Annotated Bibliography

1924 1. Sawyer, C. L. "White Brick Form Permanent Centerline in Ohio County Road." Engineering News-Record, v. 93, p. 965, 1924.
White bricks were placed in the centerline of a brick road to act as the traffic stripe. Cost of these bricks was $185 per mile.

1925 2. Mattimore, H. S. "Highway Traffic Line Paint." Proc. Highway Research Board, v. 5, pt. 1, pp. 177-184, 1925.
The conditions under which traffic paints are used suggests that the following are the most important factors involved and are those for which laboratory tests of one kind or another are essential in selecting paint for such service: I. Consistency, II. Spreading Rate, III. Hiding Power, IV. Drying time, V. Light Resistance, VI. Visibility, VII, Durability.

3. "Painting Traffic Lines." Automotive Ind., v. 53, p. 1034, Dec. 17, 1925.
Ault traffic line marking machine is manufactured by the Tennessee Tool Works, Knoxville, Tenn. Painting is done by the spray method. An extension spray nozzle is provided for the painting of posts, fences, equipment, etc. It weighs 160 lbs. and is operated by one man.

1926 4. "Brass Cups for Marking Pavements." Roads & Streets, v. 65, no. 3, p. 149, March 3, 1926.
A description of a brass cup used for marking pavements. The cups are 3 in. or 4½ in. in diameter. They are driven in place and are adaptable to asphalt, macadam, wooden block, amiesite, warrenite, and new concrete pavements.

5. "Cost of Traffic Line Marking With Marker Built on the Job." Engineering News-Record, v. 96, p. 780, May 13, 1926.
A traffic line marker capable of marking 8 mi. per day has been put into use in the Santa Ana district of California. The cost of the machine is $35.00 and the cost of marking is $9.00 per mi.

6. Nelson, H. A. & Werthan, S. "Traffic Paint." Ind. & Eng. Chem. v. 18, pp. 965-970, Sept., 1926.
Quantities of paint are being used for marking traffic lines and directions on streets and highways. This paper covers the results of a study of the proper formulating and suitable means for the testing of this type of paint.
The properties of paints designed for this purpose, considered in more or less detail, are consistency, drying, hiding power (opacity), color and color retention, visibility (day and night), and durability.

7. "Permanent Marking of Roads and Streets by Brass Spots." Engineering News-Record, v. 96, p. 260, 1926.
Traffic control information and guide lines may be permanently built into the pavement by use of new brass traffic spots. It is claimed that they are permanent, non corrosive, highly visible, easily inserted, and require no upkeep.

8. "Traffic Lines Easily Marked in Youngstown." Elect. Railway J., v. 68, p. 336, Aug. 28, 1926.
The proposed line is fully marked out and the machine pulled along over this, automatically leaving a clean, white band in its wake.
This road marker is manufactured by the Continental Products Co., Euclid, Ohio.

1928 9. MacDonald, C. "Tar Paint Traffic Lines Increase Road Capacity." Engineering News-Record, v. 100, p. 28, Jan. 5, 1928.
The 3/4-in. radius joints between adjacent strips of concrete are filled with a tar joint filler. Following up the crew which was filling the joints, two men, using the same filler, painted a 4- to 6-in. wide black band on the pavement at these joints.

10. "Marking Streets with Canvas." Engineering News-Record, v. 101, p. 262, 1928.
Strong canvases, paint impregnated, whose backs are coated with an adhesive which makes permanent application easy, have been used for street markings.

11. "Traffic Stripes on California Highways." Concrete, v. 33, p. 36, July, 1928.
In this traffic line marker used by the California Highway Dept., three steel wheels are attached to a light framework of structural steel bars and braced at certain points. Thirteen-inch discs are bolted to two of the wheels to act as a flange or guide along the pavement edge.

1929 12. "Brite Mark Monel Metal Traffic Markers Will Be Shown in Use." Good Roads, v. 72, p. 72, Jan., 1929.
These markers are rust-proof and will not tarnish. They function winter and summer, rain or shine, whereas paint will wash away and is practically useless in winter.

13. "Centerline Painting on Iowa Highways." Concrete, v. 34, p. 30, April, 1929.
Iowa is making use of a specially equipped war surplus truck. It marks a wide black line along the concrete highways at a rate of 2-mi. per hr. Only two men are necessary to operate the equipment.

14. Pope, J. "Rock Asphalt Strip in Concrete Road Makes Permanent Center Line." Engineering News-Record, v. 103, no. 17, Oct. 24, 1929.
A space 1-ft. wide is left in the center of a concrete pavement. This space is then filled to within 1½-in. of the surface with rock asphalt.

15. "Scovill Stop Spot Traffic Markers." Public Works, v. 60, p. 48, Dec., 1929.
A description of a special brass marker which is claimed to remain securely imbedded under heaviest traffic. The marker uses an expanding plug which spreads the lower end as it is driven into place.

1930 16. Beach, A. E. "New Road Marking Equipment." Can. Engineer, v. 59, p. 36, July 8, 1930.
The Littleford trailer attachment is designed to take the place of an operator pushing the Traf-O-Mark along the center of the road following a guide line.

17. Burr, G. D. "Effective Traffic-Line Marker of Cast Aluminum." Engineering News-Record, v. 105, no. 2, pp. 68-69, July 10, 1930.
Discs 4 5/8-in. in diameter and 3/16-in. thick fastened to the pavement with steel pins have proven effective. This article contains a sketch of the marker and method of installation.

18. "Expansion Joints Mark Traffic Lanes, Paving Practice in Los Angeles." Engineering News-Record, v. 105, no. 9, p. 340, Aug. 28, 1930.
The new design consists of spacing the expansion joints and contraction joints so that they are not only adequate for their original purpose but also divide the pavement into traffic lanes of standard width.

19. "Marking Traffic Lanes on California Pavements." Engineering News, v. 104, pp. 408-10, Mar. 6, 1930.
Specifications for paint call for a yellow lacquer that will dry dustproof in 5 minutes and hard in 45 minutes. Analysis of this paint is as follows:

1930 pigment - 30 percent; plasticizer - 2½ percent; nitrocellulose and gum - 27½ percent; solvent and thinner - 40 percent.

20. "Washington Experiments With Street Markers." Elect. Ry. J., v. 74, p. 742, Dec., 1930.
White rubber inserts are the latest of a number of devices to be tried by the Washington Traffic Bureau with the aim of developing a satisfactory traffic lane marker. The inserts are in the shape of a rectangular box with slanting sides 3-in. wide by 2-ft. long by 3-in. deep.
They are expected to be as permanent as the roadbed but the installation is very expensive.

1931 21. Erb, A. K. "Blotting Paint with Sawdust Cuts Costs." Engineering News-Record, v. 107, no. 722, p. 722, Nov. 5, 1931.
An automatic device is described for blotting paint with sawdust immediately following the application of the marking paint. The sawdust blots the paint sufficiently to allow traffic to infringe upon the stripe without causing excessive smearing and has little or no detrimental effect upon the visibility of the line.

22. "Los Angeles Pavement has Built-In Traffic Markers." Eng. and Contr. v. 70, pp. 155-6, June, 1931.
After the concrete had been deposited on the subgrade it was screeded and tamped. A slot was then cut in the fresh concrete to receive the traffic marker. To cut the slot, a guide and wheel were used. The slot was cut to a depth of 3½-in.

23. Stanton, T. E. "State Research Experts Develop Durable Traffic Paint." California Highways & Public Works, pp. 8-9, 11, Dec., 1931.
The material must have certain well-defined characteristics to make it of value for the purpose. It must dry to such an extent in approximately one-half hour or less that it will not be injured by traffic. Other factors to be considered are solution of asphalt by solvents, brittleness of gums, softness of residue, resistance to abrasion action, and retention of color. Extensive investigations have resulted in a specification, which is expected to insure a high grade product with a resultant saving in cost and increase in utility. Further investigations have been conducted to devise equipment for measuring relative visibility.

1932 24. Barker, W. E. "Minnesota's Combined Traffic Line and Expansion Joint." Public Works, v. 63, no. 34, Jan. 1932.
Construction of this joint begins with a heavy wheel pulled by the finishing machine which cuts a groove in the concrete pavement. A built-up T-bar is forced into the groove. After finishing, the T-bars are removed, leaving a joint which, when filled with bitumen, becomes a traffic line.

25. Gardner, H. A. "Paints for Highway Markers." Am. Paint and Varnish Manu. Assoc., no. 410, p. 154, May, 1932.
Many proposals have been received suggesting the use of aluminum paints for highway markers. Results of tests are given showing that panels painted with such a material are hardly visible when viewed by the light of an automobile head light 75 yds. from the panels, with the panels placed at an angle of 30 deg. to the source of the light. This phenomenon is brought about by the numerous shiny scales which act as mirrors reflecting the light only in one direction.

