DEPARTMENT OF HIGHWAY TRANSPORTATION ECONOMICS

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REPORT OF COMMITTEE ON TRACTIVE RESISTANCE AND ALLIED PROBLEMS

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BIBLIOGRAPHY OF TRACTIVE RESISTANCE AND ALLIED PROBLEMS

SYNOPSIS

In this bibliography there are about 240 items arranged in chronological order. These data relate to four subjects, the road, the vehicles, the tires, and brakes, which are indicated by the letters A, B, C, and D, respectively. Various characteristics of these four subjects are discussed, such as skidding, surfaces, hill climbing, tractive resistance, air resistance, and so forth, which are all considered in outline form on one of the first pages. On the succeeding pages may be found the papers indicated by numbers which have been written on each characteristic of each subject. Then on each reference which is numbered, as before, according to chronological order, may be found letters a, b, c, d, and so forth, which indicate which subjects and which characteristics they cover.

CLASSIFICATION OUTLINE

DESIGNATION OF CONTENT

Subject		Characteristics
A	Road	a General
		b Surfaces
		c Coefficient of friction
		d Skidding
		e Cornering
		f Deceleration—stopping distances
		h Hill climbing
		j Tractive resistance
		k Rolling resistance
		l Grade resistance
B	Vehicle	a General performance
		d Skidding
		f Deceleration—stopping distances
		g Acceleration
		h Hill climbing
		i Fuel consumption—mileage
		j Tractive resistance
		k Rolling resistance
		l Grade resistance
		m Air resistance
C	Tires	a General performance
		b Tread surface
		c Coefficient of friction
		d Skidding
		e Cornering
		f Deceleration—stopping distances
		k Rolling resistance

D Brakes ....a General performance
d Skidding
f Deceleration—stopping distances

CLASSIFIED INDEX

ROAD

Aa Road—General
4–16–18–24–30–35–36–39–43–47–48–50–51–62–72–83–98–99–100–101–103–122–127–167–174–175–188–207–216–217–220–244

Ab Road—Surfaces
8–9–12–18–22–26–30–47–62–69–72–76–83–98–99–100–101–103–121–122–124–127–146–160–166–168–174–175–188–197–204–217–218–220–231

Ac Road—Coefficient of Friction
8–9–12–19–69–72–76–83–98–99–100–101–103–121–122–127–146–166–174–188–217–218–220–231

Ad Road—Skidding
8–9–12–30–69–72–76–99–100–101–146–160–166–168–174–196–197–204–218–231

Ae Road—Cornering
8–168–197

Af Road—Deceleration, stopping distance
30–51–69–168–196–197

Ah Road—Hill climbing
48–124–235

Aj Road—Tractive Resistance
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Ak Road—Rolling Resistance
19–24–26–62–98–244

Al Road—Grade Resistance
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Ba Vehicle—General Performance
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Bd Vehicle—Skidding
8–9–29–30–69–72–73–74–76–81–99–100–101–104–105–119–120–130–133–134–146–151–160–166–168–174–196–197–203–219–222–231–233

Bf Vehicle—Deceleration, stopping distance
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Bg Vehicle—Acceleration
15–16–40–45–97–111–113–115–116–118–120

Bh Vehicle—Hill climbing
7–48–110–111–113–115–116–117–118–124–132–150–235

Bi Vehicle—Fuel consumption, mileage
18–24–25–37–48–56–62–71–78–88–93–142–143–144–153–154–161–175–194–207–211–216–223–240

Bj Vehicle—Tractive resistance
3–10–14–16–24–26–36–37–40–50–51–56–66–93–98–113–117–121–122–123–127–150–175–236–244

Bk Vehicle—Rolling resistance
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Bl Vehicle—Grade resistance
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Bm Vehicle—Air resistance
1–11–17–24–28–31–41–42–46–49–57–59–60–61–63–68–71–73–75–77–78–79–80–85–86–98–102–108–112–123–126–128–140–141–142–143–144–145–147–152–153–154–156–157–159–161–162–163–164–169–170–171–172–173–176–177–179–180–181–182–185–186–187–189–191–193–194–198–199–200–201–202–209–211–212–213–214–215–223–227–238–239–240–241–243–244

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Cb Tires—Tread surface
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Cc Tires—Coefficient of friction
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Cd Tires—Skidding
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Ce Tires—Cornering

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Ck Tires—Rolling resistance
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Da Brakes—General performance
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Dd Brakes—Skidding
69–72–73–74–90–91–129–130–146–151–203

Df Brakes—Deceleration, stopping distance
51–69–73–74–87–90–91–195–198–203–208–210–221

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2. Ba "The Driving Power." E. J. Stoddard. *Horseless Age,* Dec. 5, 1900. Mathematical analysis.

3. Baj "Resistance of Road Vehicles to Traction." Prof. H. S. Hele-Shaw. *Auto. Journal,* Sept., 1900. Abstract of a paper read before the British Association. On the need of investigation and proposed experiments with brief report of preliminary experiments.

4. ABCa "Road Locomotion." H. S. Hele-Shaw. Institute of Mechanical Engineers, 1900. Discusses the general principles of the engineering features of the question, the behavior of the tire upon the road, steering and turning, motive power and transmission, etc.

5. Ca "Some New Ideas in Wheels and Tires." Harry H. Dey. *Horseless Age,* June 26, 1901. An illustrated discussion of design, and the power consumed.

6. Ba "The Tractive Horse-Power of Vehicles." W. F. D. Crane. *Electrical World and Engineer,* June 1, 1901. Tables for the calculation and comparisons of the h.p. required are given with explanatory notes. 3300 w.

7. Bah "Horse-Power at Various Speeds." *Automobile,* May 9, 1903. Gives curves for seven weights of cars, showing power needed for driving each at speeds above twelve m.p.h. on the level and on grades.

8. ABbcde "Some Considerations Relating to Skiding Due to Changing the Direction of Motion." E. J. Stoddard. *Horseless Age,* Feb. 11, 1903. Considers the action of the wheels upon the roadbed, velocity of turning, forces created, etc.

9. ABbcd "Side Slip in Motor Cars." Horace Danouir and C. V. Barton. *Autocar,* Sept. 10, 1904. An explanation of one of the causes of skidding of wheels on motor cars when on slippery roads.

10. Baj "A Critical Examination of Some Methods of Measuring the Tractive Power of Automobiles." (French) J. Auclair. Bulletin du Lab. d'Essais. Nov. 12, 1907, No. 89714F.

11. Bm "Wind Resistance." Douglas Leechman. *Auto. Journal,* Aug. 24, 1907. Discusses some effects of wind pressure, the importance of form, and related subjects, as applied to motor vehicles.

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13. Cbcd "Wheel Slip at the Road." S. F. Edge. Ill. *Autocar,* Oct. 3, 1908. Experiments by S. F. Edge on Brooklands Track to determine amount of slip at the point of contact between the road and the wheels.

14. Baj "Horse-Power at the Road Wheels." *Autocar,* May 2, 1908, No. 92235A. Illustrated description of a machine to test the effective power of any car, with records of four tests.

15. Bafg "Measurements of Road Resistance of Automobiles." H. E. Wimperis. *Engineering News,* Aug. 4, 1910. Reports of two road resistance tests made by the author.

16. ABagj "Tractive Efforts and Acceleration of Automobile Vehicles on Land, Air, and Water." F. W. Lanchester. *Auto. Journal,* May 2, 1910. Serial, 1st part. Read before the Institute of Mechanical Engineers. Discusses neglected aspects of the subject, explaining the method employed by the author for the measurement of acceleration and tractive effort, and showing the uses of acceleration diagrams.

17. Bm "Body Design and Wind Resistance." W. G. Aston. *Autocar,* Aug. 26, 1911. An illustrated study.

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19. ACck "The Wheel and the Road" A. Mallock. *Autocar,* April 15, 1911. Extracts from a paper read before the Institute of Automotive Engineers. Investigates the forces acting upon, and ratios of tire, axle, and load.

20. Ba "Motor Sizes and Drive Ratios for Commercial Vehicles." E. P. Batzell. S.A.E. *Transactions,* 1912. Part 2, p. 91.

