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Thomas J. Yager and John L. McCarty
Langley Research Center
Hampton, Virginia

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SUMMARY

A test program was conducted at the Langley aircraft landing loads and traction facility to evaluate friction performance and wear characteristics on wet runways of three 30 × 11.5-14.5, type VIII, aircraft tires having two different tread patterns and natural rubber contents. All three test tires had the standard three circumferential groove tread, but two of the tires had molded transverse grooves which extended from shoulder to shoulder. The tread rubber content of the two tires with transverse grooves differed in that one had a 100-percent natural rubber tread and the other had a rubber tread composition that was 30 percent synthetic and 70 percent natural. The third test tire (without transverse grooves) had the conventional 100-percent natural rubber tread.

Results of this investigation indicate that the differences in tire tread design and rubber composition do not significantly affect braking and cornering friction capability on wet or dry surfaces. Braking performance of the three tires decreases with increased speed, with increased yaw angle and, at higher speeds, with increased wetness of the surface. Tread-wear data based on number of brake cycles suggested that the tire with a blend of synthetic and natural rubber experiences significantly less wear than the other two test tires. The unyawed braking test runs showed that the tires with transverse tread grooves experience less wear than the conventional tire without transverse tread grooves.

INTRODUCTION

In recent years, the aircraft tire has been the subject of considerable research aimed at improving tread wear life and traction under adverse weather conditions. As pointed out in references 1 and 2, tire replacement accounts for a high percentage of the overall landing gear maintenance costs of current jet airplanes. Aircraft tire manufacturers have been trying to develop tread rubber compounds which resist cutting and to improve wear life without compromising design strength or traction capability. Correspondingly, studies (refs. 3 to 6, for example) have shown that aircraft braking and cornering capability are reduced during wet-runway operations because of tire dynamic hydroplaning effects, and attempts have been made to eliminate or delay hydroplaning by providing improved escape routes for the water in the tire footprint. Both of these problems are being addressed in a United States Air Force (USAF) program directed toward increasing the wet friction and lifetime of tires designed for high performance aircraft.

This paper presents the results of an investigation conducted at the Langley aircraft landing loads and traction facility, at the request of the USAF, to determine wet-runway behavior of high performance aircraft tires having two different tread patterns and different natural rubber contents. Three 30 × 11.5-14.5, type VIII, 24-ply-rating tires supplied by the USAF were tested to define their braking and cornering friction characteristics. These characteristics included the drag-force and cornering-force friction coefficients obtained for the tires operating on dry, damp, and flooded surfaces over a range of yaw angles from 0° to 12° at nominal ground speeds from 5 to 100 knots (1 knot = 0.5144 m/sec). The objective of the tests was to compare on the basis of these friction characteristics a tire with conventional tread (labeled tire C in this study) with (1) a tire having a modified tread pattern to promote water drainage in the tire footprint (tire A in this study) and (2) a third tire (tire B in this study) which like tire A had molded transverse grooves and wherein a percentage of the natural rubber in the tread had been replaced by synthetic rubber to reduce tread wear.

SYMBOLS

Values are given in both SI and U.S. Customary Units. Measurements and calculations were made in U.S. Customary Units. Factors relating the two systems are presented in reference 7.

$\mu_{d,max}$ maximum drag-force friction coefficient, $\dfrac{\text{Maximum drag force}}{\text{Vertical force}}$

$\mu_{d,skid}$ skidding drag-force friction coefficient, $\dfrac{\text{Skid drag force}}{\text{Vertical force}}$

$\mu_{s,max}$ maximum cornering-force friction coefficient, perpendicular to direction of motion, $\dfrac{\text{Cornering force}}{\text{Vertical force}}$

APPARATUS AND TEST PROCEDURE

Tires

The tires used in this investigation were 30 × 11.5-14.5, 24-ply-rating, type VIII, aircraft tires which are the same kind as those used on a current high performance jet fighter. Photographs of the three test tires (A, B, and C) are presented in figure 1. All three tires had the standard three circumferential groove tread currently in the USAF inventory, but tires A and B had molded transverse grooves which extended from shoulder to shoulder similar to a "rain tire" tread design evaluated and discussed in reference 8. The comparable tire of reference 8 had a conventional tread which had been modified by hand with transverse cuts. The tread rubber content of tires A and B differed, however, in that tire A had a 100-percent natural rubber tread; whereas tire B had a tread composition of 30-percent synthetic and 70-percent natural rubber. Tire C had the conventional 100-percent natural rubber tread and no transverse grooves. All tires were tested at an inflation pressure of 1827 kPa (265 psi), and the vertical load ranged from 57.8 kN (13 000 lb) to 66.7 kN (15 000 lb).

Test Facility

The investigation, conducted at the Langley aircraft landing loads and traction facility described in reference 9, utilized the main test carriage pictured in figure 2. The aircraft test tire, wheel, and brake assembly were mounted as shown in figure 3 on an instrumented dynamometer which measured the various axle loadings. Figure 4 illustrates the dynamometer instrumentation which consisted, in part, of load beams to measure vertical, drag, and side forces, and links to measure brake torque, all at the wheel axle. Additional instrumentation was provided to measure brake pressure, wheel angular velocity, and carriage horizontal displacement and velocity. Continuous time histories of the output of the instrumentation during a run were obtained by tape recorders mounted on the test carriage.

Test Surfaces

Three approximately equal segments of a 183-m (600-ft) section of the concrete test runway were maintained in dry, damp, and flooded conditions. For the damp condition, the surface was wetted to a depth of less than 0.03 cm (0.01 in.); the water depth for the flooded surface ranged from 0.5 to 0.8 cm (0.2 to 0.3 in.). Photographs of the overall test runway and the three surfaces are presented in figure 5. Texture depth values which provide an indication of potential surface frictional characteristics were measured by the grease sample technique described in reference 5. Results from these measurements indicated that the dry concrete test surface had an average texture depth of 91 μm (0.0036 in.); the damp concrete section, 114 μm (0.0045 in.); and the flooded test section, 145 μm (0.0057 in.). The damp and flooded runway sections of this investigation are the same sections used in the tire program described in reference 10. That investigation used conventional tires of the size similar to the tires tested in this investigation.

Test Procedure

For most test runs the carriage was propelled to the desired ground speed, the drop test fixture was released to apply the preselected vertical load on the tire, and the tire was subjected to controlled brake cycles on three surfaces: first, on the dry surface; subsequently, on the damp and flooded surfaces. The procedure was the same during other runs except that the brake cycles were limited to the wetted surfaces only. A brake cycle consisted of actuating the brake-pressure solenoid valve at predetermined locations along the track (thus, braking the tire from a free-rolling condition to a locked-wheel skid) and then releasing the brake pressure to allow tire spin-up prior to the next cycle. Nominal carriage speeds for these tests were 5 knots (obtained by towing the carriage with a ground vehicle) and 25, 50, 75, and 100 knots (obtained by propelling the carriage with the water jet). Evaluation of combined tire braking and cornering traction was achieved by rotating and locking in place prior to each run the entire test fixture dynamometer to yaw angles of 0° to 12° in 4° increments. No combined braking and cornering test was undertaken on the dry pavement because of the extensive wear associated with braking a yawed tire on a high-friction surface. The instrumentation measurements were recorded on tape and provided a complete time history of the test tire behavior during the course of a run.

RESULTS AND DISCUSSION

Tire-to-ground forces in the vertical, drag, and side directions and wheel angular velocity were recorded throughout each test and were used to compute time histories of the drag-force friction coefficient parallel to the direction of motion and the maximum (unbraked) cornering-force friction coefficient perpendicular to the direction of motion.

For each test condition, the maximum cornering-force friction coefficient $\mu_{s,max}$ measured just before braking was initiated, the maximum drag-force friction coefficient $\mu_{d,max}$ encountered during wheel spin-down, and the skidding drag-force friction coefficient $\mu_{d,skid}$ measured at the instant of wheel lockup were determined from faired curves of the time history data. These data for the three test tires are presented in table I. The following sections discuss the variations of $\mu_{d,max}$, $\mu_{d,skid}$, and $\mu_{s,max}$ for the three test tires with respect to both ground speed and yaw angle and conclude with comments relative to the wear characteristics of the different tires.

Effect of Ground Speed on Friction Characteristics

The effect of ground speed on the selected tire braking and cornering characteristics developed during operations on dry, damp, and flooded surfaces is shown in figure 6 for each test tire at yaw angles of 0°, 4°, 8°, and 12°. The data for all three test tires are faired by a single curve for each surface and yaw angle condition; in general, these fairings describe the coefficients for all tires. Thus, it would appear that there is no significant effect on braking and cornering friction, wet or dry, attributed to differences in the tread design and rubber composition of the tires evaluated in this program. The data of figure 6 agree well with results from tests on similar tires in earlier programs. (See refs. 8 and 10.)

Maximum drag-force friction coefficient.- The data of figure 6 indicate that the values of maximum drag-force friction coefficient $\mu_{d,max}$ decrease with increasing ground speed. The decrease is observed under all runway surface conditions although it is much less pronounced on the dry than on the two wetted surfaces. This decrease corroborates the trends observed in references 3 to 6 for aircraft tires in general and in references 8 and 10 for tires of the same size as tires used in this study. The figure also shows that $\mu_{d,max}$ in the unyawed condition is essentially the same on all three surfaces at very low speeds. The magnitude agrees well with the prediction (0.64) from the empirical expression developed in reference 11 for maximum friction under nearly static conditions.

In general, values of $\mu_{d,max}$ on the flooded surface are the same as those on the damp surface for similar test conditions. The similarity is perhaps due to the following reasons. First, the texture depth of the flooded surface is approximately 25 percent greater than that of the damp surface.