26. "How Shall We Mark Traffic Lanes?" Public Works, v. 63, pp. 28-9, Aug., 1932.
The article discusses different types of markers used in various localities in the United States. These include white rubber markers, metal markers, yellow cotton striping, concrete stripes, asphaltic stripes, and colored paints.

1932 27. "Marking Highways in Indiana." Public Works, v. 63, pp. 36-7, July, 1932.
A centerline marker, material used and season of the year, and cost of marking are discussed briefly. Information is taken from 1931 Report, Indiana Highway Commission.

28. "Necessary Characteristics of Traffic Line Paint." Public Works, v. 63, no. 3, p. 18, March, 1932.
The lacquer vehicle in which the white or colored pigment is ground consists of a nitro-cellulose or a gum dissolved in some highly volatile solvent such as alcohol, benzol, acetone, etc. The residue must be highly resistant to abrasive action.

29. "White Mortar Bands Mark Highway Traffic Lanes." Engineering News-Record, v. 109, no. 19, p. 553, Nov. 10, 1932.
Inlaid strips of white mortar replace painted traffic lines. This account covers the materials and the construction procedures for white concrete inlays and curb surfacing. The materials are white cement, white shiny sand and diatomaceous earth.

1934 30. Bryson, H. C. "Road Marking Paints." Paint, Col., Oil, Varn., Ink, Lacquer, Manu., v. 4, p. 205, 1934.
Good road-marking paints may be made from sodium or calcium caseinate combined with latex in the presence of a stabilizer, with or without a drying oil and containing a fairly high proportion of lithopone, or yellow chrome. Faster drying paints with less hiding power may be produced from spirit solutions of lac, gum copal or the like.

31. "Galvanized Steel Channel Forms Traffic-Lane Marker." Engineering News-Record, v. 112, p. 640, 1934.
A novel, permanent traffic lane marker, forming an integral part of a special light-weight steel and asphalt floor, has been used on the new Dorer Bridge. The marker consists of a heavy weight, 3-in., galvanized-steel channel, laid toes down and arc-welded to the high channels of an interlocking steel channel floor deck.

32. "Raised Center Stripe Used on Mississippi Roads." Public Works, v. 65, p. 14, Nov., 1934.
The raised center stripe is composed of aggregate (crushed stone, gravel, or slag) bound to the surface with a bituminous binder and is applied in one operation. It is 3/8 in. thick and 3-in. to 8-in. wide. A machine is used to do the work.

33. Williams, A. "Rubber Traffic Markers." India Rubber World, v. 90, no. 42, Sept., 1934.
A description is given of molded rubber blocks which are to be used for traffic markers in rubber block pavements. They are also adaptable for use with granite or wood blocks or in asphalt pavements.

1935 34. Martin, G. "Machine Capable of Painting 15 Miles of Stripes Per Day." Engineering News-Record, v. 114, p. 391, March 14, 1935.
This machine, capable of painting 15-mi. of stripes per day, is pushed by a truck. This truck carries the compressor and the paint tanks.

35. Schnell, W. G. "Luminous Highway Paint." Am. Paint Journal, v. 19, no. 23, pp. 52-53, 1935.
The use of luminous paints containing radioactive ingredients for traffic signs on roads is suggested. A new process for obtaining concrete paint preparations from American radioactive minerals will probably render this economically possible.

36. Smith, W. A. "Traffic Striping in California." Roads and Streets, v. 78, pp. 391-3, Dec. 1935.
This is an account of the machines, methods and materials used for striping in California. Specifications are given for a white traffic line marking lacquer that is in use.

1936 37. "Striping Adds Safety to Highways in California. - Review of California Practice Including Equipment, Tests & Paints." Western Constr. News, v. 11, no. 6, p. 198-200, June, 1936.

A review of California practice, including a brief history of traffic striping in California, and a description of the equipment used. A composition specification based on a natural resin vehicle is given, together with test requirements.

38. Sweatt, J. H. "A Machine for Testing the Wearing Qualities of Paints." Maine Tech. Exp. Sta., Univ. of Maine, paper No. 19, June, 1936.

The machine consists essentially of a circular table of concrete to which the traffic paints being tested are applied. This surface is rotated against a tire which functions as an abrading wheel. Power is applied from a $\frac{1}{2}$ H.P. motor by means of a wheel with a tire that serves as one of the supporting bearings for the table.

39. "Traffic Striping in California." Roads and Streets, v. 79, p. 66, March, 1936.

A new type of highway marking in California uses reflector buttons. These are Ross traffic markers and are a non-corrosive metal housing hardened to withstand traffic and so designed that they present no hazard to vehicles passing over them.

1937 40. "Centerstriping Machine Built in Nevada State Highway Department." Contr. & Engr. Monthly, v. 34, no. 2, pp. 1 & 11, February, 1937.

Describes the specification for a special striping machine built by Nevada State Highway Department. Machine is automotive type rear-wheel-drive unit — 94 in. wheelbase and a maximum width of 50 in. Cruising speed of 45 mi. per hr. - paints at 4½ - 5½ mi. per hr. Paint tank holds 65 gal. Spray head assembly is of special design and is non-clogging and self-cleaning.

41. Hickson, E. J. "Some Properties and Tests of Traffic or Zone Paints." U. S. Bur. Standards, Jn. of Research, v. 19, pp. 21-30, 1937: Also, Nat. Paint, Varn. & Lacquer Assoc., circular 532, p. 156, April, 1937.

The article includes the following:

1. Characteristics of the paint are heavy pigmentation, quick-drying, etc.
2. Road exposure tests on eight different types of paints.
3. Machine for accelerated wearing test with photos, description, and method of use.
4. Specification for white traffic paint including the constituents and the results of tests.
5. Specifications for yellow traffic paints.

42. MacGregor, J. "Balto. P.V.P.C. Hears MacGregor on Paints." Oil, Paint & Drug Rep., v. 131, p. 25, May 10, 1937.

In discussing the visibility and durability of highway paints Mr. MacGregor recommended the use of white pigment for the most visible surface and the use of active pigment for the better wearing paint film. The phenomenon of paint failure is caused by the liquid solidifying through gelation and then shrinking.

43. "Modern Equipment for Painting Stripes on Highways." Comp. Air Mag., v. 42, p. 5426, Sept., 1937.

California's highway striping machine paints stripes at the rate of 2 mi. per hr. It is capable of painting a single or a double 4-in. stripe.

44. Nelson, H. A. and Schmutz, F. C. "Accelerated Laboratory Service Tests and Their Possible Use in Specifications for Highway Paints." Repr. Proc. 14th Annual Meeting, Assoc. of New England & N. Y. Res. Engrs., pp. 179-183, 1937.

An evaluation of accelerated weathering tests revealed that these performance tests produce worthwhile results but also have distinct limitations which should be considered before incorporating the tests into highway specifications.

1938 45. Broome, D. C. "Use of Colored or Decorative Asphalt for Roads and Bridges." Journal of the Society of Chem. Industry, v. 57, p. 99-106, 1938.

The mixtures discussed are grouped under headings of mastic, rolled, and rock asphalt; materials in which the principal decorative effect is obtained by the use of colored aggregates, traffic sign mixtures, and paints. Stress is laid on the importance of the bitumen and the pigment employed, and reference is made to the measurement of color, both of the bitumen and of the finished mixture.

46. "General Iron and Steel Corp. Zone Marking Machine." Roads and Streets, v. 81, p. 66, Dec., 1938.

A new zone marker will paint 2-in. to 8-in. width traffic marks. It is a one man machine. Pressure for painting is obtained by pumping the paint with a specially designed pump driven by a 1 H.P. gasoline engine. There are no gages or release valves. The action is simple and positive.

47. Greeves-Carpenter, C. F. "New Reflector Type Curb." Public Works, v. 69, p. 9-10, March, 1938.

Of all the types constructed, it was found that one which had small recesses or reflecting facets was markedly superior. The depth and angle of these reflecting facets naturally determines the degree of visibility created. Two designs were adopted for trial; one, having a wedge-shaped indentation, is particularly effective for use in central dividing strips where traffic parallels the curb; the other is a block type so designed that all faces of the indention are so sloped as to give the maximum reflecting value.

48. "Growing Use of Concrete in Marking Highways." Concrete, v. 47, no. 28, Aug., 1938.

The pigments most suitable for colored concrete are certain metallic oxides, notably those of iron, chromium and manganese, and a few other inorganic materials such as ultramarine and lamp black.

49. Hall, H. W. "Improving Paints, Lacquers and Varnishes by the Use of Diatomaceous Silica." Paint, Oil & Chem. Rev., v. 100, no. 8, pp. 16, 18-20, April 14, 1938.