21. Ba "The Scientific Determination of the Merits of Automobiles." Riedler. General Oil Pub. Co. Ltd., 1912. 625.6 R55s.

22. Abjl "Some Recent Tests to Determine Effects of Grade and Surface of Roads on Tractive Force." E. B. McCormick. *Engineering and Contracting,* Nov. 6, 1912. Abstract of paper by E. B. McCormick, read before the American Road Congress. Describes tests run with a traction dynamometer wagon, giving tabulated results.

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24. ABaijkm "Road Tests for Automobiles." Wm. D. Ennis. *Horseless Age,* April 2, 1913. Report of tests made at Brighton Beach on a truck to determine the variation in road resistance, air resistance, transmission loss, and fuel consumption with variations in speed.

25. Bai "Detecting Resistance—Saving Fuel." W. C. Marshall. *Automobile,* April 17, 1913. Serial, 1st part. Describes the accelerometer, which gives complete check on the motor and running gear.

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27. Ba "Power and Performance of Gasoline Motor Trucks." C. T. Myers. S.A.E. *Transactions,* 1914. Part 2, p. 122.

28. Bm "Wind Resistance—the Purloiner of Power, the White Plague of Speed." R. W. A. Brewer. *Automobile,* Mar. 12, 1914. Shows that the surface contour of the car has important bearing on fuel consumption and speed.

29. Bdf "How Weight Distribution Affects Skidding." E. P. Batzell. *Automobile,* July 30, 1914. Considers a heavy rear less liable to skid but more dangerous.

30. ABabdf "Skidding Vehicles and Street Pavements." *Surveyor,* May 8, 1914. Summarizes the considerations brought forward in recent discussions.

31. Bm "Considerations of Body Design." W. G. Aston, Ill. *Autocar,* Aug. 8, 1914. Discusses wind resistance, weight distribution, and frame distortion.

32. Ba "The Practical Testing of Motor Vehicles." A. B. Browne and E. H. Lockwood. S.A.E. *Transactions,* 1915. Part 1, p. 68.

33. Ba "A Formula for the Comparison of Gasoline Automobile Performance." C. T. Myers. S.A.E. *Transactions,* 1915. Part 2, p. 187.

35. ABa "Tractive Resistance Tests with an Electric Motor Truck." *Engineering and Contracting,* Dec. 20, 1916. Results of tests made by M.I.T.

36. ABaj "Traction Resistances to a Motor Delivery Wagon on Different Roads and at Different Speeds." A. E. Kenelly and O. R. Schurig. A.I.E.E. *Proceedings,* June, 1916. 28 pp. Report of investigation.

37. ABij "Tractive Resistances to a Motor Delivery Wagon on Different Roads and at Different Speeds." A. E. Kenelly and O. R. Schurig. M.I.T. Bulletin No. 10, June, 1916. Also Am. Inst. Elec. Engrs., 33rd Annual Convention, June 30, 1916. bul. Investigation with wagon equipped with solid rubber tires: 1) overall efficiency of truck mechanism and 2) tractive resistance of a number of typical urban roads.

38. Ck "Power Losses in Pneumatic Tires." E. H. Lockwood. S.A.E. *Transactions,* Part I, 1917, p. 377.

39. ABa "Traction on Bad Earth Roads." L. A. Legros. Read before Inst. Mech. Engrs. *Auto. Ind.,* March 7, 1918. Serial, 1st part. Comparison of wheel and chain-track methods of drive.

40. ABagj "Performance Tests by Accelerometer." H. C. Skinner. *Auto. Industries,* April 25, 1918. Means of determining traction resistance; calculation of engine horsepower.

41. Bam "Aeroneutical Experience Will Profoundly Affect Motor Car Practice." A. A. Remington. *Auto Industries,* V. 39, No. 18, Oct. 31, 1918, p. 776. Emphasizes necessity for greater standardization and more research work. Presidential address before British Assoc. Auto. Engrs.

42. Bm "Study of Air Resistance and Air Flow." H. Levy. *Auto. Industries,* June 12, 1919. Laws of air resistance determined for a wide range of air speeds, eddies produced by obstacles, practical application to aircraft and automobile problems.

43. ABa "Heavy Motor Vehicles in Relation to Roads." W. D. Williamson. *Engineer,* V. 128, No. 3338, Dec. 19, 1919, p. 608-610. Figures are presented which show effect of roads on running costs of vehicles. Paper read before Roads and Transport Congress.

44. Ba "Automobile Performance Analyzed by Mechanical Differentiation." Armin Elmendorf. *Auto. Industries,* Jan. 2, 1919, p. 11-16.

45. Bag "Acceleration of the Automobile and Its Measurement." P. M. Heldt. *Auto. Industries,* V. 42, No. 24, June 10, 1920, pp. 1329-1333, 9 figs. Writer shows how to plot acceleration

curve of cars not yet built, giving necessary formulae. Notes on the Wimperis accelerometer and method of using instrument; relation between acceleration, distance and time, etc.

46. Bm "Whirls and Eddies." *Autocar,* V. 44, No. 1266, Jan. 24, 1920, pp. 167-8, 2 figs. Suggests applying principles of aeroplane construction to design of automobile body.

47. ABab "Relation of Highways to Motor Truck Operating Cost." A. H. Blanchard. *Canadian Engineer,* V. 38, No. 12, Mar. 18, 1920, pp. 311-313. Results of tests carried out by White Company, Cleveland, are said to have established that on concrete and brick pavements it was practicable to operate loaded two-ton truck for average of 11.5 miles per gallon, whereas on average earth road only 5.8 was obtainable.

48. ABahil "Motor Operation Costs as Affected by Highway Location and Grade Design." Wilson G. Harger. *Engineering News-Record,* V. 85, No. 4 and 5, July 22 and 29, 1920. July 22: Value of eliminating rise and fall by cut and fill construction discussed. Simple case of farm wagon trailer train explained. July 29: Comparison of alternate locations from standpoint of motor operation costs. Table of capitalized operating costs on different grades established.

49. Bm "A German Passenger Car of Radical Design." *Auto. Industries,* V. 45, No. 17, Oct. 17, 1921, pp. 812-816, 12 figs. Describes Rumpler streamline car. Engine in rear and every possible obstacle on streamline body is removed to minimize air resistance.

50. ABaj "Studies of the Automobile." G. B. Upton. *Sibley Journal,* V. 35, No. 9-10, Sept. and Oct. 1921: Tractive resistance of sand and soft soils. V. 35, No. 4-5-6, Apr., May, June. 1922: Power required to drive a car.

51. ABCDafj "Some Road Tests with New Type Accelerometer." S. H. Woods. *Auto. Industries,* V. 45, No. 20, Nov. 17, 1921, pp. 970-972, 3 figs. Describes measurements of tractive effort, tractive resistance, braking effort and b.h.p. of two trucks and two passenger cars.

52. Ck "The Power Absorbed by Tyres." *Auto Motor Journal,* V. 26, No. 9, Mar. 3, 1921, p. 202, 4 figs. Comparative tests of cord and canvas tires.

53. Ba Part 2, "Elements of Automobile Fuel Economy." W. S. James. S.A.E. *Transactions,* Part II. 1921, p. 191.

54. Ba "Chassis Friction Losses." E. H. Lockwood, p. 384, S.A.E. *Transactions,* 1922, Part II.

56. ABij "Motor Truck Tractive Resistances on Road Surfaces." T. R. Agg. *Engineering News-Record,* V. 89, No. 23, Dec. 7, 1922, pp. 982-985, 9 figs. Elimination tests of measuring devices prove superiority of space-time recorders; gasoline consumption measured in relation to tractive resistance.

57. Bm "Auto Air Resistance Measured in Wind Tunnel." *Auto. Industries,* V. 47, No. 23, Dec. 7, 1922, p. 1137. Tests made at Zeppelin Works show that air resistance of modern automobiles is materially less than would be concluded from coefficients found in engineering text books; advantages to be derived from complete streamlining of cars.

58. Cak "Power Losses in Pneumatic Tires." O. Enoch. *Motorwagon,* V. 25, No. 28, Oct. 10, 1922, pp. 529-531, 3 figs. Reply to S.A.E. Jour. paper giving measurement results of rolling resistance of cord and fabric tires which Prof. Lockwood, the author, claims are in disagreement with tests made in writer's laboratory and other German tests.