With all the test speeds of this program well below the computed dynamic hydroplaning speed of 147 knots for the test tire (ref. 4), this difference in surface texture should affect tire friction. Second, the flooded surface, because of its water depth, induces a significant fluid drag on the tire whereas on the damp surface (no standing water) such drag can be considered negligible.

Skidding drag-force friction coefficient.- The skidding drag-force friction coefficient $\mu_{d,skid}$ developed by all three tires is essentially the same as $\mu_{d,max}$ at very low ground speeds but decreases to somewhat lower levels at the higher speeds. This trend is noted at all test yaw angles and on the dry, damp, and flooded surfaces. Values of $\mu_{d,skid}$ on the flooded surface are generally slightly higher than those on the damp surface, particularly at the higher ground speeds, apparently for the same reasons identified in the preceding section. There are no significant differences in $\mu_{d,skid}$ values between the three test tires despite differences in tread design and rubber content.

Maximum cornering-force friction coefficient.- Since no side force is developed when the tire is unyawed, regardless of the surface condition, there are no maximum cornering-force friction coefficients shown in figure 6(a). However, figures 6(b) to 6(d) show that the effect of ground speed on $\mu_{s,max}$ developed by the yawed tire is dependent upon the surface wetness condition. When the surface is dry, $\mu_{s,max}$ is relatively insensitive to speed and decreases only slightly with increasing speed; whereas on the wetted surfaces a more rapid deterioration in $\mu_{s,max}$ is observed as the speed increases. At high speeds, this deterioration appears greater on the flooded than on the damp surface. No recognizable difference in the maximum cornering-force friction coefficients is caused by the tread rubber compositions tested, but the available data do suggest that the conventional tread pattern (no transverse grooves) generates slightly higher friction under the flooded condition at the higher speeds.

Effect of Yaw Angle on Friction Characteristics

The effect of yaw angle on the drag-force and cornering-force friction coefficients developed by the test tires under the three surface conditions at nominal ground speeds of 5 and 100 knots is illustrated in figure 7 where the data are again taken from table I. The two drag-force friction coefficients were available only at a yaw angle of 0° on the dry surface because of the excessive wear which would result from braking a yawed tire on a high-friction surface. The data for all three test tires are faired by a single curve for each surface and ground speed condition which suggests little or no differences in the friction characteristics of the tires.

Maximum drag-force friction coefficient.- The data of figure 7 indicate that the maximum drag-force friction coefficients $\mu_{d,max}$ are highest for the unyawed tire and gradually decrease with increasing yaw angle although the decrease at the higher speed is less pronounced. The figure also illustrates that $\mu_{d,max}$ is greatest when the tires are operating on a dry surface at low speeds and that the effect of yaw-angle changes on that coefficient is essentially the same for both wetness conditions at either of the two speeds.

Figure 7(a) shows that values of $\mu_{d,max}$ developed by all three tires under flooded conditions are generally somewhat higher than the corresponding values obtained under damp conditions. The higher $\mu_{d,max}$ values result from the fluid drag and surface texture effects discussed in the preceding sections. At 100 knots, the values are approximately the same for all yaw angles of the test.

Skidding drag-force friction coefficient.- Values of the skidding drag-force friction coefficient $\mu_{d,skid}$ developed by the test tires of this program are shown in figure 7 to be only slightly affected by changes in yaw angle at least up to 12°, the maximum yaw angle examined. This insensitivity to yaw angle agrees with the results of reference 10 and suggests that the footprint of the skidding tire remains effectively the same over this range of yaw angles. The figure also shows that at the lower yaw angles, the tire with a conventional tread pattern (tire C) generally develops less skidding friction than the other tires equipped with transverse tread grooves. The values of $\mu_{d,skid}$ on the damp and flooded surfaces at 100 knots are less than those developed on the dry surface because of the lubrication provided by the presence of water. The fluid drag and deeper surface texture make the flooded surface data slightly higher than the respective damp surface data.

Maximum cornering-force friction coefficient.- The maximum cornering-force friction coefficient $\mu_{s,max}$ developed by the three tires at a ground speed of 5 knots increases with increasing yaw angle up to and including the maximum test yaw angle on all surfaces. At 100 knots, the trend is the same; however, $\mu_{s,max}$ values appear to reach a maximum at yaw angles within the range tested. Figure 7(a) also shows that at low speed, wetting the surface has only a slight effect on $\mu_{s,max}$. At high speed, on the contrary (fig. 7(b)), $\mu_{s,max}$ is reduced significantly with wetness. Although not conclusive, comparison of the cornering friction developed between the three test tires reveals that the $\mu_{s,max}$ level of the conventional tire C tends to be higher for all test conditions.

Tread-Wear Considerations

During this experimental program, tire tread wear was also monitored by measuring the depth of each groove at several positions around the tire circumference after each braking test. When these values are compared with the initial depth, the amount of tread wear can be determined. It was difficult to use this information as a basis for comparison between the wear resistance of each tire because the tires were not all exposed to identical test conditions (e.g., speed, length of each brake cycle, and yawed rolling distance). However, an indication of the relative tread wear experienced by the tires can be obtained by computing for each tire a wear index which is the ratio of the total tread wear to the total number of brake cycles. The wear index computed for conventional production tire C was 0.049 mm per cycle (0.0019 in. per cycle). The index for tire A was 113 percent of the index of the conventional tire, but the index for tire B was only 42 percent as great as that of the conventional tire. Thus, these values suggest that the tire with a blend of synthetic and natural rubber (tire B) experienced significantly less wear from brake cycles than tires with a 100-percent natural rubber tread. When only the unyawed braking test runs are considered (in order to eliminate the variable yawed rolling distance), both tires A and B, equipped with transverse grooves in their tread, experienced significantly less wear than the conventional tire without transverse grooves.

CONCLUDING REMARKS

A test program was conducted at the Langley aircraft landing loads and traction facility to evaluate the friction characteristics of three 30×11.5-14.5, type VIII, aircraft tires constructed with different tread groove patterns and rubber compounds. Two tires, each with molded transverse grooves in the tread and having conventional and blended tread rubber compositions were tested with a conventional tire without transverse grooves. The investigation consisted of braking the test tires from free-roll conditions to locked-wheel skids on dry, damp, and flooded runway surfaces at nominal ground speeds from 5 to 100 knots and at yaw angles from 0° to 12°.

The results from these tests indicate that no significant effect on braking and cornering friction, wet or dry, could be attributed to differences in the tread design or rubber composition. The braking capability of the three tires decreased with increased ground speed, with increased yaw angle, and, at the higher speeds, with increased wetness of the surface. The maximum cornering-force friction coefficients developed by the yawed test tires decreased with increased speed, but this effect was less pronounced on the dry surface. At the 5-knot nominal speed, the maximum cornering-force friction coefficient increased with increasing yaw angle up to the maximum test yaw angle on all surfaces. At the higher nominal speeds (up to 100 knots), however, the maximum cornering-force friction values appeared to peak at yaw angles within the range tested.

A comparison of the total tread loss as related to the number of brake cycles for each tire throughout the entire test program suggests that the tire with a blend of synthetic and natural rubber experienced significantly less wear than tires with a 100-percent natural rubber tread. The tire tread loss associated with only the unyawed braking tests indicated that the tires equipped with transverse tread grooves experienced less wear than the conventional tire without transverse tread grooves.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
November 18, 1977

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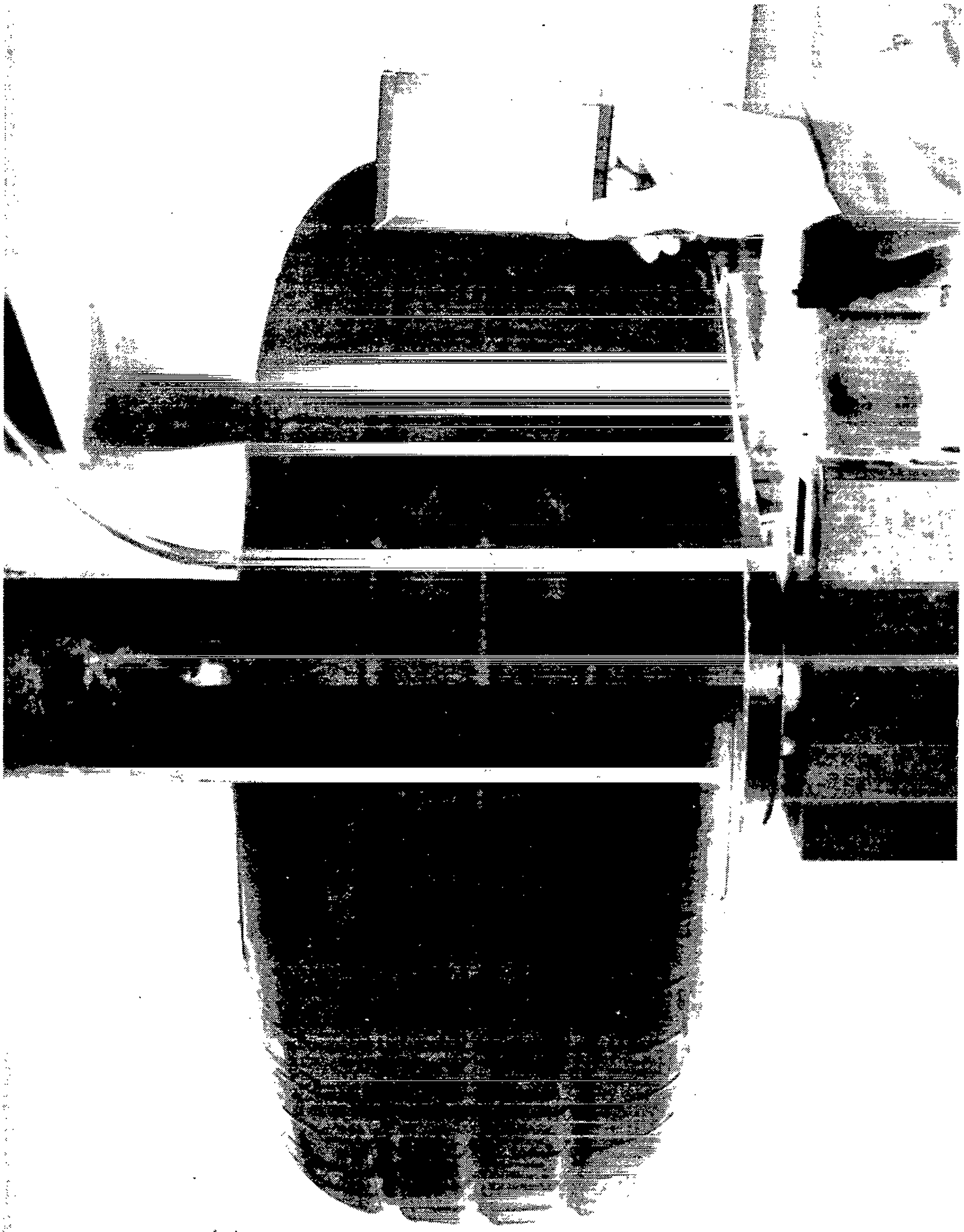
TABLE I.- SUMMARY OF FRICTION COEFFICIENTS OBTAINED FOR VARIOUS TEST CONDITIONS