High quality, carefully-processed diatomaceous silica has a definite place in modern paint, varnish and lacquer production as evidenced by its present day consumption in the industry. Manufacturers recognize the merits of this type of material in formulas for traffic paints and other semi-gloss finishes.

Adoption of traffic paint specifications by a number of states which specify diatomaceous silica in the formulas, also indicate its worth in surface coatings.

50. "Luminous Markings for Highways." Canadian Engr., v. 75, p. 18, Aug. 2, 1938.

Report of a demonstration of "Spectru-Lite" (glass beads applied to paint). Article comments on good visibility obtained and high abrasion resistance of final product.

51. "New Centerline Machine." Roads & Streets, v. 81, p. 64, Dec., 1938.

This machine employs Kelley-Creswell air curtains which maintain straight edges on the traffic line by means of a current of compressed air. This results in the elimination of heavy-edged lines.

52. "Reflecting Traffic Lines." Roads & Streets, v. 81, p. 98, March, 1938.

A coating of glass beads, approximately 0.015-in. in diameter were dropped onto the freshly marked traffic line. It is claimed that the binder compound is not effected by the ultra violet rays because of its chemical components.

53. Reindollar, R. M. "Safety Features Provided Through Pavement Markings." Roads & Streets, v. 81, no. 4, pp. 76-78, April, 1938.

Describes a new type of striping machine that is expected to paint 40 mi.

1938 of road per 8-hr. day. The paint is applied by air pressure, with the unit moving approximately 9 mph.

54. Rogers, E. M. "Inexpensive Traffic Marking Paints." Am. Paint Journal v. 22, pp. 14, 16, 56, 58, May 16, 1938. (Scientific Section, Nat. Paint, Varn. and Lacquer Assoc., Inc., Abs. Rev. N. 57, Jan., Feb. and March 1939).
Formulas given in the state specifications of New Jersey, Illinois, California, Montana, Missouri, Pennsylvania, Vermont and New York are reported. A number of the specifications call for a natural resin e.g. copals.

55. "Saylor-Beall Traffic Line Machine." Roads & Streets, v. 81, p. 74, Oct., 1938.
This machine is capable of laying down 4 mph. A dual spray attachment is available for parallel lines. The complete outfit weighs 150 lb.

56. "Some Efforts to Increase Safety of Night Driving; Luminous Traffic Lines, Reflector Buttons." Roads & Streets, v. 81, p. 48, Aug., 1938.
"Refractolite" binder compound (like paint) is applied to the highway as a traffic line. These glass spheres reflect light to the driver and make the stripe visible for several hundred feet.

57. "White Terra Cotta for Tunnel Road Markers." Brick & Clay Rec., v. 92, p. 12-13, Jan., 1938.
The centerline road markers for a new tunnel are a permanent white, vitreous terra cotta body. Terra Cotta is also used for the side wall below the safety walk.

58. Zinzer, A. L. "Centerline Paint Formulation (for Roads)." Am. Paint Journal, v. 22, no. 17, pp. 26-27, 54-9, Jan. 31, 1938.
Many factors influence traffic paint performance other than paint composition itself. Actual road exposure tests always should be directly comparative with a paint of known composition and performance characteristics, bearing in mind that the road surface is continually changing in character.
It is not economical for a highway department to purchase traffic paint with regard to low gallon price alone. The cost per mile per year must be considered.

1939 59. Barker, W. E. "Rubbed in Traffic Stripes; Pigment Rubbed into Scratched Fresh Concrete." Eng. News, v. 122, no. 107, Jan. 19, 1939.
Pigment rubbed into scratched fresh concrete forms an indelible traffic line. The pigment is rubbed into the top 1/8-in. of finished fresh concrete which is roughened to mix with the color and then is troweled smooth. This practice has been used on recent Texas roads.

60. **Bhattacharya, R.** "Shellac for Road Paints." Oil & Color Trades Journal, v. 96, p. 965, 1939.
A high quality oil-bound distemper produced from shellac (formula given) when tested on bitumen road surfaces lasted for more than two months. This paint dried on a frosty morning in 15-30 minutes.

61. "Colored Concrete for Marking Traffic Lines." Canadian Engr., v. 76, p. 22, May 16, 1939.
Taken from Highway Research Abstracts. A discussion of the general properties of colored concrete, the pigments used and the effect of these pigments on the time of set and the strength.
Pigments used are metallic oxides, especially iron, chromium, and manganese, and a few other inorganic materials such as ultra-marine and lampblack. German investigations in 1936 and 1937 showed variable behavior in time of set, some pigments causing acceleration and other retarding. The strength ratios were not affected beyond experimental error. The surface of the colored concrete may become obscured by efflorescence. This can be reduced by using cement which is thoroughly burnt and well matured and by attention to clearness of the sand and purity of the water.

1939

62. Gardner, H. A. "Physical and Chemical Examination of Paints, Varnishes, Lacquers & Colors." Institute of Paint & Varnish Research, Wash., D. C., 9th Ed., p. 44, 1939.

P. H. Hamilton reports the results of tests which indicated that panels painted with aluminum paint were hardly visible when viewed by the light of an automobile headlight 75 yd. from the panels, with the panels placed at angles of 30 deg. to the source of light. White paint because of its chalking characteristics sometimes increases in reflective value, whereas aluminum paints may become soiled by the accumulation of dust and gradually become lower in reflective value.

63. "How Colored Concrete Traffic Lines are Placed into Pavement." Concrete, v. 47, p. 30, March, 1939.

Traffic stripes are formed by working mineral oxide in yellow and black into the finished concrete to a depth of $\frac{1}{4}$-in., and hand floating to finish the stripe.

64. Maddox, F. S. "Center Striping; District 15." Texas Information Exchange, no. 73, p. 33, July 15, 1939.

Describes use of a split 4-in. paint brush attached to striping machine to prevent the splashing of paint underneath the runners of a small striping machine on open and rough pavements. Several illustrations.

65. "New Type of Road Paint Now Used in Quebec." Commerce Reports, p. 1132, Dec. 2, 1939.

One paragraph news note concerning use of a traffic paint containing ground glass. The new paint was reported to be more durable than ordinary paint.

66. "Permanent Lane Markers." Am. City, p. 49, Oct., 1939.

The construction of double line markers of white cement and asphalt is discussed. Sketches of the construction are shown.

67. Root, R. "Black Traffic Stripes Made of Asphalt Mastic." Engineering News-Record, v. 122, p. 563, April 27, 1939.

A traffic stripe of asphalt mastic about 7/8-in. thick has shown good service in a trial installation at Des Moines, Iowa.

68. Sawyer, J. S. "Specifications for Constructing Colored Asphalt Traffic Lines." Public Works, v. 70, no. 10, pp. 20-21, Oct. 1939.

Specifications call for the markers to consist of sand and pigment mixed with "albino" asphalt. In addition the necessary equipment and detailed directions for construction are presented. Development of the Shell Oil Co.

69. Schafer, N. F. "Marking Traffic Lines." Engineering News-Record, v. 122, p. 400, March 16, 1939.

A description of the marker used on Indiana highways is given. A heavy cutback asphalt is used on all types of surfaces. Work done when the temperature is below 40 deg. F. and when the pavement is dry is easier because no cover material is required under these conditions.

70. Shuger, L. "Traffic Paint." Drugs, Oils & Paints, v. 54, pp. 343-44, 346, 414-416, 418, 420, Oct., Dec., 1939; v. 55, pp.12-15, 126, 128-130, 229-232, 378, 380, 382-84, 385, Jan., April, July, Nov., 1940. In 1940 became The Paint Industry Magazine.

Oct. '39: Essential requirements of a traffic paint-methods of test; good package characteristics, proper drying characteristics, short pick-up time, settling, consistency, drying time and visibility are discussed.

Jan. '40: Continuation; hiding power, color retention, and bleeding.

Dec. '39: Continuation; flexibility, abrasion resistance, comparison of road rating to laboratory rating (U.S. Dorry Hardness Abrasion Loss).

April '40: Comparison of present state highway traffic paint specifications.

Composition and requirements for: I. Color, II. Percent pigment in paint;

1939 III. Composition of pigment, IV. Percent non-volatile in vehicle, V. Composition of vehicle non-volatile, VI. Added thinners, VII. Composition of Solvent, and VIII. Oil length.
July and Nov. are continuations.

71. Stalnaker, R. H. "Evolution of the Striping Machine." Calif. Highways and Public Works, Oct., 1939.
A new stripe marking machine has been designed for use in the Division of Highways. Changes in construction include additional capacity, wider range of vision for the driver and an additional tank for yellow paint for use on double line work. Descriptions and photographs of previously used striping machines are included.