59. Bm "Calculation of Energy Output of Automobiles with Special Regard to Air Resistance." P. Jaray, *Motorwagon,* V. 25, No. 29, Oct. 20, 1922, pp. 551-559. Results of measurements of air resistance of automobiles with different types of bodies, made in large wind tunnel of Zeppelin Works at Friedrichshafen. Air resistance was found to be considerably less that has been generally assumed heretofore. Advantages of streamline form.

60. Bm "Streamline Bodies." Ernst Neumann-Nearder. *Motorwagon,* V. 25, No. 22, Aug. 10, 1922, pp. 418-420. Advantages and disadvantages of changing present shape of bodies.

61. Bm "Air Resistance Investigations on Automobile Models." W. Klemperer. *Zeit. für Flugtechnik ü Motorluftschiffahrt,* V. 13, No. 14, July 31, 1922, pp. 201-206. Based on ideas and designs developed by P. Jaray, series of systematic tests were carried out in large wind tunnel of Zeppelin works to determine what advantages could be gained by building automobile bodies along aerodynamically favorable lines; investigations of Jaray streamline cars and other models.

62. ABabikl "Surfaced Roads Would Save $23,000,000." A. W. Campbell. *Contract Record,* V. 36, No. 25, June 21, 1922, pp. 581-582. This amount would be saved to motorists in decreased gasoline consumption alone, aside from lower repair costs; effect of road surfaces and grades on tractive resistance.

63. Bm "Streamline Autos." P. Jaray. *Motorwagon,* V. 25, No. 17, June 20, 1922, pp. 333-3336, 7 figs. New type of construction to reduce air resistance; results of experiments made in Zeppelin wind tunnel; fuel consumption, etc.

65. Ck "Power Losses in Auto Tires." Holt and Wormeley. Bureau of Standards, May 20, 1922, Paper No. 213. Technologic Paper.

66. Bj "Resistance to the Translation of Motor Vehicles." T. R. Agg. Iowa State College of Agriculture and Mechanic Arts, Official Pub., Bul. No. 64. V. 20, No. 53, May 31, 1922, 32 pp., 18 figs. Deals with abortive attempts to measure so-called tractive resistance and describes methods finally adopted. Results seem to show that rolling resistance is about half of total resistance to translation when vehicle with good tires is operated on hard, smooth road surfaces, and resistance due to impact is very small on such surfaces.

67. Ck "Power Losses in Automobile Tires." W. L. Holt and P. L. Wormeley. U. S. Bureau of Standards, Technological Papers, V. 16, No. 213, May 20, 1922, pp. 451-461, 8 figs. Relates to power loss or energy dissipated as heat in automobile tires when operating under different conditions of axle load, inflation pressure, speed, and tractive effort.

68. Bm "Rear Wheel Dynamometer Tests and Their Significance to the Engineer." Herbert Chase. *Auto. Industries,* V. 46, No. 16, Apr. 20, 1922, pp. 859-868. Description and data from apparatus in Mason Laboratory, Sheffield Scientific School, Yale University. Includes comments on rolling friction, wind-resistance, tractive effort, and fuel economy.

69. ABCDbcdf "Bureau of Standards Makes Definite Checks on Brake Performance." Herbert Chase. *Auto. Industries,* V. 49, No. 22, Nov. 29, 1923, pp. 1092-96. Relative effectiveness of various arrangements and operating means are graphically recorded; use of front-wheel type does not double rate of deceleration, surprising values for friction coefficient between tire and road obtained.

70. Cab "Dynamometer Tests of Auto Tires." W. L. Holt and P. L. Wormeley. U. S. Bureau of Standards Technologic Paper No. 240, Sept. 24, 1923, 559-579. Details of power-loss tests on a large number of tires, and comparative results for the 3½, 4, and 5" sizes, both cord and fabric; analysis of effect of different parts of tire on power loss; points out and gives examples showing how dynamometer tests may be used as a help in studying details of tire design.

71. Bim "Comparative Trial Trips with Jaray Streamline Automobile." R. Conrad, *Motorwagon,* V. 26, No. 23-24, Aug. 31, 1923, pp. 355-63. Results show economic advantages of Jaray car over standard type automobiles.

72. ABCDabcd "Quality of Brakes has Marked Effect on Capacity of Highways." W. S. James. *Auto. Industries,* V. 49, No. 9, Aug. 30, 1923, pp. 412-14. Minimum stopping distance is usually controlled by friction between tires and road and proportion of weight on wheels which are braked. Slippery road surfaces and unsafe brakes reduce number of vehicles per hour roads can handle.

73. BDacdfm "Distances Required for Stopping." P. M. Heldt. *Auto. Industries,* V. 48, No. 6, Feb. 8, 1923, pp. 280-81. Application of brakes produces effect of transferring weight from rear to front wheels; stopping time less with 4-wheel type; effect of air resistance.

74. BDcdf "Skidding of Vehicles in Quick Braking." Ottorino Sessini. *Ingegneiria,* V. 2, No. 4. Apr. 1, 1923, pp. 87-88. Discusses theory of skidding and calculates forces in question.

75. Bm "Streamlining a Closed Car." *Autocar,* V. 50, No. 1428, Mar. 2, 1923, pp. 354-6. Details of streamline. Farmans, both open and closed, and other examples.

76. ABbcd "Theory and Advantages of Balanced Brake Forces." Geo. L. Smith. S.A.E. *Journal,* V. 14, No. 2, Feb., 1924, pp. 111-116. Describes two methods of brake application in use in U. S., and expounds theory of balanced brake forces; practical applications of equalizing mechanism used in road tests of automobile; tests on wet pavements with study of skidding effects and skid-checking means; results of tests on hills and effects of speed and pressure.

77. Bm "The Automobile in Air Currents." E. Rumpler. *Zeit für Flugtechnik ü Motorluftschiffahrt,* V. 15, No. 3-4, Feb. 26, 1924, pp. 22-25. Discusses progress made in recent years in application of airplane theories to automobile design; introduction of streamline automobile developed by author in 1921; results of experiments carried out at Aerodynamic Experimental Station in Göttingen.

78. Bim "A Streamlining Development." *Autocar,* V. 52, No. 1486, Apr. 11, 1924, pp. 662-4. Unconventional body designed by a Danish engineer, P. Forostovsky, Jr., and fitted to a 2-liter Bignan chassis; head resistance diminished, resulting in increased speed and reduced gasoline consumption; but with no loss of comfort.

79. Bm "The Rumpler Cars, 1924." A. Conrad. *Motorwagon,* V. 27, No. 34, Dec. 10, 1924, p. 673-684. Describes latest model of Rumpler streamline car, first model of which was developed in 1922.

80. Bam "The Future High-Speed Automobile." A. Persu. *Allgemeine Automobile Zeitung,* V. 25, No. 18, May 3, 1924, pp. 25-26. Author states future high-speed car will be streamline type, in which all 4 wheels are built within streamline form, the two driving wheels will be less distance apart than front wheels, passenger seats will be in front and power plant in rear.

81. Bad "Testing Wheel Slip." *Autocar,* V. 52, No. 1474, Jan. 18, 1924, pp. 96-98. Results of trials with special instrument evolved to register action of differential.

82. Cbcd "Two Notable Tyre Developments." *Motor Transport,* (London) V. 39, No. 1017, Aug. 25, 1924, pp. 243-4. Low pressure pneumatic and new design of solid tire that show phenomenal non-skid capacity.

83. ABabc "Tractive Resistance and Related Characteristics of Roadway Surfaces." Bul. No. 67, 1924, Iowa State College, Eng. Exp. Station. An investigation conducted by the Iowa Engineering Experiment Station in co-operation with the U. S. Bureau of Public Roads and Iowa Highway Commission.

85. Bm "Wind Resistance of Motor Vehicles." L. E. Conrad. *Public Roads,* V. 6, No. 9, Nov. 1925, pp. 203-6. Progress reports of tests conducted by Kansas State Ag. Coll. in co-operation with Bur. of Pub. Roads. Resistance of full-sized cars measured in wind tunnel; effect of size of tunnel and other test conditions; complete tests on 15 cars; Buick touring car was found to have highest wind resistance; Ford roadster the lowest; develops equation for calculation.