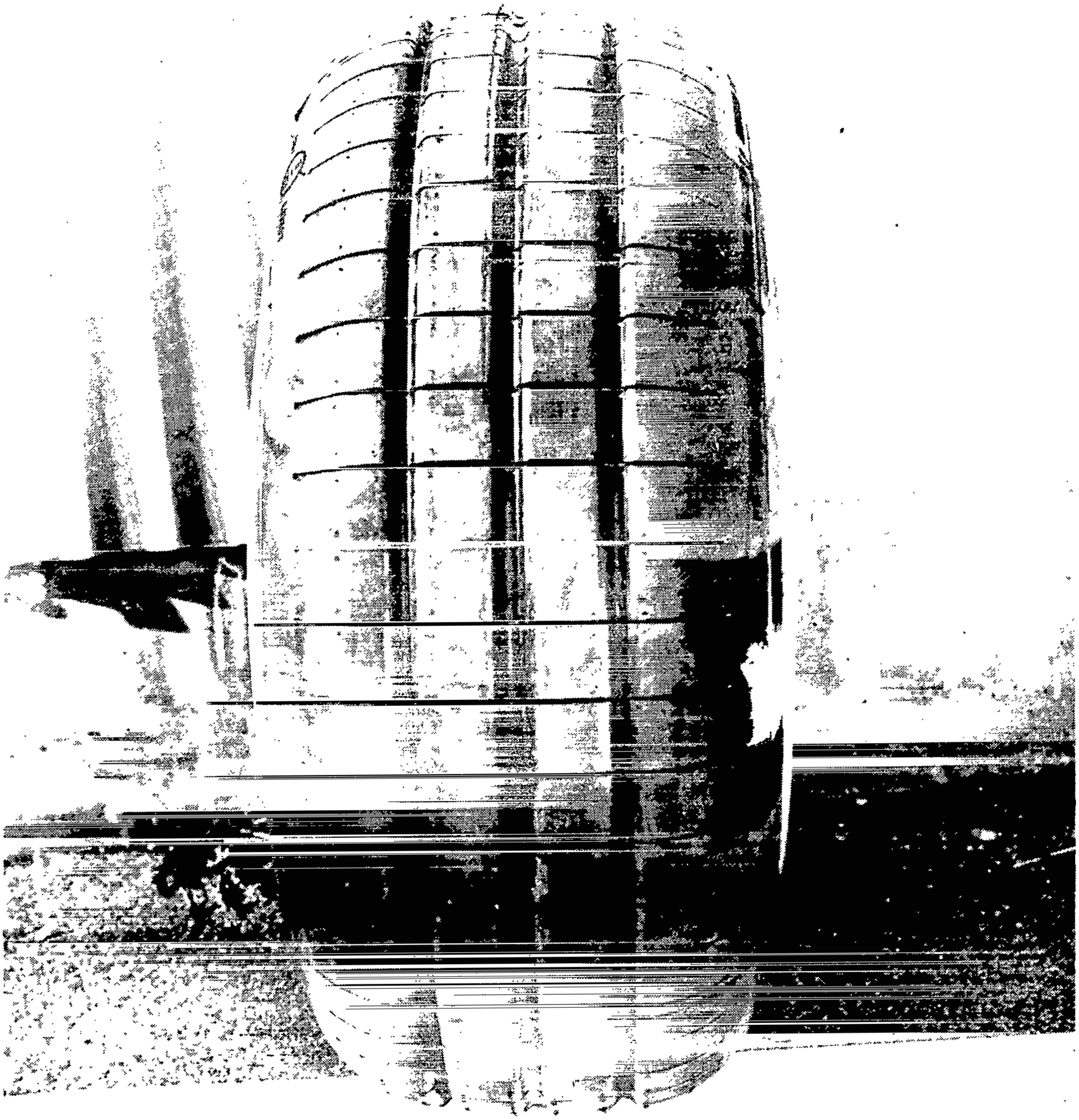
Tire	Yaw angle, deg	Dry surface				Damp surface				Flooded surface			
		Speed, knots	$\mu_{d,max}$	$\mu_{d,skid}$	$\mu_{s,max}$	Speed, knots	$\mu_{d,max}$	$\mu_{d,skid}$	$\mu_{s,max}$	Speed, knots	$\mu_{d,max}$	$\mu_{d,skid}$	$\mu_{s,max}$
A	0	6	0.62	0.62	0	6	0.62	0.62	0	6	0.61	0.61	0
	0	30	.52	----	0	29	.47	----	0	29	.40	----	0
	0	53	.48	.37	0	52	.32	.26	0	51	.30	.28	0
	0	75	.48	.22	0	74	.23	.18	0	72	----	.18	0
	0	101	.46	.19	0	100	----	.12	0	97	.11	.10	0
	4	---	----	----	----	4	.54	.54	.26	4	.43	.43	.25
	4	27	----	----	.32	26	.35	.31	.27	25	.37	.30	.23
	4	51	----	----	.31	50	.36	.31	.17	48	.19	.17	.18
	4	---	----	----	----	75	.19	.17	.18	71	.26	.24	.12
	4	102	----	----	.28	100	.19	.12	.09	96	.15	.11	.06
	8	4	----	----	.37	4	.39	.38	.32	4	.39	.38	.32
	8	27	----	----	.44	26	.25	.24	.19	25	.27	.24	.24
	8	52	----	----	.40	51	.17	.13	.13	49	.19	.14	.15
	8	77	----	----	.41	75	.19	.09	.07	72	.21	.12	.08
	8	102	----	----	.41	100	.11	.07	.06	97	.12	.09	.02
	12	4	----	----	.48	4	.38	.37	.35	4	.45	.44	.46
	12	26	----	----	.49	25	.21	.18	.20	23	.29	.24	.21
	12	51	----	----	.47	50	----	.16	.12	49	.23	.18	.14
	12	76	----	----	.44	74	----	.07	.08	71	.14	.12	.06
	12	101	----	----	.44	100	.09	.05	.11	98	.11	.10	.02
B	0	5	0.60	0.49	0	5	0.56	0.54	0	5	0.57	0.54	0
	0	5	.62	.58	0	5	.67	.54	0	5	.71	.56	0
	0	12	.54	.50	0	10	.54	.43	0	9	.54	.47	0
	0	15	.54	.49	0	13	.51	.47	0	11	.57	.51	0
	0	29	.63	.49	0	28	.57	.30	0	27	.53	.41	0
	0	40	.50	.37	0	38	.33	.27	0	38	.36	.28	0
	0	62	.41	.23	0	60	.26	.12	0	58	.23	.13	0
	0	100	.50	.22	0	98	----	----	0	95	.19	.12	0
	0	101	.43	.16	0	96	.15	.10	0	94	.11	.09	0
	4	---	----	----	----	6	.47	.46	.28	6	.54	.52	.30
	4	23	----	----	.32	22	.38	.36	.25	20	.41	.40	.28
	4	51	----	----	.31	50	.40	.31	.19	48	.30	.28	.21
	4	---	----	----	----	73	.23	.11	.16	70	.19	.16	.10
	4	102	----	----	.32	100	.15	.08	.11	96	.13	.12	.02
	8	6	----	----	.43	6	.42	.42	.35	6	.41	.41	.37
	8	29	----	----	.44	28	.27	.23	.22	26	.31	.29	.24
	8	53	----	----	.44	51	.27	.14	.14	49	.23	.19	.19
	8	72	----	----	.42	70	.24	.12	.15	67	.21	.17	.10
	8	---	----	----	----	100	.15	.08	.06	97	.14	.11	.02
	12	6	----	----	.52	6	.40	.39	.34	5	.47	.46	.40
	12	29	----	----	.49	28	.24	.22	.26	26	.33	.32	.30
	12	50	----	----	.47	49	.18	.14	.16	48	.20	.16	.18
	12	76	----	----	.44	74	.14	.08	.16	70	.13	.10	.07
	12	104	----	----	.41	102	.11	.04	.13	98	.08	.06	.03
C	0	8	0.63	0.52	0	8	0.54	0.46	0	8	0.63	0.46	0
	0	24	.60	.58	0	23	.40	.34	0	22	.52	.50	0
	0	52	.51	.22	0	50	.32	.21	0	49	.31	.24	0
	0	74	.52	.15	0	72	.25	.11	0	70	.23	.13	0
	0	102	.42	.14	0	99	----	.07	0	96	.12	.07	0
	4	7	----	----	.39	7	.40	.37	.26	7	.45	.40	.28
	4	101	----	----	.37	99	.11	.04	.09	97	.11	.07	.10
	8	6	----	----	.51	6	.39	.38	.34	6	.47	.46	.43
	8	98	----	----	.48	96	.12	.05	.12	92	.13	.08	.10
	12	5	----	----	.57	5	.36	.36	.34	5	.44	.43	.41
	12	102	----	----	----	100	.11	.07	.13	96	.10	.08	.09



L-76-702.1

(a) Tire A: 100-percent natural rubber tread with molded transverse grooves.