72. "Striping for Safety; How It's Done the Country Over." Better Roads, v. 9, no. 4, pp. 33-36, April, 1939.
Description of the equipment used by different highway departments. Odd elongated trucks, hand-pushed carts and 4-wheeled carriages are used in applying traffic lines.

73. "Traffic Paint Formulations." Natural Resins Handbook, p. 91, Am. Gum Importers Assoc., Brooklyn, New York, 1939.
Traffic paint formulations taken from governmental specifications over a wide range of states have been tabulated. All of these formulations have been brought to the same basis.

74. Waters, C. R. "Lane Marking by Broken Lines Placed Automatically by Regular Paint Striping Machine." Roads and Streets, v. 82, pp. 37-38, Dec., 1939.
Describes a mechanism which may be attached to a regular paint striping machine. It provides for the automatic placing of dash lines.

75. Wells, C. D. "Permanent Traffic Stripe on Concrete Pavement." Texas Information Exchange, Texas Highway Department, no. 78, p. 9, 1939.
This article describes procedure for constructing a permanent center stripe in fresh concrete pavement using a dry powder of black magnetic oxide of iron. Illustrations and description of a construction bridge used to cut fresh concrete and from which iron oxide is applied are included. A brief discussion of experimental stripes using orange and red iron oxide with 8 to 10 mesh glass beads is included also.

76. "White Center Line in Ancient Highway in Mexico." Concrete, v. 47, p. 31, May, 1939.
Describes a center line of light colored stones on a section of Mexican highway over 350 years old.

1940 77. "Armor-Flex, New Type Traffic Marker." Roads and Streets, v. 83, p. 89, Sept., 1940.
A plastic marker, 1/8-in. thick, is described that is applied with a special bituminous cement to any type of road surface.

78. "Barford Road Line Marker." Engineer, v. 169, p. 167, Feb. 16, 1940.
Paint carried in the container is gravity fed to the marking roller through rubber tubes connected to the distributor header. When the paint-applying roller is lifted clear of the road, paint control bars fitted across the feed tubes come into operation and the flow of paint is stopped.

79. "B.M.B. Engineering Companies Safety-Line Marking Machine for Roads and Factories." Engineering, v. 150, p. 487, Dec. 20, 1940.
This machine has 3 wheels and is pushed by a man. The paint spray is operated by a pump driven by a four-cycle air-cooled 3/4-horsepower engine.

80. Bryson, H. C. "The Use of Chlorinated Rubber and Diatomaceous Silica in Road Paint." Paint Tech., (London) v. 5, pp. 86-87, 1940.
It is difficult to find a paint capable of withstanding the alkaline salts of the concrete and the aromatic solvents present in coal tar. Casein-based

1940 water paints dry too slowly so the types generally used are cold-cut resin solutions, both natural as well as modified phenolic, coumarone, ester gum and "100 percent phenolic" resins.

Chlorinated rubber is capable of high pigmentation while being resistant to alkaline attack and abrasion.

The use of diatomaceous silica containing a high proportion of spicules gives a high matting effect, decreases drying time and almost doubles the amount of light diffused under night driving conditions.

81. "Experience of Cities with Painted Traffic Lines." Am. Public Works Assoc., Bull. No. 4, Chicago, Ill., Aug., 1940.

The information in this bulletin has been compiled as a result of numerous inquiries which the Association has received concerning painted traffic lines. The bulletin assembles, in convenient form, information on the experience of cities with traffic paint, including durability, frequency of painting, and other pertinent factors.

Specifications in use in six cities are included as well as information on road exposure tests.

82. Hamilton, Russell D. "Traffic Paint Formulation is a Live Subject; Discussion Continued." Paint, Oil and Chem. Rev., v. 102, pp. 24, 26, Sept. 26, 1940.

The failure discussed here is a vehicle deterioration forming a white film which is very unsightly over a dark colored enamel. This whitening is caused by exposure first to sunlight, then to moisture. On white or light color no bad appearance is noticed; however for darker shades appearance is very unsightly. It is concluded that Manila D.B.B. cannot be used satisfactorily for the darker shades of traffic paints.

83. Haufe, K. "The Stability of Concrete Road Marking Sign Paint." Kurt Haufe-Asphalt Teer Strassenbautech, v. 40, pp. 447-54, 1940, Nat'l Paint, Varn. & Lacquer Assoc., Abs. Rev., no. 83, p. 116, 1944.

Tests are described comprising road application, resistance to cold, heat and water; the Reich Auto Bahn paint-testing machine, the Graf test machine, and the Freilager test, with test forms, details, data and illustrations.

84. "'Invicta' Traffic-Line Marking for Roads (Machine by Aveling-Barford, Lt'd.)" Engineering, v. 149, no. 3867, p. 209, Feb. 23, 1940.

This is a hand marking machine, very small and compact, that is pulled along by a handle.

85. "Kelley-Creswell Traffic Striping Machine." Roads and Streets, v. 83, p. 91-92, Sept., 1940.

This machine is designed to mark 1, 2 or 3 stripes at a time using one or two different colors. Intermittent dot-dash striping may be applied.

86. Kesting, B. G. "Permanent Traffic Lines for Concrete Pavements; Use of Black Magnetic Iron Oxide for Coloring." Public Works, v. 71, no. 42, Sept., 1940.

A stripe 6-in. wide and embedded to a depth of 1/8 to ¼-in. is used. Specifications call for the coloring material to be magnetic oxide of iron, or ferrosoferric oxide, made by a process of chemical precipitation so as to form a pigment of uniformly small particle sizes.

87. Kopf, C. W. & Mantell, C. L. "Traffic Paints." Paint, Oil & Chem. Rev., v. 102, pp. 7-8, 28-30, May 23; pp. 44-46, 48-49, June 6; pp. 9-11, 24-27, July 4; pp. 10-11, Oct. 24, 1940.

I. Natural resins in quick drying traffic paints: Natural resins, because of their own low cost and their solubility in cheap solvents, are fitted for traffic paint use and have found wide acceptance. This report includes a discussion on desirable properties, on colors, on California vehicle formula, natural resins in traffic paints and a summary of formulations.

II. The effect of Chinawood and other oils in quick drying vehicles: Different paint formulations were used on test stripes on a bituminous surface

1940 along the Brooklyn waterfront and on a concrete highway. The application on asphalt was made to determine the effect of bituminous roads on the color of paints. This discussion on durability is based solely on the results from the concrete road tests while the color was from both applications.

III. Formulations and performance tests of quick drying vehicles, with photographs: The addition of asbestines makes better paint.

88. Meyers, J. E. "Survey of Traffic Paint Testing Procedures." Highway Research Abstracts, pp. 6-8, March, 1940.

There has been increased interest in laboratory and road tests that might be standardized and give accurate information about the service life of paint and laboratory scale road tests.

Questionnaires were sent out on November 20, 1939, to the representatives of 51 state and city organizations as to the type of work and tests they perform. Fifteen had been returned and the results are given here.

89. "New Multi-Stripe Road Marker Used by Nevada State Highway Dept." Comp. Air Mag., v. 45, p. 6243, Sept., 1940.

This machine is capable of painting three stripes simultaneously. It is a small vehicle pushed in front of a truck, and is capable of painting a white center stripe with a yellow stripe on each side.

90. "Paints for Traffic Line." Highway Research 1920-1940, Highway Research Board and American Association of State Highway Officials, Washington, D. C., pp. 107-9, 1940.

An annotated list of research projects conducted or initiated during the period 1920-1940 on the subject of traffic paints. Studies include abrasion testing, performance tests, paint formulation, etc.

91. Skett, A. and Holzberger, J. H. "Preliminary Study of White Traffic Paints." Am. Paint Journal, v. 24, pp. 18-19, 22, 24-25, April 22; pp. 18, 20-22, 65-69, May 6, 1940. (Scientific Section, Nat. Paint, Varn. and Lacquer Assoc., Inc., Abs. Rev. No. 62, p. 60, April, May, June, 1940.)

Part I. Three series of paints were made up. Each series contained different forms of natural resin. The paints were applied in a transverse manner on a road in a stripe 6 in. wide and 10 ft. long. Six ounces of paint were used on each stripe. All three series were brittle due to insufficient plasticizing.

Part II. Linseed, blown soybean, bodied perilla, oiticica, bodied fish, dehydrated castor and blown castor were used in an attempt to plasticize a paint using Manila resin as a base. Blown castor proved best, dehydrated castor and bodied fish oil next, linseed, soybean and perilla intermediate, and oiticica definitely inferior. Addition of gum elemi had no effects upon the basic formula. The pigment - binder ratio was varied and the optimum pigment volume was 35 - 40 percent. A tung oil to resin ratio 2:8 or a little better is about optimum. Titanium-Calcium pigment gave the best results of the pigments used. Thermally processed Batu scraped is the resin used. Traffic paints of equal performance can be made with spirit type vehicles as with cooked vehicles.