86. Bm "Full Scale Wind Tunnel." E. R. Dawley. *Aviation,* V. 19, No. 8, Aug. 24, 1925, p. 212. Wind tunnel of Kan. State Ag. College, designed primarily for determining aerodynamic resistance of automobile, but has several features in it of interest to aeronautical engineers.

87. BDaf "Factors Determining the Minimum Stopping Distance of an Automobile." H. H. Allen. S.A.E. *Journal,* V. 17, No. 2, Aug. 1925, pp. 192-4. Summarizes and explains derivation of some of the relations that are essential to a correct determination of possible deceleration; all variables that are of significance or of sufficient magnitude to affect appreciably performance of a car under a given set of conditions of vehicle or of environment have been included.

88. BCik "Effect of Tire Resistance on Fuel Consumption." W. L. Holt and P. L. Wormeley. Bureau of Standards Technologic Papers, V. 19, No. 283. Apr. 6, 1925, pp. 213-23; also (abstract) in *Auto. Industries,* V. 52, No. 21, May 21, 1925, p. 902-4. Result of investigation shows that rolling resistance of balloon tires is slightly higher than that of high-pressure cord tires, but substantially lower than that of high-pressure fabrics; however, ability of tire to absorb road shocks and its durability are more important than slight effect it may have on fuel consumption.

90. Dadf "Braking of Automobiles." E. Essers. *Automobil-Rundschau,* V. 28, No. 16 and 17, Nov. 3 and Dec. 1, 1926, pp. 373-6 and 403-6. Calculation of shortest braking distance by means of nomogram; effect of rolling and sliding friction.

91. Dadf "Calculation of Car Travel with Brakes Applied." A. Stadie. *Motorwagon,* V. 30, No. 4, Feb. 10, 1927, pp. 64-73. Forces which have decelerating or braking effect on vehicle are external resistance, internal natural resistance, and resistance caused by braking; first two forces, even though small in comparison with resistance through braking. must be taken into consideration in accurate calculation.

92. BCak "Measuring Running Resistance of Automobiles." E. Essers. *Automobil-Rundschau,* V. 29, Nos. 18, and 19, Sept. 15 and Oct. 1, 1927, pp. 359-64 and 384-90. Report of experimental study, done at automobile lab. of Aachen (Aix-la-Chapelle) Institute of Technology; method consisted in keeping engine idle and causing auto to coast on normal road; rolling resistance with various types of cord and balloon tires.

93. ABCaij "The Motor Truck Tire in Its Relation to the Vehicle and to the Road." J. A. Buchanan, S.A.E. *Journal,* V. 20, No. 4, Apr. 1927, pp. 469-77. Presents some important data that have resulted from researches by the Bur. of Public Roads; general view is given of effects of vehicle type, wheel load, tire equipment. and road conditions on gasoline consumption, tractive resistance and impact relations.

94. Ccd "Resistance of Tires to Skidding." R. H. Baldock. *Rubber Age,* 44: 28, Oct., 1928.

97. Bg "Acceleration." E. C. Wadlow. *Auto. Engineer* V. 18, No. 249, Dec. 1928, pp. 440-2, 482-6. Comparison of conditions on road and on test bed; resisting torque and tractive resistance on road; torque-speed characteristics of friction, air, hydraulic, and electric dynamometers; from viewpoint of both resistance law and inertia of system, electrical swinging field dynamometer stands out as being by far best adapted to making acceleration tests previously outlined.

98. ABCabcjkm "Tractive Resistance of Automobiles and Coefficients of Friction of Pneumatic Tires." T. R. Agg. Iowa State College, Official Pub., Eng. Exp. Stat., Bull. No. 88, May 2, 1928, 60 pp., 50 figs. Report deals principally with investigations of certain actions and reactions between road surfaces and tires used on self-propelled vehicles; measurements of air resistance on automobiles by method of mounting auto. on dynamometer carried by flat car and to push car ahead of electric locomotive; coefficient of friction between auto. tires and road surfaces.

99. ABCabcd "Causes of Skidding" Institute of Municipal and County Engrs. *Journal,* V. 55, No. 26, June 26, 1928, p. 12. Investigations by British Ministry of Transport in causes of skidding and means of prevention; building of arterial roads in greater London has furnished opportunity of employing large variety of surfacing materials; skid tests; small portable machine designed and constructed for measuring coefficients of friction between rubber tires and road surfaces commonly used in Greater London areas; consideration of design of vehicle; special model vehicle has been constructed to carry out experiments to determine effect of stability.

100. ABabcd "Investigations into Causes of Skidding and Means of Prevention." *Roads and Road Construction,* V. 6, No. 64, Apr. 2, 1928, pp. 122-123. List is given showing wide range and distribution of materials; skid tests; vehicles; consideration of design of vehicle.

101. ABCabcd "The Causes of Skidding and Means of Prevention." *Surveyor,* V. 73, No. 1885, Mar. 9, 1928, pp. 303-304. Research necessary to determine respective parts played by materials and methods of road construction, and design of vehicles, tires, brakes, etc.; list shows wide range and distribution of materials; skid tests; small portable machine designed and constructed at Nat. Research Lab. for measuring coefficients of friction between rubber tires and various road surfaces.

102. Bm "Kansas Tests Give New Value for Air Resistance Coefficient." *Auto. Industries,* V. 58, No. 18, May 5, 1928, pp. 692-3. Tests of Eng. Exp. Stat. of Kan. State Ag. College; experiments conducted in specially constructed wind tunnel, show coefficient for passenger cars to be .0024 and for trucks .0025; racers also tested; wind tunnel features, differences in tunnel and on road kept in mind; distribution of air flow.

103. ABCDabc "Solid-Tired Buses Easier to Brake, According to French Tests." *Auto. Industries,* V. 58, No. 14, Apr. 7, 1928, pp. 560-1. Able to stop in shorter distance than when equipped with pneumatic tires; brakes also prove to be more effective on standstone pavement than on asphalt or on wood blocks; comparison between different road pavements, different conditions of road surface, different types of tire and different states of wear of tires; tests made with four conventional-type of four-wheel, 28 passenger buses. Report published in "Le Poids Lourd."

104. Bd. "The Skidding of a 4-wheeled Vehicle on a Slippery Road." L. H. G. Dines. *Engineer,* V. 145, No. 3759, Jan. 27, 1928, pp. 94-95. At exhibition at Nat. Phys. Lab. at Teddington there was shown simple and effective model which demonstrated remarkable fact that if 4-wheel truck, unprovided with steering lock, be traveling on smooth surface and have its front wheels suddenly locked by means of a brake, there is no tendency for truck, as a whole, to spin round; it continues to travel in straight line as before, till sliding friction brings it to a stop.

105. BCcd "Stopping Distance of Vehicle Independent of Gross Weight." E. Favary. *Power Wagon*, V. 41, No. 283. July, 1928, pp. 5-6. Minimum stopping distance of motor vehicle when all wheels are provided with brakes; retarding force and turning effort; slippage between tires and road; effect of drum diameter in chassis dynamometer tests.

106. Ba "Commercial Vehicles on Test." *Modern Transport*, V. 20, No. 495, Sept. 8, 1928: 4-speed Chevrolet truck; hill tests, etc. V. 20, No. 496, Sept. 15, 1928: 30 cwt. Bear engine; hill climb, accel. and brakes, etc.

107. Cab "Pneumatic Tyres." W. H. Paull. *Motor Transport*, V. 47, No. 1240, Dec. 17, 1928, pp. 739-741. Magnitude of power losses in tires; area of contact; estimated wear. Abstract of paper presented before joint meeting of Instr. Rubber Industry and Inst. Auto Engrs.

108. Bm "Air Resistance of Automobiles." E. H. Lockwood. *Proceedings*, Highway Research Board, Vol. 9, 1929.

109. Cck "North Carolina Tire Tester." Shaw and Fontaine. *Proceedings*, Highway Research Board, Vol. 9, 1929.

110. Bah "Road Passenger Vehicles on Test." *Modern Transport*, V. 22, No. 560 and 562, Dec. 7, 1929, pp. 19-20 and Dec. 21, pp. 18-19. Road performance characteristics—of buses—hill-climbing tests, among other things.