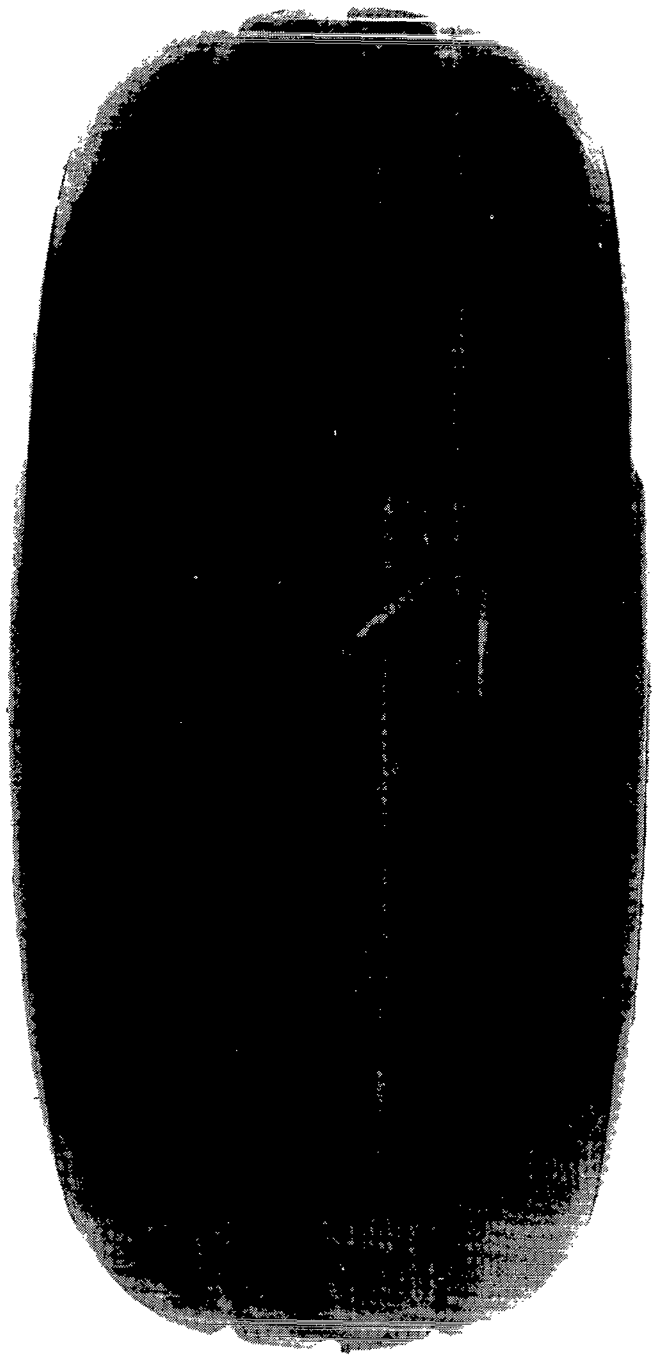
Figure 1.- Test tires.



L-76-958

(b) Tire B: 30/70-percent synthetic/natural rubber tread with molded transverse grooves.

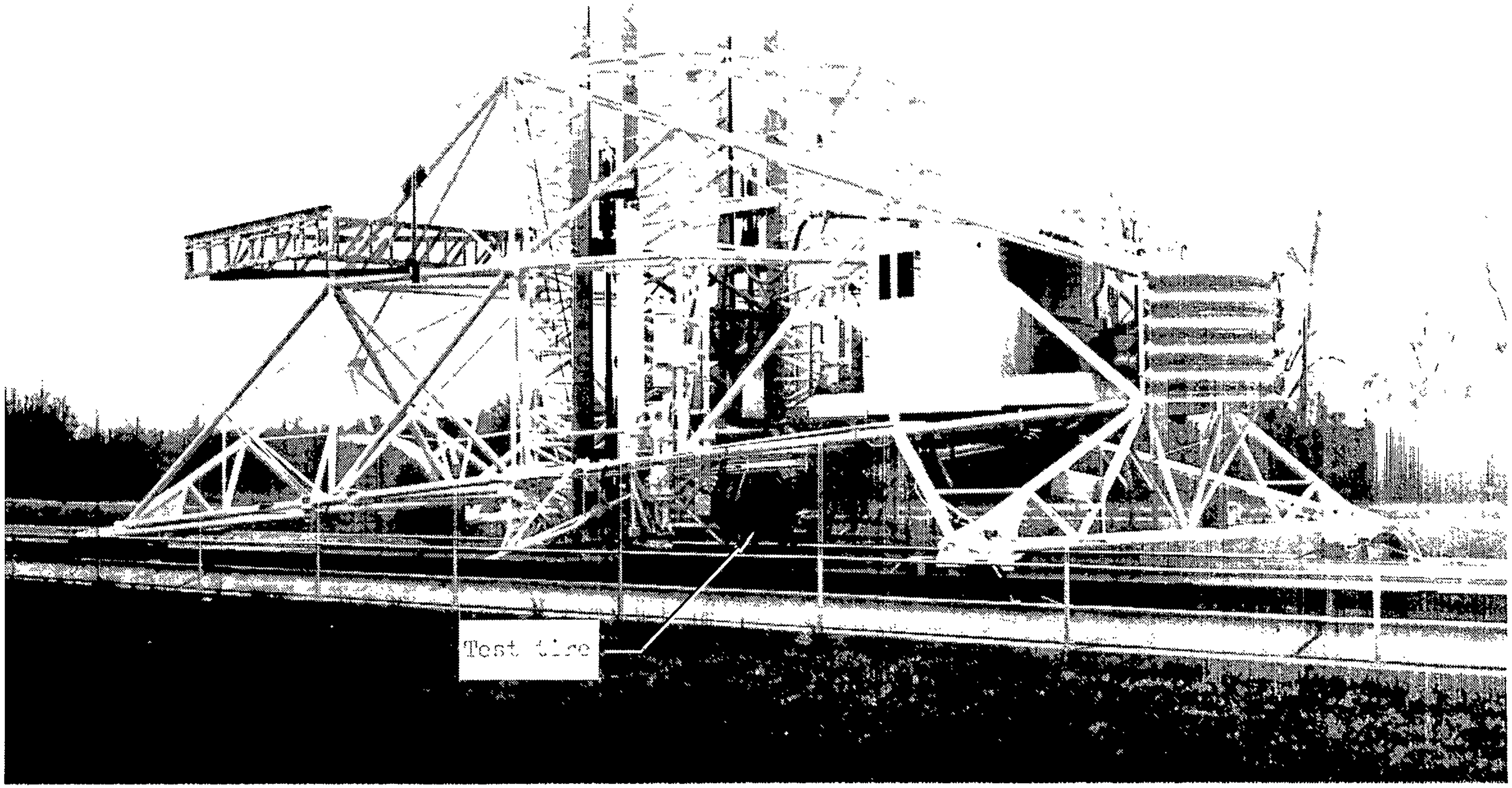
Figure 1.- Continued.