92. Stanton, T. E. "Traffic Paint Article by Kopf and Mantell Stirs Interesting Discussion." Paint, Oil and Chem. Rev., v. 102, pp. 15-16, Aug. 1, 1940.

Stanton defends the California traffic paint formula against criticisms by Mantell and Kopf. Stanton disagrees that castor oil is superior to Chinawood oil as a plasticizer. California tests showed that in addition to inferior durability, castor oil was found to be slower drying and to possess a higher gloss when fresh. The California procedure for manufacture of traffic paints is given.

93. "Traffic Painting in St. Louis." Public Works, v. 71, no. 6, p. 30, June, 1940.

A special paint machine which has resulted in savings in labor costs and in paint used has been put into use in St. Louis. This paint machine instead of marking a single 6-in. stripe, marks 3 stripes, each 1½-in. wide with a 3/4-in. spacing between.

1940 94. Waters, C. R. "High Speed Highway Lane Marking With Automatic Device for Dash Lines." Public Works, v. 71, p. 34-36, May, 1940.
This machine puts down solid or broken lines, two-color if desired, one or more lines, 20 to 40 mi. per day. Description and operation of equipment is given.

1941 95. Bloom, S. A. "The Place of Chemistry in Highway Materials Control." Highway Builder, pp. 4-7, 17, June, 1941.
A discussion of method of tests and testing problems related to various highway materials. The discussion on traffic paint includes a list of desired properties of the paint, also the necessity for a sand-paper texture for visibility is shown. The difficulties in measuring durability because of the many variables are discussed. The proper design of test instruments to correctly evaluate reflector buttons is also covered.

96. Bryson, H. C. "Road Paint." Oil & Color Trades Journal, v. 99, p. 175, 1941.
Spirit-soluble Manila copal gums are widely used in road marking paints. Spirit-soluble ester gum is cheap, possesses a uniformity beyond any natural product and has excellent resistance to water and to discoloration by light and tar products. Solvent-retention characteristics are overcome by the addition of a high viscosity ethyl-cellulose solution. The wear factor is considerably increased. A formula is included.

97. "Colored Lane Speeds Traffic on Mountain Highways." Concrete, v. 49, p. 4, Jan., 1941.
Red oxide was added to portland cement in Tennessee and Kentucky to color an extra truck lane on long grades.

98. Corder, Leon W. "Center-Striping Missouri Highways." Better Roads, v. 11, no. 3, March, 1941.
Missouri practice of traffic striping is a state-wide program. Describes equipment used for striping, method of laying the stripe, types of paint used and the author's ideas on the future development in traffic painting.
Missouri is conducting experiments on the use of ester gums and alkyd resins as substitute for natural gums.

99. Edelstein, Edwin. "Zinc Resinate Traffic Paints." Paint Industry Mag., v. 56, pp. 347-48, Oct., 1941.
Twenty or more paint formulations using cheap zinc resinates were tried in service. Included in each group of paints was one made according to specifications quite commonly used by various State Highway Departments.
Listed are three complete formulations that are now in use with suggested modifications.

100. Glanville, W. H. "Plastic White Lines for Roads." Roads & Bridges, v. 79, no. 12, p. 48, 1941.
A description of the British development of a thermo-plastic material to be used as an alternate to traffic paint. Details of the composition, grading, and manufacture of the plastic material are given. The material is recommended only for open and medium-textured bituminous road surfaces which must be clean and dry. Preliminary tests indicate that a useful life of at least six months may be expected. (This article is essentially the same as that appearing in Commonwealth Engr., v. 29, no. 5, pp. 120-121, Dec. 1, 1941 under the same title).

101. Goetz, W. H. "Field and Laboratory Investigation of Traffic Paints." Proc. Highway Research Board, v. 21, pp. 233-259, 1941.
Only durability of traffic paint is considered. Object of study was to establish a correlation between field performance and laboratory tests and to determine the characteristics of the paint film necessary to good durability on the road. Samples of traffic paints tested represent the specification material of eight different states. Old concrete, new concrete and bituminous surfaces were used. Special attention has been given to abrasion and flexibility tests.

1941 102. Herbert, M. S. "Some Effects of Pigmentation upon the Durability of Traffic Paints." Am. Paint Journal, v. 25, pp. 14, 18, 20, 24, 58, 60, Aug. 11, 1941. (Scientific Section, Nat'l Paint, Varn. and Lacquer Assoc., Abs. Rev. No. 68, p. 228, Sept. and Oct., 1941).

Consumption of traffic paints is constantly increasing. Tests were conducted by painting cross-lines on roads where the traffic was from 1,800 to 5,700 cars per day. The paints were applied by a Line-O-Graph on a smooth stretch of road. The consistencies of all paints were determined before use. The study was divided into four parts; effect of inert extenders, effect of pigment volume, effect of white prime pigments, and effect of colored pigments. Results have shown that with proper pigmentation the modified California lacquer, which contains no China Wood oil, has good durability characteristics. The durability of 12 specification traffic paints which were used as controls was generally inferior to that of the experimental paints.

103. Mantell, C. L. and Kopf, C. W. "Traffic Paint." Paint, Oil & Chem. Rev., v. 102, no. 22, pp. 10-11, Oct. 24, 1940. (Nat'l Paint, Varn. & Lacquer Assoc., Abs. Rev., no. 64, p. 2, 1941).

The writer adds another chapter to the forum on traffic paint formulation by answering an open letter relative to the use of Manila DBB gum in traffic paint.

104. "Marking Highway Lanes with Stone Chips (Stones Sealed with Asphalt)." Engineering News-Record, v. 127, pp. 27-8, July 3, 1941.

Stripes of contrasting stone chips are being used in experiments in lane marking on highways in Texas and South Dakota. These stripes may be applied at low cost and have been found to show up well in all kinds of weather.

105. Mattiello, Joseph J. "Protective and Decorative Coatings." John Wiley & Sons, Inc., New York, v. 1, p. 239, 1941.

The Manila resins are widely employed in traffic paints, of which a typical formulation is given. These traffic paints dry to a semi-gloss finish in half an hour or so to form hard surface films which resist abrasion by the wheels of vehicles, do not pick up in traffic, and withstand a wide range of climate, weather conditions and temperature changes.

106. O'Brien, M. A. "Tiny Glass Beads Used to Make Traffic Lines Brighter at Night." California Highways & Public Works, v. 19, no. 1, p. 16, 1941.

The process of placing glass beads in traffic paint has proved successful in making the striping brighter and more effective at night. Manufacturer's claims are that use of beads approximately doubles the life of the painted lines. A method of application is described and photographs are included.

107. O'Brien, M. A. "Improving Night Time Visibility of Traffic Lines - California." Roads & Road Constr., v. 19, pp. 102-103, 1941.

A report of California experiments with glass beads on traffic paint. Good reflection is obtained and the beads are cleaned by traffic. The higher costs of application and cost of beads limit their use to special cases.

108. "Plastic White Lines for Roads." Commonwealth Engr., v. 29, no. 5, pp. 120-121, Dec. 1, 1941.

A description of the British development of a thermo-plastic material to be used as an alternate to traffic paint. Details of the composition, grading, and manufacture of the plastic material is given. The material is recommended only for open and medium-textured bituminous road surfaces which must be clean and dry. Preliminary tests indicate that a useful life of at least six months may be expected.

(This article is essentially the same as that printed under the same title - by W. J. H. Glanville, in "Roads & Bridges," v. 79, no. 12, p. 48, 1941).

109. "Research on Marker Paint." Roads & Bridges, v. 79, p. 25, Oct., 1941.

Editorial comment on the advantages of glass beads in traffic paints and a description of its wide usage in Canada. The need for additional research to develop more rapid drying time and bead-holding properties is cited.

1941

110. Schafer, N. F. "Centerline Marking on Indiana's Pavements (Stones Sealed with Asphalt)." Public Works, v. 72, no. 2, pp. 17-18, Feb., 1941.

Black and white traffic lines are discussed. Brief specifications are given for applying the lines with cutback asphalt on light colored surfaces and for white marks on black surfaces.

111. Skett, A. and Herbert, M. S. "Accelerated Testing of Traffic Zone Paints." Proc. Highway Research Board, v. 21, pp. 223-232, 1941.

The purpose of this investigation was to determine the practical value of laboratory tests used at the present time to evaluate the actual durability of traffic paint under service conditions. Nine paints were used in the investigation; - 6 white and 3 yellow. Eight laboratories cooperated in laboratory tests. Paints were applied to 12 localities for service tests. General conclusion drawn was that no one laboratory test, or combination of laboratory tests is sufficient to evaluate correctly the relative durability of traffic paints.