111. Bafgh "Road Passenger Vehicles on Test." *Modern Transport*, V. 22, No. 556, Nov. 9, 1929, p. 31-2. Brief description of test of 6-cylinder Mandslay; good hillclimbing; suspension tests; brake and acceleration tests; technical details.

112. Bm "Science in Body Building." H. E. Thomas. *Autocar*, V. 63, No. 1775, Nov. 8, 1929, p. 1029. Description of coupé body, designed for 30 to 98 h.p. Vauxhall automobiles which weigh less than driver; insulation; ventilation; etc. And: to investigate behavior of air currents around body, scale model of car was made and extensive wind tunnel tests carried out under varying conditions.

113. Baghj "Performance Evaluation." *Auto. Engineer*, V. 19, No. 259, Oct. 29, pp. 387-8. Description of Tapley Performance Meter for determination of general performance of motor vehicles; object is to furnish direct reading evaluations of performance, giving measure in lbs. per ton that engine is exerting on driving wheels; methods of measuring top gear acceleration; hill-climbing capacity; tractive resistance, actual power output, and engine friction.

114. Cc "Friction Coefficient Between Rubber and Various Materials." R. Ariano. *Politecnico*, V. 77, No. 5, May, 1929. pp. 259-274. See also *translated abstract* in *India Rubber Journal*. V. 78, No. 10, Sept. 17, 1929, pp. 351-353. Methods and results of series of tests, made at engineering lab. of Societa Italiana Pirellis, to determine wear of rubber-tired wheels travelling over concrete, wood-block and other types of roads; summary of results of American and German studies.

115. Bafgh "Commercial Vehicles on Road Test." *Modern Transport*, V. 22, No. 554, Oct. 26, 1929, pp. 10-11. Description of performance 80 h.p. Mercedes-Berg crude oil chassis with load of 10 tons; ease of handling; hill test; brake test; perfect engine performance; power unit; fuel and oil supply; transmission arrangement.

116. Bafgh "Commercial Vehicles on Road Test." *Modern Transport*, V. 22, No. 549, Sept. 21, 1929, pp. 19-20. Description of test on new 1½ ton Morris commercial truck; ease of control, remarkable climbing performance acceleration tests.

117. Bahj "Commercial Road Vehicles on Test." *Modern Transport*, V. 21, No. 544, Aug. 17, 1929, pp. 21-22. Description of road tests of 26.9 h.p. Renault chassis; resilient suspension; hill-climbing qualities, 6 cylinders cast in 2 pairs of 3; side by side valves, etc.

118. Bafgh "Commercial Road Vehicles on Test." *Modern Transport*, V. 21, No. 540, July 20, 1929, pp. 18-19. Commer 30 cwt. (1½ ton) chassis designed for light transport, given full load road tests, acceleration, gear changing, braking, hill climbing, technical description of chassis.

119. Bd "Can Front Wheel Drive Aid Trucks?" P. M. Heldt. *Commercial Car Journal*, V. 37, No. 4, June 1929, pp. 18-19, 48 and 57. Claims that front-wheel-drive vehicle is less given to skidding are taken up.

120. Bacdg "Starting and Skidding of Automobiles." F. Raout. *Pratique des Industries Mecaniques,* V. 12, No. 4, July, 1929, pp. 167-169. Relation existing between force at rim, adhesion, and resistance to traction is discussed; what skidding consists of; practical means of increasing adhesion by increasing coefficient of friction, and by increasing loads supported by moving wheels.

121. ABbcj "Elements of Tractive Resistance Analyzed in Automotive Tests." L. E. Crooks. *Auto. Industries,* V. 60, No. 24, June 15, 1929, pp. 915-916. Results of 4 yrs. testing of automobiles, their air-resistance and coefficient of friction between tires and road surfaces, made upon highways in vicinity of Iowa Engr. and Exp. Stat.; forces opposing vehicular progress are increased 50 per cent by light gravel road surfaces and total 700 lb. per ton in deep mud; discussion of Iowa State College—Bull. No. 88, by T. R. Agg.

122. ABabcj "Tractive Resistance and Related Characteristics of Roadway Surfaces." T. R. Agg. Iowa State College Bull. No. 67, Feb. 6, 1924.

123. Bjklm "Air Resistance of Automobiles." E. H. Lockwood. *American Highways,* V. 8, No. 2, Apr. 1929, pp. 1-4. Results of four series of air resistance measurements carried out during past 8 yrs. in Germany and United States; rolling resistance and air resistance of sedans, coupés, roadsters, and touring cars of various makes on different grades.

124. ABbh "Light Truck Tractors for Oil Deliveries Given Strenuous Road Tests." R. B. Stafford. *National Petroleum News,* V. 21, No. 17, Apr. 24, 1929, pp. 32-34. Notes on tests of six makes of tank truck tractors at Gates Mills, near Cleveland, Ohio; tabulation of specifications and of results achieved on two hills and two types of road, along measured courses whose grades were determined; tests were conducted to show petroleum industry what could be expected of each type in actual service.

125. Ba "Bearing of Automobile Highways." J. Petier. Société Industrielle de l'Est. Bull. No. 192, Jan., Feb., Mar., 1929, pp. 36-41. General study of mechanics of motion of vehicles over highway; utilization of power, adherence, and stability of vehicles, vibration, critical velocities, shimmying, and pseudo-shimmying; progress in comfort, safety, and elimination of vibrations.

126. Bam "Influence of Form of Body on Speed and Fuel Consumption." M. Convierne. *Vie Automobile,* V. 26, No. 940, Feb. 25, 1930, pp. 65-68. Theoretical discussion and curves for calculation of required driving power, from weight, speed, coupling, and coefficient of air penetration.

127. ABabcj "Practical Tractive Ability Methods." A. M. Wolf. S.A.E. *Journal,* V. 27, No. 6, Dec., 1930, pp. 655-664. Importance of engine torque in relation to tangential force exerted by driving wheels at their points of contact with the road; typical tractive factors of modern motor trucks develop economic factor mathematically and thus be prepared to discuss tractive resistance as opposed to tractive effort; diagrams and charts illustrate air resistance and effect of different tires, and roadways.

128. Bm "Wind Resistance of Automoblies." F. N. Pawlowski. S.A.E. *Journal,* V. 27, No. 1, July, 1930, pp. 5-13 and (discussion) p. 14. Principles of aerodynamics and air flow around various shapes; coefficient of resistance to motion of streamlined body is approximately 1/30 that of flat plate having same frontal area; various methods of determining air resistance of automobiles, graphs and sketches illustrate test methods and results.

129. Dad "Effect of the Center of Gravity on Skidding Tendencies is Studied." J. Bradley and S. A. Wood. *Auto. Industries,* V. 63, No. 3, Dec. 6, 1930, pp. 833-834. Effect of moment of inertia about c.g.; effect of longitudinal position of c.g.; effect of height of c.g.; effect of transverse position of c.g. Abstract of paper read before Inst. of Auto. Engrs.

130. BCDad "The Skidding of Road Vehicles." *Engineering,* V. 130, No. 3388, Dec. 19, 1930, pp. 777-78. Editorial review of two papers read before Institute of Automobile Engineers, "Experiments on Factors Affecting Motion of 4-Wheeled Vehicle when some of its Wheels are Locked," and "Factors Affecting Behavior of Rubber-Tired Wheels on Road Surfaces," J. Bradley and R. F. Allen. (P. 149, E. Ind. 1930.)

131. Baf "Possibilities of Front Wheel Drive." *Commercial Motor,* V. 51, No. 1325, Aug. 5, 1930, pp. 884-6. How distribution of load and position of center of gravity affect wheel grip, acceleration, and retardation; difficulties of universal joints; larger amount of passenger space.

132. Bah "Front-Wheel Drive for Commercial Vehicles." Manlik. *Automobiltechnische Zeit,* V. 33, No. 3, Aug. 20, 1939. pp. 552-6. Investigation of traction and acceleration for various gradients show disadvantages of front-wheel drive for commercial vehicles.