L-74-7402

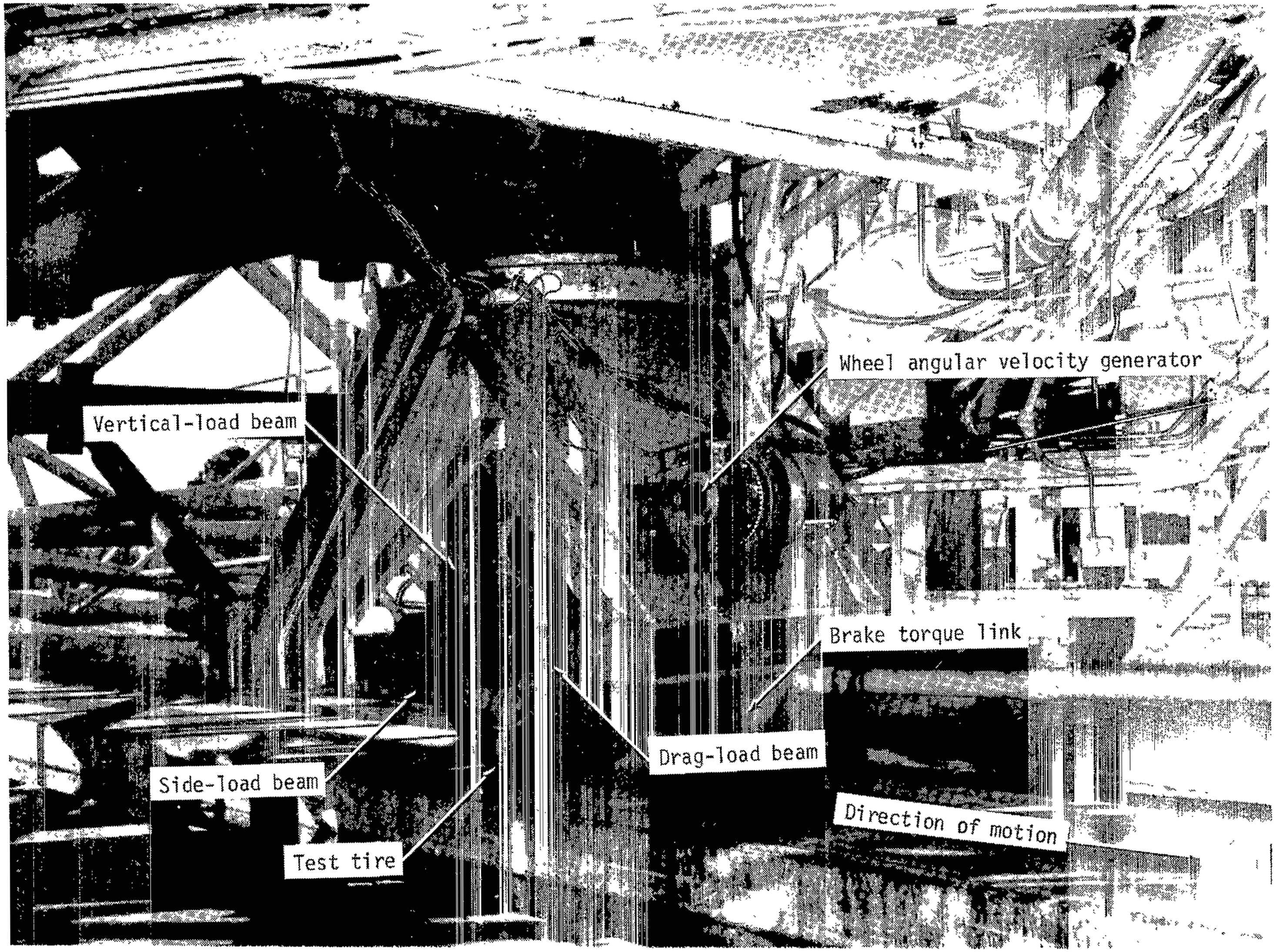
(c) Tire C: Conventional tread (100-percent natural rubber) without transverse grooves.

Figure 1.- Concluded.



L-75-2997.1

Figure 2.- Main test carriage at Langley aircraft landing loads and traction facility.



L-77-375

Figure 3.- Close-up of test tire installed on dynamometer.

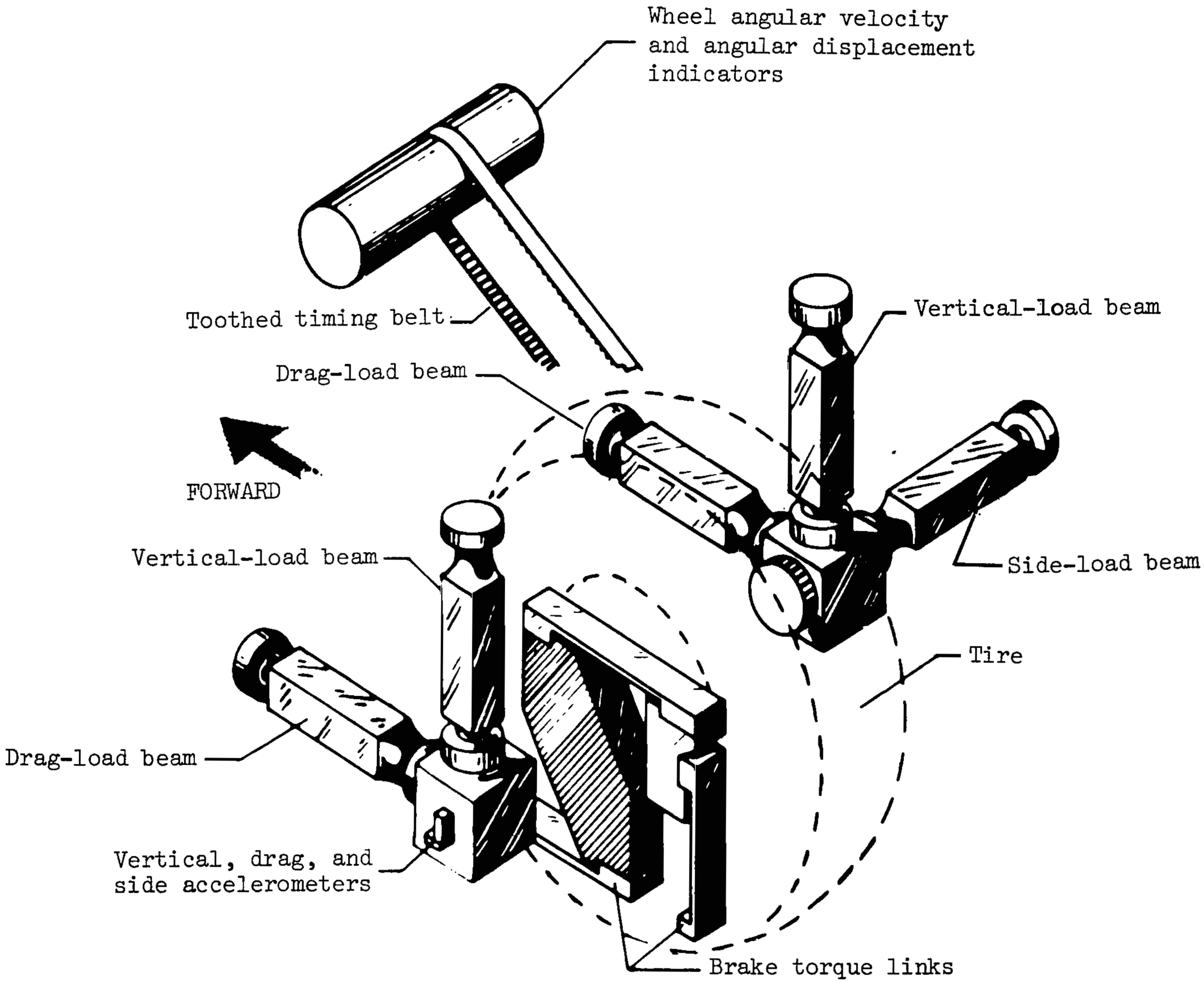
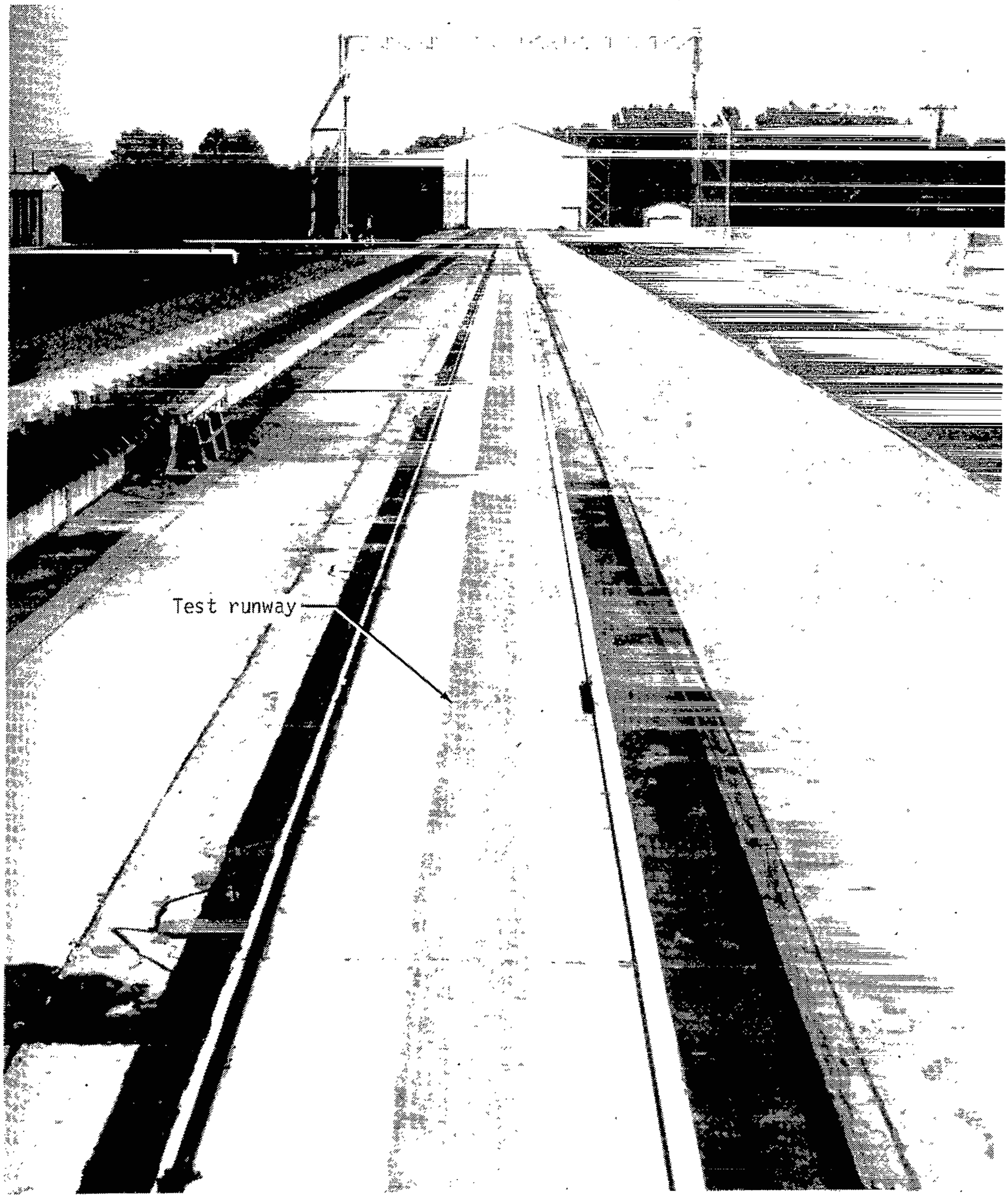