112. Skett, A. and Holzberger, J. H. "Progress in Natural Resin Research." Am. Paint Journal, v. 26, pp. 7-9, 60, 62, 64, June 2; pp. 56-59, June 9; pp. 18, 20, 22-23, 26, June 16, 1941; Fed. of Paint and Varnish Production Clubs Official Digest, no. 207, pp. 346-361, 1941.

This work is concentrated on cold cut varnishes. The formulation of the best white Manila spirit paint thus far found is given. It is superior to cooked vehicles in color, color retention, drying, non-bleeding properties, ease of manufacture, and lower in cost.

Among the cooked paints very little difference is shown in durability between Batu, Pale East India, and modified phenolic.

Blown castor oil is superior to china wood, dehydrated castor, fish, soya and linseed oil in the Manila paints, but poorest with Batu and Pale India resin. The most promising oils with these latter resins seem to be dehydrated castor, china wood and fish.

113. "Texas Improves Traffic Stripe (Stones Sealed with Asphalt)." Roads & Streets, v. 84, p. 54, June, 1941.

This stripe is built up to about 1/4-in. thick. Small black stones are spread into the asphalt stripe on concrete surfaces. It is non-skid, non-glaring and its visibility is good.

114. "Traffic Lines." Sci. Am., v. 164, p. 298, May, 1941.

Method used in California to increase the effectiveness of the traffic stripe after dark utilizes glass spheres or beads. These reflect headlight beams and hence make the traffic stripe more visible.

To apply the beads, a bead dispensing machine is placed directly behind and approximately 18 in. away from the spray nozzle.

115. "Traffic Paints." New Jersey Zinc Co., Paint Progress, v. 2, no. 4, p. 8, Oct., 1941.

Highway departments have been considering raw materials such as Batu (natural) resin, zinc resinate, and combinations of ester gum with dehydrated castor oil, oiticica and other oils for use in traffic paints. In order of durability, the best two white formulations of this type at the present time are a 50:30:10:10 titanated lithopone-zinc oxide-mica-magnesium silicate pigment combination in a cooked Batu resin-linseed oil vehicle, and the same pigment combination in a "cold-cut" Batu resin-processed oil vehicle.

116. "Traffic Paint Substitute (Soybean Oil)." Engineering News-Record, v. 127, p. 881, Dec. 18, 1941.

Soybean oil has been substituted for tung oil in traffic paints. Experimenters think it will prove a very satisfactory substitute.

117. "Trends in Traffic Stripes; Advances with Zinc Pigments." New Jersey Zinc Co., Paint Progress, v. 2, no. 3, pp. 6-8, July, 1941.

Traffic paints must be fast drying. To obtain this the paint chemist must pigment his product high and decrease the non-volatile constituent of

1941 the vehicle. The vehicle is most often manipulated to meet varying climatic conditions and "non-bleeding" requirements.

In the final analysis, the object is a paint having satisfactory durability and economy. For this reason, the zinc sulfide pigments - lithopone and titanated lithopone have been widely used.

118. Wells, C. D. "Permanent Traffic Stripe in Fresh Concrete." Concrete, v. 49, p. 6, July, 1941.

In Texas, placement of a permanent stripe by incorporating magnetic black iron oxide in the freshly placed concrete has been practiced. Three pounds of oxide were found necessary per 100-ft. length. The equipment and procedure for applying the stripe are discussed.

1942 119. Cullimore, W. H. "Modern Brick Pavements - A Review of Recent Practice and the Development of Centerline and Traffic Lane Markers." Roads & Streets, v. 85, no. 1, pp. 49, 52-53, Jan., 1942.

The installation of permanent brick lane markers of clearly contrasting color insures the engineer of full utility of the street width between curbs. Brick may be used effectively as permanent lane markers on other type pavement surfaces.

120. "805 Paints in New Jersey Zinc Traffic Paint Testing Program." New Jersey Zinc Co., Paint Progress, v. 3, no. 3, pp. 2-3, Oct., 1942.

Paints have been applied in many localities and on many types of roads. The majority of tests have been on concrete highways in Pennsylvania. The paints fail more rapidly and show greater differences between good and poor paints on concrete surfaces.

The results of these tests have been shared with paint manufacturers and consumers, and have contributed to the development of new and improved paint finishes based on zinc sulfide and zinc oxide pigments.

121. Flocks, K. "Paint for Traffic Control. 1941." U. S. 2, 232, 023 Nat'l Paint, Varn., & Lacquer Assoc., Abs. Rev., no. 71, p. 42, 1942.

A discussion on the use of fine glass rods embedded in painted road lines. There is a great increase in night visibility.

122. Lotz, P. L. "Project No. 1 - Traffic Paints." (Consolidated report) Official Digest, Federation of Paint & Varnish Production Clubs, no. 212, pp. 4-9, Jan., 1942. (Scientific Section, Nat'l Paint, Varn. & Lacquer Assoc., Inc., Abs. Rev. no. 72, p. 90, July, 1942.)

Summaries of work by several Production Clubs on paints to camouflage roads are given. Formulae recommended include cold cut Manila, Batu or East India, cold cut resin, casein in oleoresinous vehicles.

123. Mantell, C. L. & Others. "The Technology of Natural Resins." John Wiley & Sons, Inc., New York, pp. 373-408, 1942.

I. A discussion of the desirable properties of traffic paints.

II. Table containing 39 traffic paint formulae from 26 states of the Union. These formulae use both oil and spirit vehicles.

III. Data on the formulation, and laboratory test results of several traffic paints.

IV. Photos showing different paints after having been on the road for a period of time.

124. Mitchell, R. A. "Glass Beaded Paint for Blackout Traffic Control." Engineering News-Record, v. 129, no. 20, p. 720, Nov. 19, 1942.

White paint surfaced with glass beads has been found superior to any other type of painted pavement marking. 500 miles of this type have been laid in Philadelphia and found to be very satisfactory.

Although glass-beaded paint costs more than twice as much as ordinary traffic paint, experience shows that it wears 4 to 5 times as long.

125. "Night-Time Visibility of Surface-Dressed Traffic Lines." Public Works, v. 73, no. 10, p. 22, Oct., 1942.

1942 Road Research Laboratory in Great Britain has been studying the production of white traffic lines by use of white or light colored stone chips held to the surface by tar or asphalt. The visibility of different size and texture stone chips is discussed.

126. Shisler, J. A. "Permanent Lane Markers at Canton." Engineering News-Record, v. 129, p. 221, Aug. 13, 1942.
The center marker strip is a solid line of marker brick formed by the overlap of two lines of the buff colored brick, while the intermediate marker strips are formed by laying a buff colored brick in every other row of bricks.

127. Shuger, L. and Rodli, G. "Marker (Prismo Holding Corporation)." Nat'l Paint, Varn. & Lacquer Assoc., Abs. Rev., no. 72, p. 93, 1942.
A reflecting pigment binder is described. This marker is said to have great durability and resistance to shock.

128. Shuger, L. and Rodli, G. "Road-Marking Lines." Nat'l Paint, Varn. & Lacquer Assoc., Abs. Rev., no. 74, p. 202, 1942. Leroy Shuger - U. S. 2,268, 537, Dec. 30, 1941; C.A. 38, 2743 (1942).
Lines are formed with the use of a reflecting binder comprising a pigment, a non-volatile oil, and a resin, with a series of autocollimating units such as small glass spheres partially embedded in the binder, the ratio by volume of pigment to non-volatile oil and resin being less than 50 percent. U. S. 2, 268, 538 relates to various details of laying similar markers.

129. Skett, A. and Holzberger, J. H. "Traffic Paint Studies - 1941." Am. Paint Journal, v. 26, pp. 56, 58, 60-61, March 16; pp. 51, 54, 56, 58-59, March 30; pp. 52-53, 56, 58, April 13, 1942. (Scientific Section, Nat'l Paint, Varn., Lacquer Assoc., Inc., Abs. Rev. no. 73, p. 167, August 1942.)
A study of a variety of paints exposed in three locations indicates that Batu resin in cooked varnishes is superior to modified phenolic. Tung oil gives the best durability, but linseed oil is almost as good. Batu spirit varnishes are almost as durable as cooked varnishes. Pigment formulas for Batu, East India and Manila spirit paints are recommended.

130. "Surface-Dressed Traffic Lines." Surveyor, v. 101, no. 2630, pp. 207-9, June 19, 1942; also, Roads & Road Constr., v. 20, no. 235, pp. 147-152, July, 1942.
White or light colored chippings are held to road surface by tar of bitumen.
The most important feature of the surface dressed line is that it shows to a better advantage at night. This is because the surfaced dressed line retains a rough textured surface which reflects light at night. Dimensions of the line, type of stone chippings, size of stone chippings, type and viscosity of binder and rate of spread of binder are discussed.