133. Bd "The Skidding Danger." *Motor Transport,* V. 50, No. 295. Jan. 6, 1930, pp. 9-11. Various non-skidding devices for motor truck; success of chains in Switzerland; Parsons chains; Wheway anti-skids; Sheppee non-skids; Gilco non-skid chains.

134. Bad "How Do 6-Wheel Vehicles Affect Tire Performance?" G. M. Sprawls. *Power Wagon,* V. 44, No. 301, Jan. 1930, pp. 40, 45-8. Includes discussion of skidding and traction, among other things.

135. Ba "Automotive Engineer's Pocket Book." H. K. Thomas. 1931, pp. 16-20. Horsepower calculations and air resistance coefficient and formula.

139. Cbck "Tire Factor in Auto Riding Quality." R. W. Brown. *Rubber Age,* (N. Y.) V. 29, No. 8, July 25, 1931, pp. 361-63. Methods for measuring characteristics of tires which affect riding qualities, co-ordination between service performance and laboratory tests; tread design and tire traction.

140. Bm "Wind Tunnel Tests and Body Design." J. Andrade. S.A.E. *Journal,* V. 29, No. 1. July, 1931, pp. 29-32 and 56, 8 figs. (See also *Auto. Engr.,* V. 21, No. 287, Nov. 1931, pp. 542-544, 7 figs.) Wind tunnel tests of auto models, as made at U. of Detroit; general body and fender design to reduce air resistance and produce good appearance; methods of making tests so as to include ground effect and determine air flow pattern around car.

141. Bm "Future Auto Design Will be Influenced by Aerodynamics." A. Northup. *Auto. Industries,* V. 64, No. 24, June 13, 1931, pp. 908-909. Advantages of streamlining body contours with particular regard to appearance and efficiency.

142. Baim "Streamlining Applied to Automobiles." O. K. Marti. S.A.E. *Journal,* V. 29, No. 2, Aug., 1931, pp. 126-128 and 163. Results of wind tunnel tests of streamlined models show reduction of almost one half in wind resistance at speeds of 40 and 50 m.p.h., as compared with conventional American sedan model; theoretical analysis of horsepower required to maintain given car speed.

143. Bim "Advantage of Streamlining Lies in Power Economy at High Speeds." P. M. Heldt. *Auto. Industries,* V. 64, No. 20, May 16, 1931, pp. 762-765, 5 figs. Principles of streamlining and calculation of air resistance.

144. Baim "Wind Resistance *vs.* Car Performance." L. Schwitzer. S.A.E. *Journal,* V. 28, No. 6, June, 1931, pp. 631-635 and 668. European investigations regarding disturbance of air stream by bodies of various shapes; power losses and power utilization in car designed by Rumpler in Germany and in two German racing cars; novel design features of streamlined cars.

145. Bm "Tear-Drop Car." W. T. Fishleigh. S.A.E. *Journal,* V. 29, No. 5, Nov., 1931, pp. 353-358 and (discussion, 359-362. Automobile is developed which has remarkable possibilities in matters of decreased wind resistance, fuel economy, riding comfort, and clear vision, in addition to striking beauty and grace; result of wind tunnel tests upon models of this design and of conventional sedan.

146. ABCDbcd "Factors Affecting Behavior of Rubber Tyred Wheels on Road Surfaces." J. Bradley and R. F. Allen. Inst. Auto. Engrs., *Proceedings,* V. 25, 1930-31, pp. 63-84 and (discussion) 85-92. See also *Auto. Engr.,* V. 22, No. 277, Feb. 1931, pp. 73-78. Investigation of skidding of vehicles on road surfaces at Nat. Physical Lab.; devices for recording and analyzing forces set up in operation of tires with different types of treads on various road surfaces; sidesway force and braking force, coefficients as criteria of resistance to skidding.

147. Bm "Reo Royale Bodies Tested in Wind Tunnel at U. of Detroit." *Auto. Industries,* V. 64, No. 3, Jan. 17, 1931, pp. 96-97. Arrangement of test on models; power needed to overcome air resistance at speed of 80 m.p.h. is 12 per cent less than that required with previous type of body.

148. Ba "Four-Wheel Drive Will Improve Get-away of Today's High Powered Cars." P. M. Heldt. *Auto. Industries,* V. 64, No. 14, Apr. 4, 1931, pp. 538-540 and 546. Effect of weight distribution on tractive power, three types of differentials which can be used to distribute torque between front and rear wheels in proportion to their respective pressures on the road.

149. Ba "Practical Tractive-Ability Methods." A. M. Wolf. S.A.E. *Journal,* V. 28. No. 1. Jan. 1931, pp. 96-100. Discussion of Transportation Meeting Paper; concerned with desirability of calculating tractive ability from horsepower.

150. Bajh "Formulae for Rating Trucks." L. R. Buckendale. S.A.E. Journal, V. 29, No. 4, Oct., 1931, pp. 336-338, see also *Commercial Car Jl.,* V. 41, No. 5, July 1931, pp. 14-16 and 46; and *Petroleum World,* V. 28, No. 7, July 1931, pp. 53 and 55. Interpretation of formula taking into consideration gross vehicle weight, engine torque, total gear reduction, overall mechanical efficiency, radius of tire under load, gradient, and rolling resistance.

151. BCDd "Some Experiments on Factors Affecting Motion of Four-Wheeled Vehicle When Some of its Wheels are Locked." J. Bradley and S. A. Wood. Inst. Auto. Engrs., *Proceedings,* V. 25, 1930-31, pp. 46-62, see also *Auto. Engr.,* V. 21, No. 276, Jan. 1931, pp. 34-38. Program of Road Research at National Physical Lab. on behalf of Ministry of Transport; skidding characteristics as affected by weight distribution on wheels; height of c.g.; moment of inertia about vertical axis through c.g.

152. Bm "Elimination of Cowl Probable, Says Ralph Roberts, Briggs Designer." A. F. Denham. *Auto. Industries,* V. 66, No. 7, Feb. 13, 1932, pp. 224-7. Possibilities of streamlining illustrated by 2 examples.

153. Bim "Economy of Streamlining the Automobile." S.A.E. *Journal,* V. 30, No. 3, Mar. 1932, pp. 150-2. Investigation of air resistance in wind tunnels shows that from 60 to 84 per cent of power required to propel closed car is necessary to overcome air resistance at speeds of 40 to 80 m.p.h.; power savings by suitable streamlining of automobiles, amounting to 50 per cent at 40 m.p.h. and 65 per cent at 70 m.p.h.

154. Bim "Drag of Cars Charted in Wind Tunnel Tests." W. E. Lay. *Auto. Industries,* V. 66, No. 14, Apr. 2, 1932, pp. 520-2. Investigation of aerodynamic characteristics of simple body forms in wind tunnel of Aero. Eng., U. of M.; graphs illustrate value of air resistance coefficient as affected by shape of front and rear end of car.

155. Ba "Report of Project Committee on Tractive Resistance and Allied Problems." W. E. Lay. *Proceedings,* Highway Research Board, V. 12. pp. 66-75.

156. Bm "The Air Resistance of Motor Vehicles." W. E. Lay. Nat. Research Council Pamphlet, 1932. (Wind tunnel models.)

157. Bam "Development of Rear-Engine, Streamline Car." D. Burney. S.A.E. *Journal,* V. 30, No. 2 and 3, Feb. 1932, pp. 57-64 and (discussion) Mar., pp. 116-19. Reference to unconventional designs produced in Europe and America, such as front wheel drive and rear engined cars; elimination of nearly ½ air resistance of orthodox sedan and much steadier riding of high speed; analysis of forces and motions induced in car by location of c.g. and distribution of weight.

158. Cak "Rolling Resistance of Rubber Tires." E. H. Lockwood. *India Rubber World,* V. 27. No. 1, Oct. 1, 1932, pp. 13-15, 4 figs. Notes on rear-wheel dynamometer; measuring tire resistance; solid tire tests; cord and fabric-tire tests; loss of power in tires.

159. Bm "Aerodynamic Characteristics of Automobile Models." R. H. Heald. *Journal of Research,* National Bureau of Standards, Aug., 1933.

160. ABbd "Why Cars Skid." *Motor* (London), V. 65, No. 1670, Dec. 26, 1933, pp. 1030-1. How skid commences and develops and ways in which it can be corrected; dangerous road surfaces.