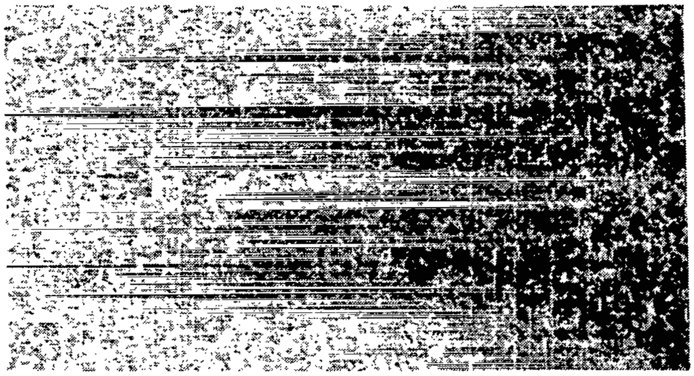
Figure 4.- Dynamometer instrumentation.



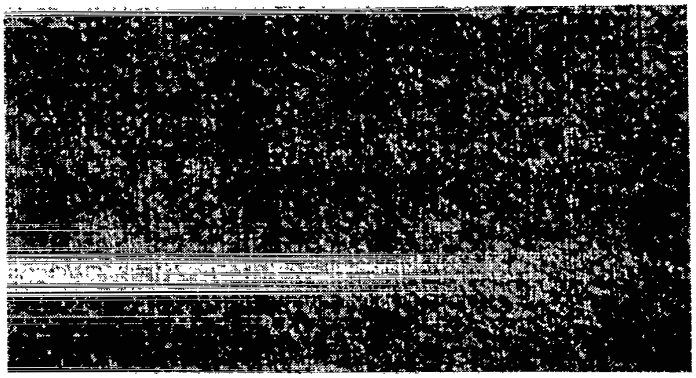
L-77-376

(a) Overall view.

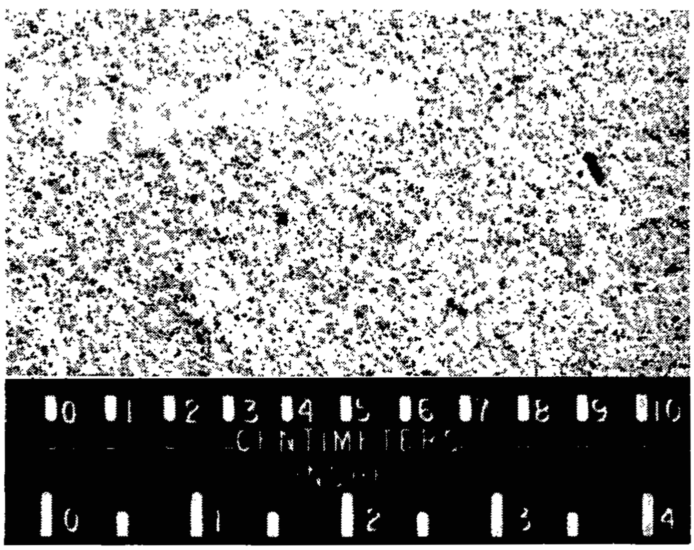
Figure 5.- Photographs of test runway surfaces used in investigation.



(b) Close-up view of test surface in dry brake cycle area.



(c) Close-up view of test surface in damp brake cycle area.



(d) Close-up view of test surface in flooded brake cycle area.

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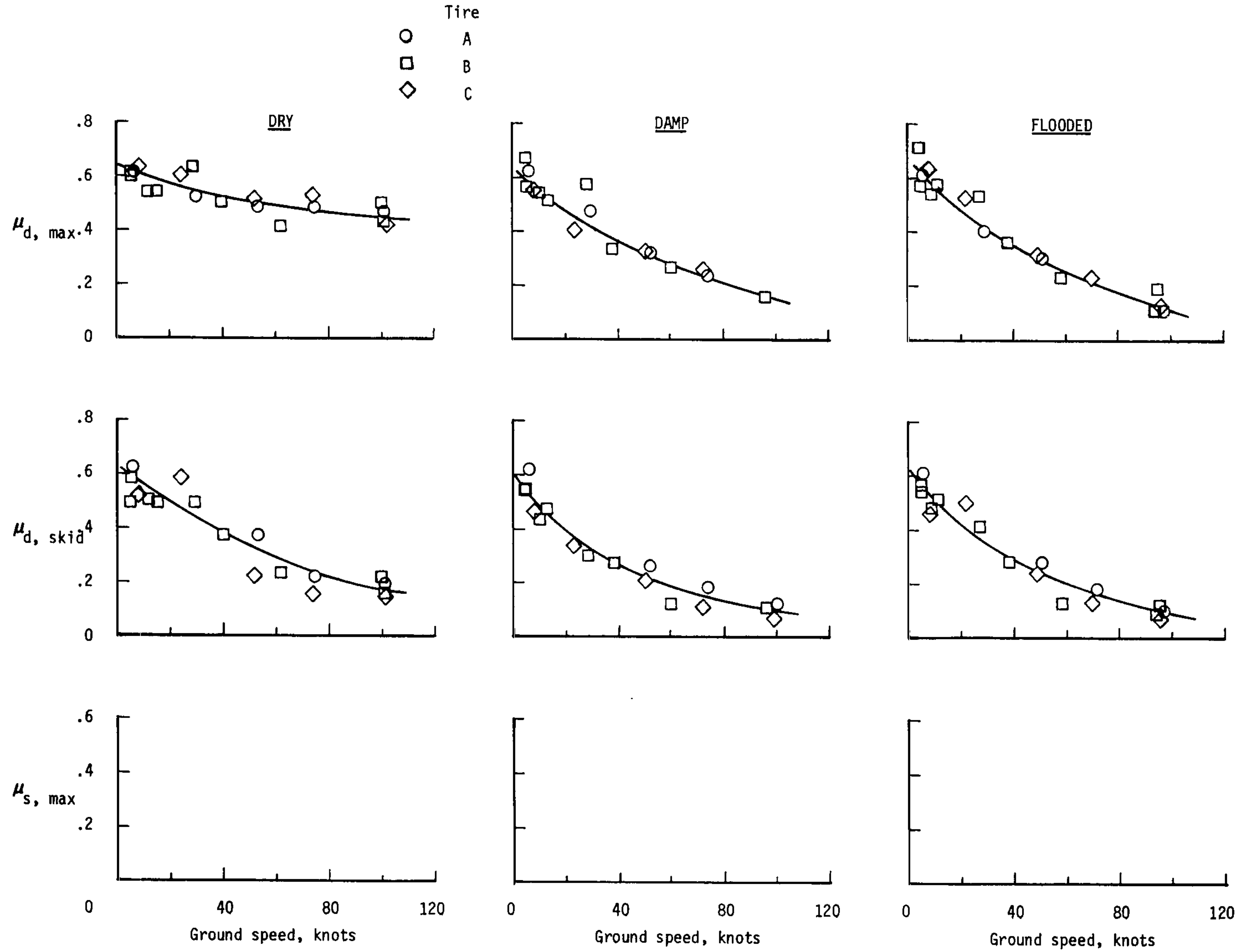
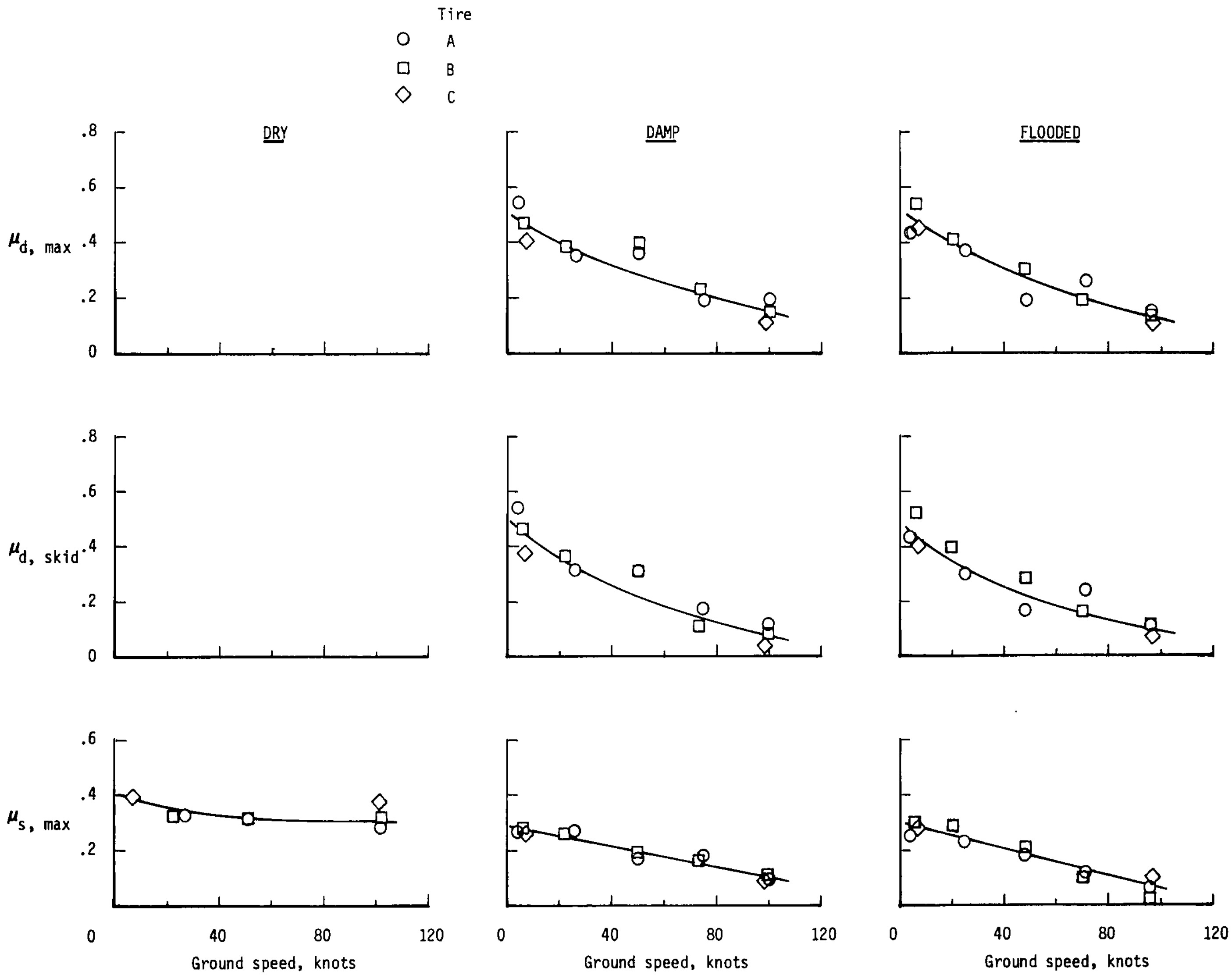
Figure 5.- Concluded.