131. "Testing the Wearing Properties of Traffic Paints; Data of Interest Where Paint is Subject to Abrasion." New Jersey Zinc Co., Paint Progress, v. 3, no. 2, p. 2, July, 1942.
It is recognized that the major factor causing failure is the wearing, chipping, and abrasion action of traffic, rather than normal weathering. New Jersey Zinc Company's instrument for measuring abrasion resistance consists of multiple rubber discs set at an angle of ten degrees with a straight arm holding them. When these wheels are rotated, both a rotating and sliding action are obtained. A layer of sand supplies the abrasion factor.

132. "Traffic Paint, Exterior, White and Yellow." Federal Specification TT-P-115, April 29, 1942.
Paints meeting the specification must show wear properties equal to or better than white and yellow comparison paints that are given.

133. "Traffic Zone Paint." Roads & Bridges, v. 80, p. 118, March, 1942.
A summary of an investigation conducted by the Highway Research Board of Canada. Six white and three yellow paints were selected for study. Ten

1942 cooperators tested each of the samples by his own methods. The conclusions arrived at are given. The chief points brought out are that road-testing is the only reliable method for testing traffic zone paints; a laboratory abrasion test used by some cooperators gave good correlation if the average of a number of tests was used, but the need for modifications was apparent; flexibility tests as conducted showed striking lack of agreement indicating a need for more study on the methods of testing.

134. Waters, C. R. "The Production of Highway Signs and Marking of Highways in Peace and War." Proceedings of 18th Annual Convention, Assoc. of Highway Officials of the North Atlantic States, pp. 31-52, 1942.

A discussion of the methods and materials used for signs in the shops of the New York State Department of Public Works. Electrolytic processes for zinc coating are used since the zinc is not removed with the paint in case of sharp impact such as caused by bullets, stones, etc. Synthetic resin paints of the glycerol phthalate type are used for painting and the silk screen process is used for stenciling. For reconditioning removable signs the same procedure is used as for manufacture, but heavy cast iron signs of a permanent nature are reconditioned by spray painting in place.

For pavement markings a "pushmobile" is described which paints at approximately 15 mph. - for word messages a stencil and hand spray are used.

The three major types of traffic paints are listed i.e., the spirit varnish, the oleoresinous, and the lacquer. The extent of use for each of these is given. A report of tests to compare the service behavior of the California type (spirit varnish) paint with a New York paint which is specified on the basis of performance tests is given. These tests were inconclusive as to the relative durability but the California paint was superior for night visibility during the first two months after application and the California paint dis-colored less on bituminous surfaces.

A discussion of pavement markings and materials to be used under blackout conditions is included.

135. Wethan, Sidney. "Performance Tests as an Aid in Maintenance of Traffic Paint Quality." Fed. of Paint & Varn. Prod. Clubs. Official Digest, no. 213, pp. 75-93, Feb., 1942. Paint Industry Mag., v. 57, pp. 82, March, 1942. (Scientific Section, National Paint, Varnish and Lacquer Assoc., Inc., Abs., Rev. no. 73, p. 166, August, 1942.)

Especially during periods of raw material shortages, adequate performance tests are necessary to evaluate paint products. Many tests are already accepted for traffic paints, but methods of measuring some properties are still to be standardized. Night visibility may be evaluated in a dark room with conditions of illumination and view similar to road conditions, by visual comparison with a standard. Drying time is tested with a loaded wheel. A portable machine driven by hand for determining resistance to wear is described. Results correlate well with road tests. Some suggestions on formulation are given.

136. "White and Yellow Traffic Paints." Nat. Paint, Varn. & Lacquer Assoc. - Circ. no. 632, p. 13 & 17, Jan. 15, 1942.

General requirements are given for paint that shall be ready mixed and suitable for either concrete or bituminous surfaces.

Detail requirements include drying properties, hiding power, color and daylight reflectance, consistency, flexibility, bleeding test, and water resistance.

White and yellow paints are compared and discussed.

1943 137. "Bead Striping for Dimout Areas Now Regular California Practice." Concrete, v. 51, p. 38, Oct., 1943.

The mixing of glass beads with traffic paint for center striping has become standard practice on all principal highway routes in California. There is no sparkle to indicate the presence of beads; the line is simply brighter at night. The operation of a bead dispensing machine is described. The average diameter of the beads is about 1/100 in. Improved methods of handling have reduced the cost to the point where the process may be economically used on main highways.

1943 138. Davis, W. W. "Measuring Optical Properties of Reflectorized Materials." Traffic Engineering, v. 14, no. 2, p. 27-29, Nov., 1943.

A report of the test method developed by the Army Engineers for measuring the optical properties of reflectorized materials such as paint with glass spheres for lane markings or signs. The equipment consists of a goniophotometer in which the test surface may be illuminated at various angles and a photoelectric receptor. Minimum requirements for optical properties of reflectorized materials recommended for military traffic control are given. A discussion on measuring the optical properties of reflectorized materials is included. Mr. R. S. Hunter, Bureau of Standards, Washington, D. C. assisted in preparing the paper.

139. Dawson, D. H. and Skett, A. "Accelerated Testing of Traffic Zone Paints." Proc. Highway Research Board, v. 23, pp. 267-272, 1943.

The effort to correlate laboratory tests on traffic-zone paints with practical road service tests has been continued.

Ten white paints differing widely in durability characteristics were applied on nine roads in New Jersey, New York and Pennsylvania. They were observed throughout their life and graded by several observers. Observations were made over a 15 to 18 month period.

The same paints were submitted to seven cooperators for tests with particular emphasis on the use of abrasion tests and overall ratings, using a variety of laboratory testing methods.

140. Edelstein, Edwin. "The adaptability of Resinates in Present-Day Formulation Problems." Paint, Oil, & Chem. Rev., v. 105, no. 7, pp. 12-14, 16, April 8, 1943.

Due to their greater availability, there is now considerable interest in methods for processing the soft oils so as to convert them into fast drying, high viscosity vehicles of satisfactory stability.

The quick solvent release demonstrated in the Sward Hardness Rocker Tests, together with the properties of fair water resistance, excellent compatibility with zinc oxide and outstanding adhesion to all kinds of surfaces makes the zinc resinates exceptionally well suited for traffic-paint formulation.

141. "More Than 800 Paints Used in Extensive Traffic Paint Testing Programme." Canadian Paint & Varnish Mag., v. 17, pp. 5-6, 42, April 15, 1943.

An announcement of a program of testing by the research division of the New Jersey Zinc Company and a general discussion of the need for such tests. (No information as to the paints used or the results obtained is given.)

142. "Reflector Beads and Safety." Western Constr. News, v. 18, no. 5, p. 217, May, 1943.

Use of these beads increases visibility greatly. They are only about 1/100-in. in diameter and give no impression of roughness or irregularity. They become embedded to about $\frac{1}{2}$ of their diameter and are practically immune to crushing. A striping machine constructed by the California Division of State Highways will paint three stripes simultaneously and drop glass beads into the wet paint.

143. "Road Marking for Blackout Conditions." Public Works, v. 74, no. 9, pp. 47-8, Sept., 1943.

Tests show that embedding glass beads in the paint used for road markings more than doubles the visibility under blackout conditions. It has been found valuable for marking and numbering airports.

A white centerline on concrete is of practically no value. A black line on concrete is observed 30 percent of the time. On bituminous surfaces a white line was 40 percent effective. When glass beads, about 1/10 in. in diameter, were embedded in the paint, the line was 83 percent effective on concrete and 90 percent on bituminous surfaces.

144. "Substitute for White Paint Road Markings." Roads & Bridges, v. 81, pp. 31-32, June, 1943.

The material presented in this article was extracted from the Wartime Road Note No. 6 of the British Road Research Laboratory. The available substitutes for the standard paints are listed as: (1) Alternate traffic paints; (2) plas-

1943 tic white line; (3) surface dressed white lines. Information concerning the durability and other properties such as composition and methods of construction is given for each of these types.

145. "Surface-Dressed Road Markings." Roads & Bridges, v. 81, p. 41, Sept., 1943.

Detailed information concerning the materials, specifications and methods of application for surface-dressed road markings. This information was abstracted from Wartime Road Note No. 6 of the British Road Research Laboratory. The traffic lines consist of a strip of light colored aggregate held to the road by a tar binder. The aggregate must be light in color and must not crush under traffic. The best nominal size is passing 3/8 in. and retained on $\frac{1}{4}$ in. mesh. The binder used is the hot application type - the amount used and exact grade is varied according to road conditions and type aggregate etc.

146. "Traffic Paints." (British Standards Institution Spec. B.S./A.R.P. 38, 1943) Nat'l Paint, Varn. & Lacquer Assoc., Abs. Rev., no. 86, p. 200, 1943.