161. Bim "Is 50 Miles per Gallon Possible with Correct Streamlining?" W. E. Lay. S.A.E. *Journal,* V. 32, No. 4 and 5, Apr., 1933, pp. 144-56 and May, pp. 177-86; see also Editorial Remarks in *Engineering,* V. 135, No. 3513, May 12, 1933, pp. 521-2. April: Tables and Charts illustrating results of mathematical analysis and wind tunnel tests of variety of body designs. May: Study of test methods used; better fuel mileage with proper gear ratios; drawbar dynamometer for measuring air force on "floating envelope," fuel consumption at most efficient engine operation, suggestions offered to car builders.

162. Bm "Differences Between Wind-Tunnel and Road Conditions." S.A.E. *Journal,* V. 33, No. 2, Aug. 1933, pp. 261-7. Comments on paper by W. E. Lay (indexed from issues Apr. and May 1933) including: "Potent Factors Neglected in Many Streamline Tests," M. C. Horine; "Constructive Questions on Important Features," P. Altman; "Car-Resistance Reduction and Skin Friction Drag," H. G. Winter; "Dust Swirl Fuel Wastage Challenges Car Designers,"

E. G. Reid; "Wind-Tunnel Results Need Kid-Glove Handling," R. H. Upson; "Lay Amplifies Test Method Data and Answers Critics," W. E. Lay.

163. Bm "Side Winds Abate Performance Gains Hoped for from Streamlining." R. H. Heald. S.A.E. *Journal,* V. 33, No. 5, Nov. 1933, pp. 18-21. Data submitted are not considered to be applicable to all types of bodies, but are useful in indicating order of magnitude of lateral and longitudinal forces which arise as result of action of natural wind against moving automobiles.

164. Bm "Streamlining—Latest Researches." M. Platt. *Motor* (London). V. 63, No. 1645, July 4, 1933, pp. 903-6. Study of methods available for reduction of air resistance; main lines of attack on air resistance summarized as streamlining, smoothing and slimming; economizing power expenditure; selecting top gear ratio; influence of cross winds; streamlining reduces noise.

165. Ca "Future for Low-Pressure Tires Gradually Grows Brighter." A. F. Denham. S.A.E. *Journal,* V. 32, No. 4, Apr. 1933, pp. 138-41, (discussion) 141-3. Factors of appearances, riding qualities, traction, mileage, steering, blow-outs, and costs as related to low-pressure tire problem; experiences recorded by individual companies and engineers during past year.

166. ABbcd "Further Coefficient of Friction Tests." Stinson and Roberts. *Proceedings,* Highway Research Board, V. 14. pp. 131-147, 1934. Covers effect of tire tread and inflation and road surface on rolling coefficient: 1. Vertical-fiber wire-cut lug brick roads, asphalt; 2. Snow conditions.

167. ABa "Motor Vehicle Power Requirements on Highway Grades." Moyer, R. A. *Proceedings,* Highway Research Board, V. 14, pp. 147-186, 1934. *Lab. tests* on rolling resistance, power and fuel consumption. *Road tests* on gas. consumption on various surfaces and grades, free wheeling tests; rolling, air and engine resistance; acceleration and tractive effort.

168. ABbdef "Further Skidding Tests With Particular Reference to Curves." Moyer, R. A. *Proceedings,* Highway Research Board, V. 14, pp. 123-130, 1934. Skidding and braking tests on snow and ice, coefficients given for use in highway design.

169. Bm "Reflection Plate Representing Ground." Stalker E. A. *Aero. Sciences Journal,* V. 1, No. 3, Jl. 1934, pp. 151-2. Use of plate upon which boundary layer is removed or energized so that it does not present drag to air stream; reference to author's tests on auto bodies at Univ. of Mich.

170. Bm "Belt Method of Representing Ground." Klemin, A. *Aero. Sciences Journal,* V. 1, No. 4, Oct. 1934, pp. 198-9. Discussion of paper by Stalker, No. 169.

171. Bm "'Moving Ground' Developed for Wind Tunnel Testing of Car Models." A. Klemin. *Auto. Industries,* V. 71, No. 5, Aug. 4, 1934, p. 140. Results obtained so far bear out following general theory: 1) Absolutely free air resistance is apt to be unduly high; 2) mirror method approaches correct results more closely, but may deviate in either direction from correct results; 3) fixed ground board, owing to boundary-layer formation, gives results far too low.

172. Bm "Comparison of Ground Plane and Image Methods for Representing Ground Effect in Tests on Vehicle Models." R. H. Heald. National Bureau of Standards, *Journal of Research,* V. 13, No. 6, Dec. 1934, pp. 863-70. In order to simulate full scale conditions in wind tunnel it is necessary to represent presence of ground; approximate representation of ground effect obtained by means of either fixed ground-plane method or image method; experimental comparison of two methods.

173. Bm "Air Forces and Yawing Moments for Three Automobile Models." R. H. Heald. National Bureau of Standards, *Journal of Research,* V. 13, No. 6, Dec. 1934, pp. 871-8. Lift, drag, cross-wind force and yawing moment for 3 models having substantially different body shapes measured in a wind tunnel; results of model investigation, extrapolated to full scale, indicate presence of rather large lift, lateral force, and yawning moment under certain conditions of car speed and natural wind speed.

174. ABabcd "Skidding Characteristics of Auto Tires on Roadway Surface, and Their Relation to Highway Safety." R. A. Moyer. Iowa State College Bull., No. 120, 1934.

175. ABabji "Tractive Resistance as Related to Roadway Surfaces and Motor Vehicle Operation." R. G. Paustian. Iowa State College Bull., No. 119, 1934.

176. BDam "Bremsen mit Luftwiderstand?" L. Handl. *Automobiltechnische Zeit,* V. 37, No. 18, Sept. 25, 1934, p. 406. Braking by means of air resistance; short article suggesting that in developing high-speed automobiles, principles of air resistance braking as used on airplanes may be applied to automobiles.

177. Bm "La Résistance de L'air à L'Automobile." M. Andreau. Societas de Ingenieurs de l'Automobile, *Journal,* V. 7, No. 2, Feb. 1934, pp. 2577-94. See also *Auto. Industries* V. 71, No. 3, 4, and 6, July 21, 1934, pp. 74-6, July 28, pp. 116-7, and Aug. 11, pp. 172-5. In author's opinion so-called streamlined bodies do not reduce air resistance materially; developments on fenders, running boards, and headlights seem much more promising; it is doubtful whether changes being made in body form come under head of streamlining and whether motivation is not largely commercial.

178. CDac "Brake Design." B. B. Bachman. *Auto. Engineer,* V. 24, No. 317, Mar. 1934, pp. 108-11. Analysis of certain modifying factors; coefficients of friction between ground and tire; effective weight; distribution of braking effort on front and rear wheels; space available for brakes; brake types, factors influencing arrangement of brakes; brake function, brake control mechanism, pedal pressure, brake rating.

179. Bam "Dynamics of Modern Auto." G. L. McCain. S.A.E. *Journal,* V. 35, Nos. 1, and 5, Jl. 1934, pp. 248-56 and discussion, Nov., pp. 429-30. Enumeration in simple form of some of the outstanding features of new automobile dynamics; analysis of streamlining; effects of redistribution of passengers and units; results of riding quality model tests and weight distribution; forces acting upon planetary overdrive. Bibliog. of streamlining included.

180. Bm "Grundlagen fuer Modellversuche an Fahrzeugen." O. Lutz. *Automobiltechnische Zeit,* V. 37, No. 8, Apr. 25, 1934, pp. 211-12. Fundamentals for model testing of automobiles; it is shown that Froude's Law should be applied.

181. Bm "Possibilities of Truck Streamlining for Work in Dairy Industry." *Food Industries,* V. 6, No. 2, Feb. 1934, pp. 80-1. First fully streamlined tank truck, Texaco, built by Diamond T to order for Texas Co.

182. Bm "Design of Public-Service Body Work." A. J. Romer. Inst. Auto. Engrs., *Journal,* V. 2, No. 8, May, 1934, pp. 10-28. Includes material on "minimum wind resistance."