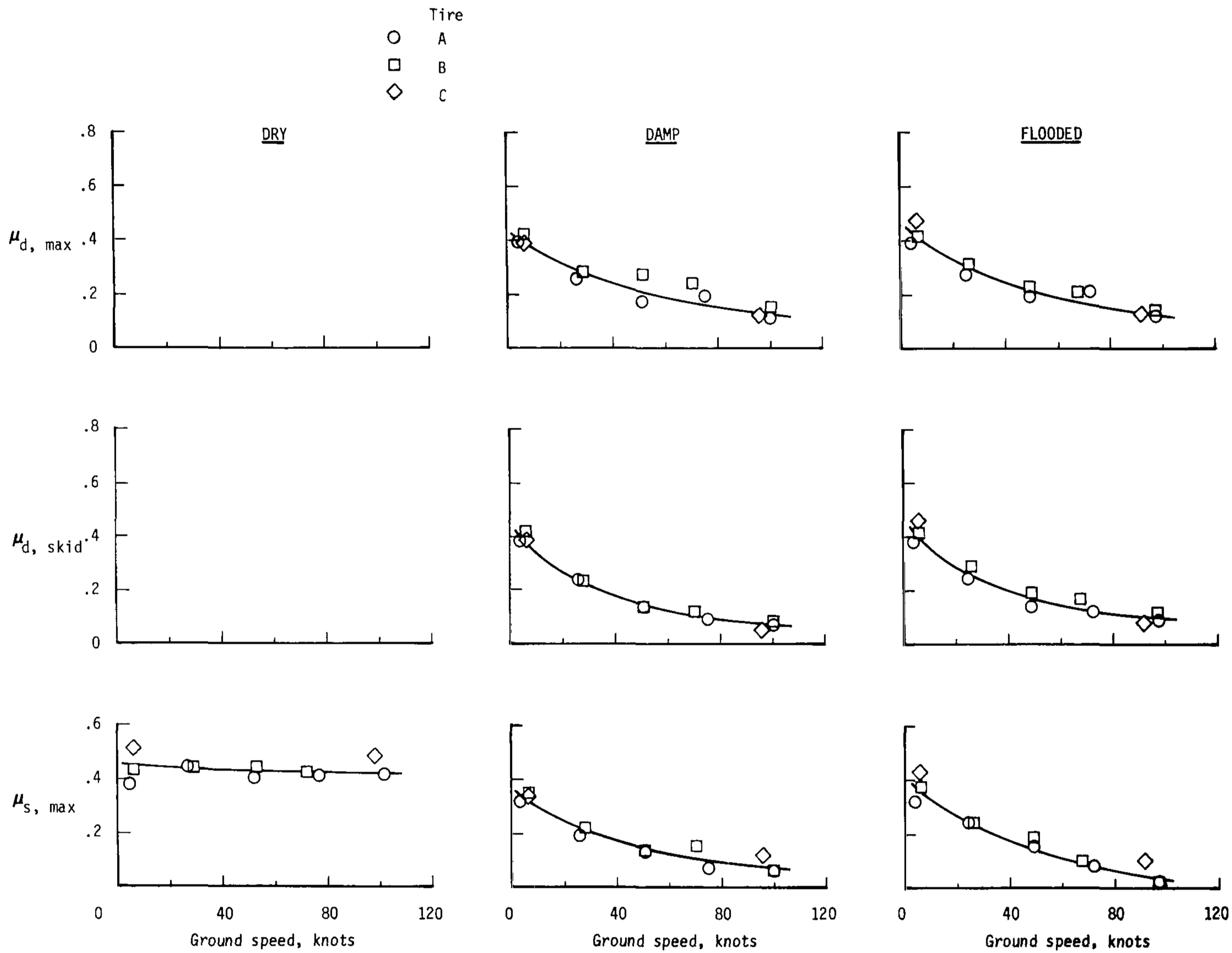
(a) Yaw angle = 0°.

Figure 6.- Effect of ground speed on friction characteristics of three test tires operating at various yaw angles on dry, damp, and flooded surfaces.



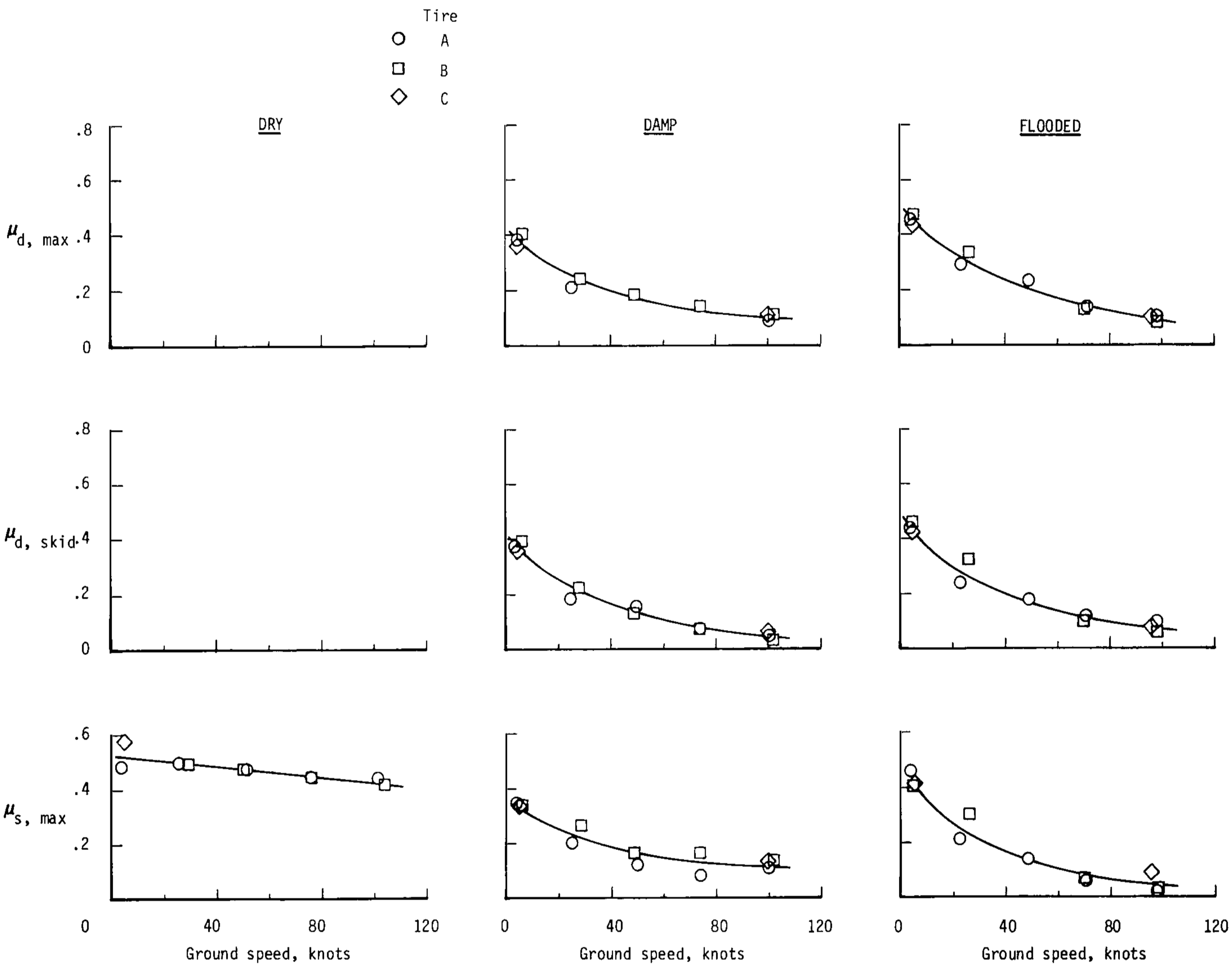
(b) Yaw angle = 4°.

