

REPORT OF COMMITTEE ON ECONOMIC THEORY OF HIGHWAY IMPROVEMENT

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The report of this Committee includes the following subjects

- A. Wind Resistance of Motor Vehicles, reported by L. E. Conrad.
- B. Investigation of Tire Wear, reported by W. C. McNown.
- C. Investigation of Tire Wear, reported by H. J. Dana
- D. Investigation of Gasoline and Oil Consumption, reported by M. L. Ireland.

A

WIND RESISTANCE OF MOTOR VEHICLES

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STATEMENT OF PROJECT

When the committee on Economic Theory of Highway Improvement of the Highway Research Board was confronted with the problem of determining all the elements of the resistance to translation of motor vehicles and the magnitude of each, it was seen at once that one vital and inescapable element was that of atmospheric resistance. The Engineering Experiment Station of the Kansas State Agricultural College undertook the problem of determining this atmospheric resistance, with the hope of being able to discover the natural laws that apply thereto. The cooperation of the U. S. Bureau of Public Roads was secured soon after the project was undertaken and the work has continued as a cooperative research.

ORIGINAL PROGRAM

It was originally planned to utilize the natural winds. For this purpose, apparatus was devised which permitted the vehicle to be placed on a float, headed into the wind, and the pull of the wind on the car measured simultaneously with the velocity of the wind. Several hundred records were taken with this equipment and fairly satisfactory results were obtained. The method had serious drawbacks. The wind is quite variable, both in direction and intensity. The velocity cannot be controlled, and rarely holds steady at speeds of twenty miles per hour or over.

These difficulties led to the design and construction of a wind tunnel large enough to accommodate automobiles of the usual type. The