183. Ca "Tire Tests." R. Paustian. *India Rubber World,* V. 90, No. 4, Jl. 1, 1934, pp. 33-4. Road tests which show behavior of pneumatic tires under operating conditions.

184. Ca "Automobile as Tyre Testing Instrument." A. H. Nellen. *Rubber Age* (London), V. 15, No. 3, May 1934, pp. 70-3. Some information accumulated during more than 10 years' intimate connection with road testing of pneumatic tires; purposes of test. From Vanderbilt News.

185. Bm "Praktische Stroemungsforschung an Kraftfahrzeugen." M. Schirmer. *Automobiltechnische Zeit,* V. 38, No. 7, Apr. 10, 1935, pp. 176-81. Practical wind tunnel tests of automobiles; relation between automobiles and model tests; possibilities of error; streamlining of racing cars; stability of streamlined cars, practical examples.

186. Bm "Farewell to the Horseless Carriage." E. G. Reid. S.A.E. *Journal,* V. 36, No. 5, May 1935, pp. 180-9. Critical study of possibilities of improved auto performance and economy by aerodynamic refinement by demonstrating analogy between motor-car air resistance and airplane parasite drag; example illustrates benefits of aerodynamic research in latter field and potentialities of similar work in former pointed out; author's reply. Also discussion of paper.

187. Bm "Aerodynamic Resistance." M. Gignereaux. (English translation), *Auto. Engineer,* V. 25, No. 328, Jan. 1935, pp. 33-5. Application of wind-tunnel testing to problem of aerodynamic resistance of vehicles; necessity of tests on reduced models; scheme of elliptical wind tunnel possible tests on reduced models; test results in table and curves; examples.

188. . ABCabc "Der Kraftschluss zwischen Rad und Fahrbahn." Schuster and Weichsler. *Automobiltechnische Zeit,* V. 38, No. 20, Oct. 25, 1935, pp. 499-504. Contact between pneumatic-tired wheel and road, and its effect on tire; tests show that range of adherence force, so-called skid resistance should be regarded as due to expansion or shrinkage of rubber to fit small irregularities in road surface, and *not* to sliding friction.

189. Bam "Air Resistance and the Automobile." M. Andreau. *Auto. Engineer,* V. 25, No. 329, 330 and 331, Feb. 1935, pp. 75-7, Mar., pp. 113-4, and Apr., pp. 147-9. Interesting information obtained from wind tunnel and practical tests; results of tests, drag, illustrations, and tables.

190. Cabc "Tyre Factors in Vehicle Control." F. G. W. King. *Engineering,* V. 140, No. 3642, Nov. 1, 1935, pp. 367-70. Study of tire behavior and part played in vehicle control, with special ref. to anti-skid properties; result of tests made by Dunlop Rubber Co.

191. Bam "Wind Tunnel Tests Show Reduction in Resistance Obtainable with Rear-Engine Streamlined Model." E. G. Reid. *Auto. Industries,* V. 72, No. 3, Jan. 19, 1935, pp. 80-1. Research work carried out at Guggenheim Aero. Lab., Stanford Univ.; tests made on 4 models of streamlined cars; power requirements of conventional and streamlined sedans shown in curves.

192. Ca "Slip Angle, Camber, Load, Speed, Pressure, Rim Width, Size—How They Affect Tire 'Cornering' Power." *Auto. Industries,* V. 72, No. 3, Jan. 19, 1935, pp. 76-7. Performance data in curves.

193. Bm "Representation of Ground in Wind Tunnel." M. Ore. *Journal Aero. Sciences,* V. 3, No. 2, Nov. 1935, pp. 40-2. Experimental study of methods of representing ground in wind tunnel work by stationary plate, moving belt and image model methods; image model method gives flow pattern more closely corresponding to moving model than stationary plate method.

194. Bmi "Economics of Streamlining in Heavy Transportation." (Abstract L. H. Brown), S.A.E. *Journal,* 39: 516, Dec., 1936.

195. BDf "Piston Friction." Taylor. S.A.E. *Transactions,* V. 31, 1936, 8200-5.

196. ABdf "Speed *vs.* Safety on Straightaways; Skidding and Braking Tests." R. A. Moyer. Ill. diags., *Civil Engineering,* 6: 801-4, Dec., 1936.

197. ABbdef "Speed *vs.* Safety on Curves." R. A. Moyer. Ill. diags., *Civil Engineering,* 6: 801-4, Dec., 1936.

198. BDafm "Kuerzere Bremswege durch Erhoeherung des Luftwiderstandes." S. Sztatecsny. *Automobiltechnische Zeit,* V. 39, No. 15, Aug. 10, 1936, pp. 382-6. Decrease of brake stopping distance by increasing air resistance; theoretical math. analysis in order to determine whether, at high speed made possible by extensive speedway construction program in Germany, increase of air resistance of car during braking period may be applied advantageously.

199. Bm "Air Resistance and Air Resistance—H.P. Chart." P. M. Heldt. *Auto. Industries,* V. 75, No. 12, Sept. 19, 1936, p. 379. Chart determines air resistance encountered by car at any given speed; example of application.

200. Bm "Atmospheric Resistance of Motor Vehicles, Tests of 1932." Conrad and Dawley. Kansas State College, Eng. Exp. Station, Bull. No. 33, V. 20, No. 1, Jan. 1, 1936, 59 p. Wind tunnel determination of wind resistance of 54 autos together with independent check on two cars made by coasting tests presented; results of investigations presented as evidence, not as proof; these cars represent 14 makes including 7 yearly models and 4 body types.

201. Bm "Luftevideratand von Kraftfahrzengen-Modellversuche und Wirklichkeit." C. Schmid. *Automobiltechnische Zeit,* V. 39, No. 17, Sept. 10, 1936, pp. 425-35. Air resistance of automobiles; report of series of tests given for comparison between model tests and actual values regarding air friction in travelling.

202. Bm "Windkanalmessungen an Omnibusmodellen." *Automobiltechnische Zeit,* V. 39, No. 6, Mar. 25, 1936, pp. 143-50. Wind tunnel measurements on motor bus models; air resistance characteristics of various types studied by aid of three component scales; measured air forces served for valuation of results.

203. BDdf "Jacknifing in the Operation of Tractor-Trailer Combinations Analyzed." P. M. Heldt. *Auto. Industries,* 75: 739-41, 759, Nov. 28, 1936.

204. ACbd "Skid Tests on Bridge Floors." Ill. *Roads and Streets,* 80: 56, D '37.

205. Ca "20,000 Tire Tests." A. F. Denham. Ill. *Auto. Industries,* 77: 876-7, Dec. 18, 1937.

206. Ca "Determination of Variation in Unit Pressure Over the Contact Area of Tires." L. W. Teller and J. A. Buchanan. Ill. diags., *Public Roads,* 18: 195-8, Dec. 1937.

207. ABai "Effect of Highway Design on Vehicle Speed and Fuel Consumption." Oregon State Highway Department, 115 p., bibliog. (p. 102), Salem, 1937.

208. BDf "Engine Friction; Degree of Error in Relation to the Motoring Tests." M. K. McLeod. *Auto. Engineer,* bibliog., 27: 57-8, Feb. 1937.

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211. Bmi "Advanced Streamlining Shows Operating Savings; New Tractor-Trailer." Ill. *Food Ind.*, 9: 522-35, 1937.

212. Bm "Aerodynamic Shrouding for Vehicles on the French State Railways." Ill. diags., *Engineer*, 164: 209-12, Aug. 20, 1937.

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214. Bm "Streamlined Vehicle." *Machine Design*, V. 9, No. 6, June 1937, p. 45.

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218. Abcd "Road Surface Resistance to Skidding." *Roads and Streets*, 80: 39, Dec., 1937.

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237. Ca "Power Losses in Automobile Tires." W. L. Holt. National Bureau of Standards, 1922, No. 213.

238. Bm "Aerodynamic Characteristics of Auto Models." R. H. Heald. National Bureau of Standards, 1933, no. 2.

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240. Baim "Economy of Streamlining the Automobile." O. G. Tietjens. S.A.E. *Transactions,* V. 27, p. 150.

241. Bm See also: "Air Resistance of High Speed Automobiles." A. Persu, p. 25-27, discussing future design of streamline autos.

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