Figure 6.- Continued.



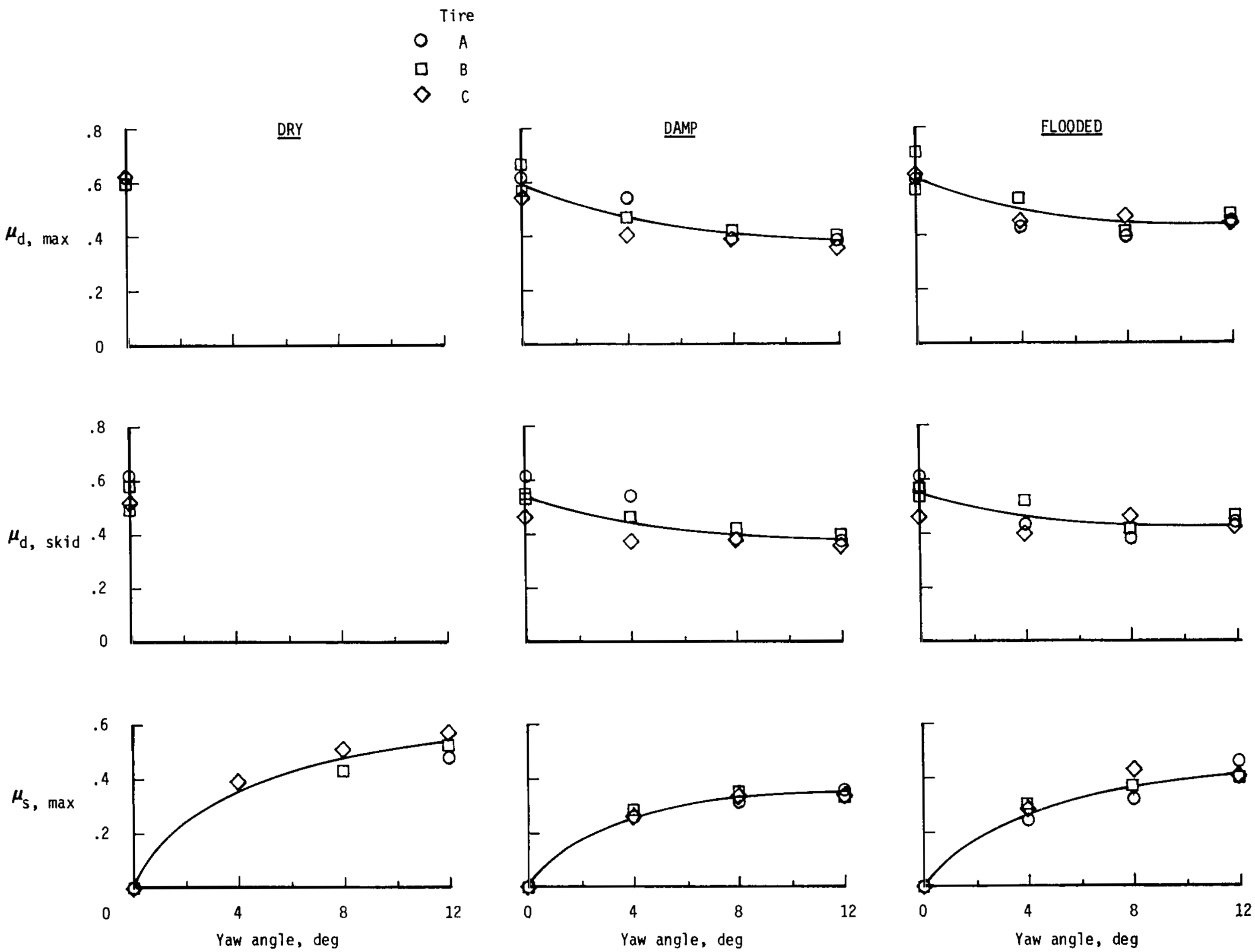
(c) Yaw angle = 8°.

Figure 6.- Continued.



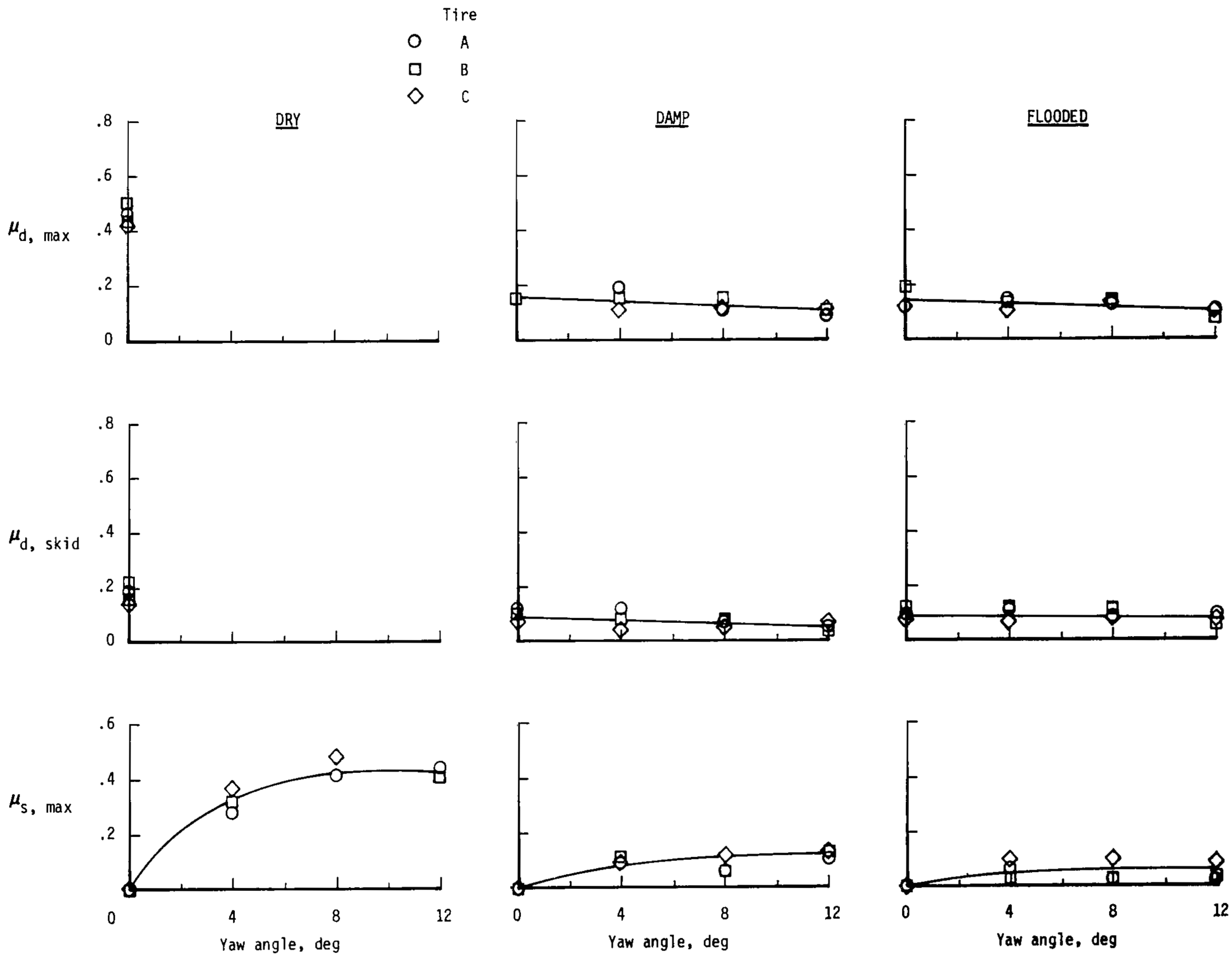
(d) Yaw angle = 12°.

Figure 6.- Concluded.



(a) Ground speed ≈ 5 knots.

Figure 7.- Effect of yaw angle on friction characteristics of three test tires operating at two nominal ground speeds on dry, damp, and flooded surfaces.



(b) Ground speed ≈ 100 knots.

Figure 7.- Concluded.

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16. Abstract

A test program was conducted at the Langley aircraft landing loads and traction facility to evaluate friction performance and wear characteristics on wet runways of three 30 × 11.5-14.5, type VIII, aircraft tires having two different tread patterns and natural rubber contents. All three test tires had the standard three circumferential groove tread, but two of the tires had molded transverse grooves which extended from shoulder to shoulder. The tread rubber content of the two tires with transverse grooves differed in that one had a 100-percent natural rubber tread and the other had a rubber tread composition that was 30 percent synthetic and 70 percent natural. The third test tire (without transverse grooves) had the conventional 100-percent natural rubber tread.

Results of this investigation indicate that the differences in tire tread design and rubber composition do not significantly affect braking and cornering friction capability on wet or dry surfaces. Braking performance of the three tires decreases with increased speed, with increased yaw angle and, at higher speeds, with increased wetness of the surface. Tread-wear data based on number of brake cycles suggested that the tire with a blend of synthetic and natural rubber experiences significantly less wear than the other two test tires. The unyawed braking test runs showed that the tires with transverse tread grooves experience less wear than the conventional tire without transverse tread grooves.

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