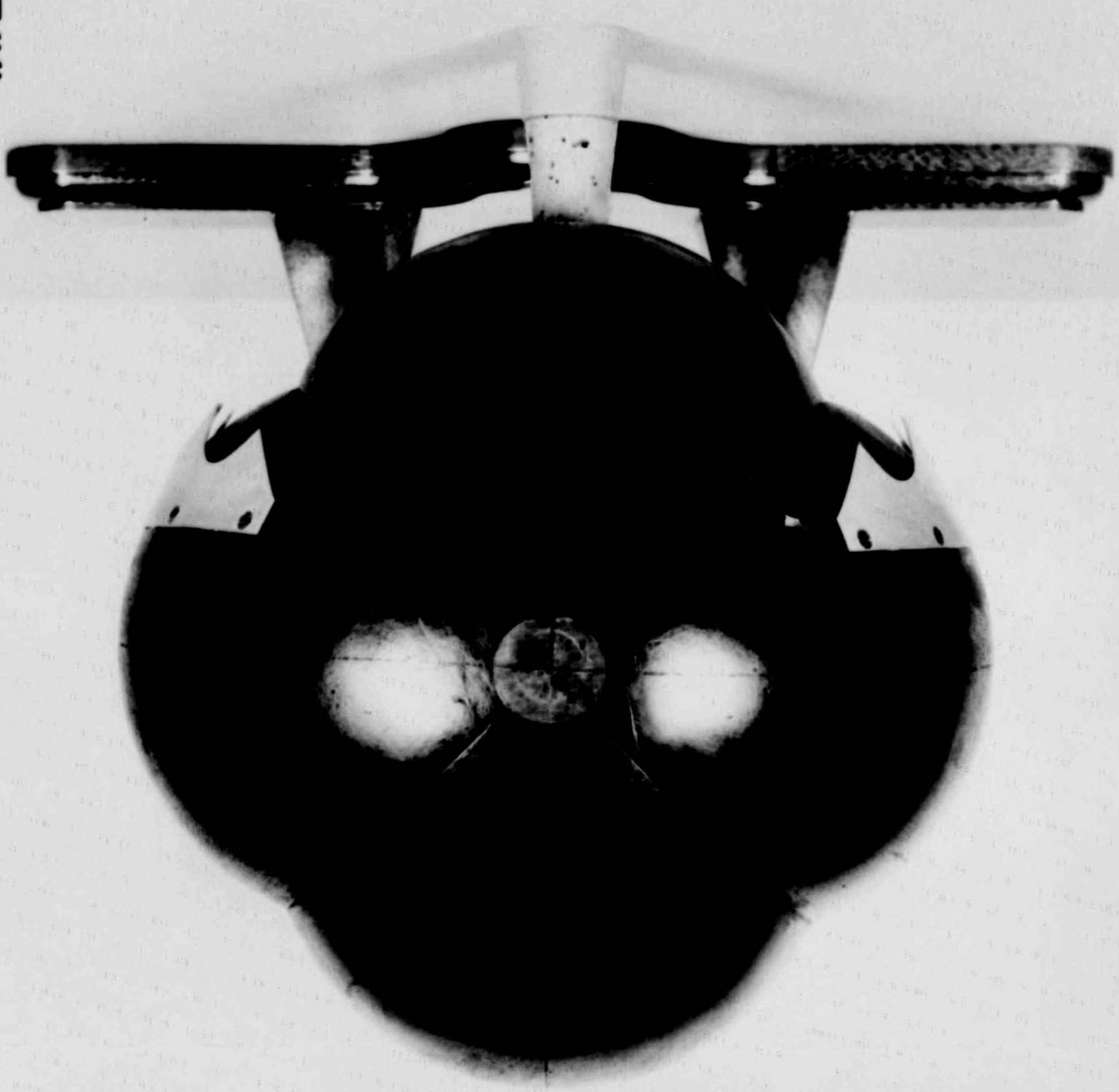

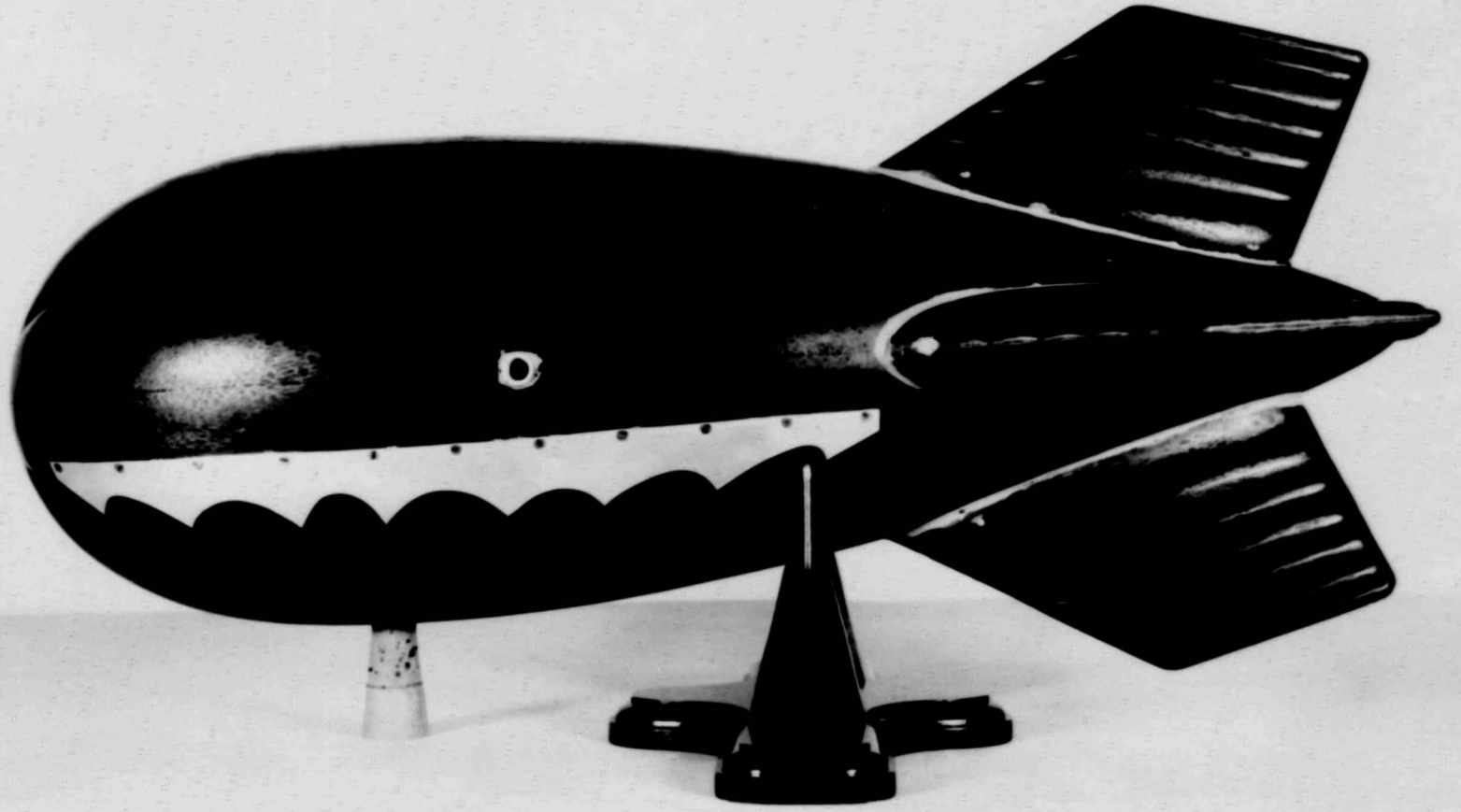

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RESTRICTED

TITLE: Five Foot Wind Tunnel Test No. 277 of 1/36-Scale Model of Goodyear Barrage Balloon for Both Deflated and Dilated Envelopes with Large and Small Fins

AUTHOR(S): Young, D. W.; Gilmore, J. H.
ORIGINATING AGENCY: Engineering Division, Air Materiel Command

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ABSTRACT:

Wind tunnel tests were made on a 1/36-scale model of a Goodyear barrage balloon to determine the longitudinal and directional stability with different size fins. Results showed that both directional and longitudinal stabilities are definitely improved by larger fins; however the small fins should provide sufficient stability about the flying cable junction, if the balloon is flown at a pitch angle of approximately +13° or more. A slight increase in directional and longitudinal stabilities should exist for the deflated envelope over the dilated envelope, provided the pitch angle does not decrease as the balloon is lowered. Addition of the suspension curtain to the model tends to reduce both directional and longitudinal stabilities slightly.

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