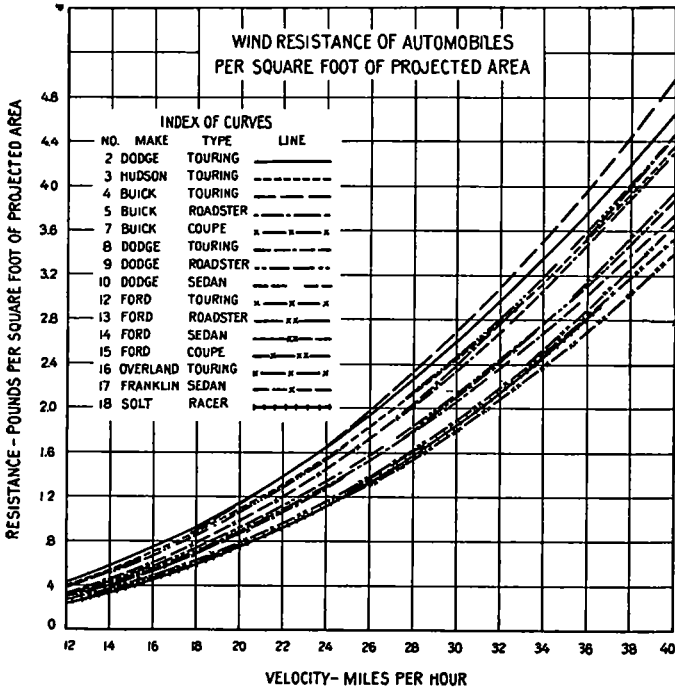


Figure 1

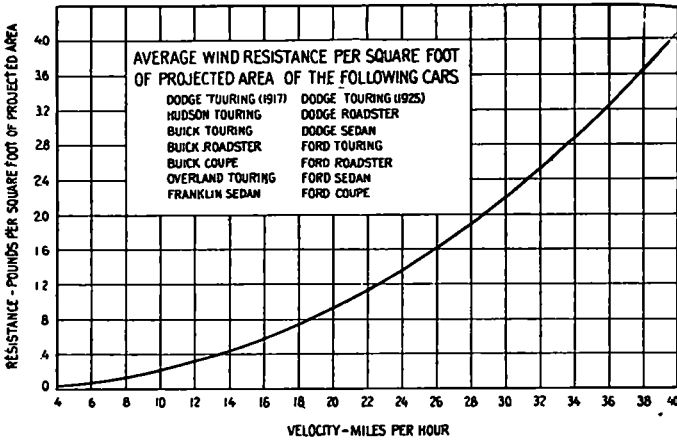


Figure 2

SUMMARY OF RESULTS TESTS OF WIND RESISTANCE OF AUTOMOBILES

Vehicle No	Make of vehicle	Type of body	Model	Windshield	Top	Curtains	Projected Area	Equations ¹		Protuberances, remarks, etc
								Total pull on car	Pull per sq ft of Projected area	
2	Dodge	Touring	1917	Shut	Up	Off	<i>Sg ft</i> 30 52	$P = 0806V^2 \text{ } ^{03}$	$P = 00264V^2 \text{ } ^{03}$	No extras, no spare tire Motometer, vizor, bumpers, spot light, tool box on right running board, two spare tires on left running board
3	Hudson	Touring	1918	do	do	do	32 56	$P = 0880V^2 \text{ } ^{00}$	$P = 00270V^2 \text{ } ^{00}$	
4	Buick	Touring	1923	do	do	do	29 48	$P = 0550V^2 \text{ } ^{14}$	$P = 00186V^2 \text{ } ^{14}$	Motometer, vizor, bumpers, spare tire at rear
5	Buick	Roadster	1923	do	do	do	28 42	$P = 0512V^2 \text{ } ^{07}$	$P = 00180V^2 \text{ } ^{07}$	Motometer, spare rim at rear
7	Buick	Coupe	1922	do	do	do	29 48	$P = 0346V^2 \text{ } ^{20}$	$P = 00117V^2 \text{ } ^{20}$	Motometer, vizor, bumper at front, spare tire at rear
8	Dodge	Touring	1925	do	do	do	27 44	$P = 0450V^2 \text{ } ^{14}$	$P = 00164V^2 \text{ } ^{14}$	Motometer, bumpers, balloon tires, spare tire at rear
9	Dodge	Roadster	1925	do	do	do	25 90	$P = 0478V^2 \text{ } ^{07}$	$P = 00185V^2 \text{ } ^{07}$	Motometer, bumpers, balloon tires, spare rim at rear
10	Dodge	Sedan	1924	do	do	do	27 75	$P = 0585V^2 \text{ } ^{08}$	$P = 00211V^2 \text{ } ^{08}$	Motometer, vizor, bumpers, balloon tires, spare tire at rear
12	Ford	Touring	1925	do	do	do	27 49	$P = 0326V^2 \text{ } ^{20}$	$P = 00118V^2 \text{ } ^{20}$	Ballon tires, spare tire at rear
13	Ford	Roadster	1923	do	do	do	25 60	$P = 0275V^2 \text{ } ^{18}$	$P = 00108V^2 \text{ } ^{18}$	Spare tire at rear
14	Ford	Sedan	1924	do	do	do	27 18	$P = 0191V^2 \text{ } ^{22}$	$P = 00070V^2 \text{ } ^{22}$	Motometer, vizor, bumpers, balloon tires, spare tire at rear, folded luggage carrier on left running board
15	Ford	Coupe	1925	do	do	do	26 55	$P = 0289V^2 \text{ } ^{19}$	$P = 00109V^2 \text{ } ^{19}$	Vizor, balloon tires, spare tire at rear
16	Overland	Touring	1923	do	do	do	27 04	$P = 0302V^2 \text{ } ^{22}$	$P = 00112V^2 \text{ } ^{22}$	Spare tire at rear
17	Franklin	Sedan	1922	do	do	do	29 70	$P = 0422V^2 \text{ } ^{18}$	$P = 00142V^2 \text{ } ^{18}$	Bumpers, spare tire at rear, folded lug- gage carrier on left running board
18	Solt	Racing	1923	None	None	None	14 05	$P = 0126V^2 \text{ } ^{25}$	$P = 00089V^2 \text{ } ^{25}$	Motometer, two spot lights, no head lights, spare wire wheel on right side

¹P = Pull in pounds V = Air velocity in miles per hour

tunnel is rectangular in cross section, with an overall length of fifty feet. Air speeds ranging from ten to forty-two miles per hour are attained

Up to the present time, fifteen different automobiles, including all the usual types of bodies, have been tested in the tunnel. By selecting periods of little or no natural wind, quite consistent and satisfactory results have been obtained

TENTATIVE RESULTS

The results thus far obtained are summarized in the accompanying table and Figures 1 and 2. The table is almost self-explanatory. The equations for resistance were calculated from the observed data by the method of averages. The projected area was obtained by tracing the photograph of the car with a planimeter. Figure 1 shows the curves for unit resistance of the cars tested. The extremes vary about 25 per cent from the average. The equation of the average curve (see Fig 2) is

$$P = 0.00149 V^2 \cdot 14$$

Where P = pressure in pounds per square foot of projected area and V = speed in miles per hour. For better comparison with other results, which are usually expressed in terms of the square of the velocity, this equation, transformed at an assumed velocity of thirty-five miles per hour, becomes

$$P = 0.00250 V^2$$

The value of the coefficient for flat plates is generally accepted as being about 0.003, while other experimenters have derived values for automobiles ranging from 0.00234 to 0.00340

REPORT

It is desired that additional tests be made in the near future to determine

- 1 Resistance of light trucks
- 2 Comparison of tunnel conditions with actual road conditions
- 3 Comparison of tunnel conditions with those of the open air tests

The Engineering Experiment Station of the Kansas State Agricultural College expects to publish a bulletin early next year, which will give, in detail, the test methods and the results which have been obtained to that time