Six types of paint are considered; (1) Type A, white line road paint: methanol/resin type; (2) Type B, white line road paint: oil base paint; (3) Types C and D, white line road paint: water paint; (4) Type E, general service traffic paint: water paint. Performance tests and instructions concerning the use of the different types are also given.

147. "What is the Best Time of Year to Apply Traffic Paint?" New Jersey Zinc Co., Paint Progress, v. 4, no. 2, p. 6-7, Oct., 1943. See also: Public Works, v. 75, no. 4, p. 28, April, 1944.

Several paints were applied over a 5-month period on the same section of highway. The results show that: (1) Weather conditions during application, drying time and exposure affects paint durability. (2) Excessive moisture during first month is detrimental. (3) Saturation of the fresh film with water accompanied by freezing promotes film failure. (4) Exposure of fresh dry paint to cold is not detrimental. (5) High grade traffic paint stands up better than a low grade paint.

148. "White - Best Color for Night Visibility." New Jersey Zinc Co., Paint Progress, v. 4, no. 1, p. 11, April, 1943.

White is the best light-reflecting color because the lighter the color, the higher the reflection of light and the darker the color, the higher the absorption of light. White possesses the highest reflectance factor and hence the best visibility.

149. "White Line Road Marking." Gr. Britain, Dept. of Science & Industrial Research, Road Research Laboratory Road Note No. 6, 13 pages, 1943.

A discussion of wartime substitute for the standard traffic paints. These are (1) Alternate traffic paints; (2) plastic white line compositions; (3) surface dressed white lines. Details of the composition and properties of the plastic line are given as well as detailed information on the surface dressed white line. The alternate paints are reported to deteriorate rapidly (about 1 month in winter and 2 in summer). The plastic lines last about a year with good retention of color, but the original color is not as good as paint. Surface dressed lines are never as white as painted lines but night visibility is good.

Note: Excerpts from this paper are published in Roads & Bridges v. 81, p. 31-22 (June) and p. 41 (Sept.), 1943, under the titles, "Substitute for White Paint Road Markings" and "Surface-dressed Road Markings," respectively.

150. Zinzer, A. L. "Good Paint - In Spite of War." Better Roads, v. 13, no. 12, p. 25-26, Dec., 1943.

Note on satisfactory war time substitute paints developed in paint laboratory of Texas Highway Dept. using raw materials & facilities available.

1944 151. Allen, C. W. "Tests for Abrasion, Adhesion, Flexibility and Hardness of Traffic Paints." ASTM Bulletin, no. 130, pp. 29-36, Oct. 1944.

Progress report of group 2 of subcommittee IV on traffic paint, of ASTM committee D-1 on paint, varnish, lacquer and related products.

1944 I. The adhesion, flexibility, and hardness tests examined show no general correlation with field service behavior.

II. The accelerated weathering and abrasion tests show close correlation with field service behavior.

The purpose of this study is to determine, if possible, the value of these tests in estimating the behavior of traffic paints in service and possibly to recommend to the Society methods of tests that are proved to be of value.

152. "Asphalt Center Stripes Stay Put." (stones sealed with asphalt) Roads & Streets, v. 87, p. 80, Aug., 1944.

The stripe is similar to an ordinary seal coat, built 6-in. wide along the centerline. It consists of an application of quick-drying cutback made with high melting point asphalt, over which is immediately placed a chip covering of 3/8 in. maximum size aggregate.

153. "Brick Found Excellent for Traffic Markings." Brick & Clay Rec., v. 104, p. 13, June, 1944.

Recent brick road construction makes for an increased use of bricks for traffic marking. Buff bricks with staggered offsets make a good traffic line.

154. Gidrani, B. S. & Kamath, N. R. "White Line Road Paints." Oil & Color Trades Journal, v. 106, p. 590, 1944. (Nat'l Paint, Varn. & Lacquer Assoc. Abs. Rev., no. 100, p. 35, 1945).

Two traffic paint formulations using water as the volatile matter and bleach lac were tested; the first dispersed in ammonia water is satisfactory in all respects and can be used on all types of roads, the second dispersed in ammonium bisulphite water and fish oil as a vehicle is faster drying and more water resistant, but bleeds on bituminous surfaces and does not have as good color retention.

155. Hassett, R. J. "Glass Beads for Road Stripes." Public Works, v. 75, no. 11, p. 18, Nov., 1944.

The use of glass beads embedded in the centerline paint to minimize accidents is very effective.

156. "How It's Done in Texas: Asphalt Center Stripes Stay Put." Roads & Streets, v. 87, pp. 80-82, Aug., 1944.

For several years the Texas State Highway Dept. has striped an increasing mileage of its pavements with sealing asphalt and chips.

157. Jelinek, O. K. "Simplifying Traffic Lane Delineation." Civil Eng., v. 14, p. 522-523, Dec., 1944.

Method used by the Chicago Park District. A 5-gal. can filled with water is fastened to the side of an automobile. As it travels along the driver turns a valve allowing the water to drip on the road. The lanes are thus defined according to the natural movement of the driver.

158. Lesser, Milton A. "Alkyd Resins in Emulsion Paints." Am. Paint Journal, v. 29, no. 6, pp. 62, 66, 68, 1944.

Paints of this type of water dispersed alkyds on asphalt and tar surfaces will pay a large part in the post war market.

159. Neal, H. E. "Rapid and Economical Traffic Striping." Engineering News-Record, v. 133, pp. 842-845, Dec., 28, 1944.

State of Ohio puts 125,000 gal. of traffic paint on 10,500 mi. of road each year at an application cost of $2.30 per mi. Striping is done with shop-assembled trucks that apply one to three stripes at a time at a speed of 15 mph. The paint is air-agitated, atomized and is blown onto the pavement.

160. "Plastic White Lines." Roads & Road Constr., v. 22, no. 256, pp. 101-102, April, 1944.

Gives results of a questionnaire directed to highway authorities of counties and boroughs, concerning the use of plastic white lines for road marking. The mileage painted, the visibility characteristics, the difficulty of installation, and the general opinion of their merit are covered.

1944 Conclusions drawn are: The plastic line is easy to apply (although not as easy to paint). Over a 2 year period it is generally cheaper than paint. It provides a reasonable visibility throughout the year although the visibility is not as good as that of a newly-painted line. Although satisfactory on bituminous roads it does not give good results on wood-block paving, granite setts, or concrete.

161. "Road Tests on Traffic Paints Show Value of Zinc Oxide for Durability." New Jersey Zinc Co., Paint Progress, v. 5, no. 2, p. 12, 1944.
Paint containing zinc oxide has properties of improved wear, weather resistance, and opacity to the ultra-violet rays of the sun. A test (road) of paints containing 0 percent, 10 percent, 20 percent, 30 percent, and 40 percent zinc oxide shows that the paint with 40 percent zinc oxide lasted much longer than the others.

162. Slate, F. O. "Thermosetting Synthetic-Resin Paints for Concrete Pavement Markings." Proc. Highway Research Board, v. 24, pp. 213-225, 1944.
The object of this study was to determine the causes of failures of concrete paints and to find paints and painting methods to overcome these causes. Both laboratory and field tests show that paints fail principally by scaling due to loss of adhesion in the presence of water. Laboratory and field tests designed to compare the durabilities of highway paints showed that the thermosetting and thermoplastic synthetic resin paints had far better water, alkali and abrasion resistance than standard paints.

1945 163. "Seabees Develop Machine to Paint Traffic Stripes." Engineering News-Record, v. 135, p. 503, Oct. 18, 1945.
This Seabee-developed machine is compact and easy to operate. It is towed by a Jeep. In addition to the driver of the towing Jeep, only two operators are required. A small gasoline-engine-driven compressor provides air at a pressure of from 75 to 150 psi.

164. Slate, F. O. "Concrete - Highway - Marking Paints." Roads & Bridges, v. 83, pp. 61-63, 96, 98, 100, 102, 104, 106-8, 110, April, 1945.
A report by the U. S. Highway Research Board. The research was designed to find the causes of failure of concrete paints now used and to find paints and painting methods to overcome these causes. The work was carried out in 1943 and 1944.

Both laboratory and field tests showed that these paints fail principally by scaling due to loss of adhesion between the paint film and the concrete. The presence of water is necessary for this loss of adhesion. The water traveling upward carries soluble salts, these salts are deposited upon evaporation of the water. The paint film offers resistance to the passage of water vapor and to the growth of the salt crystals, the resulting forces may break the bond between paint and concrete. The surface of the concrete itself may be disintegrated by the growth of these salt crystals. The thickness of the paint film which governs its resistance to water vapor has a marked influence on the rate of scaling of some paints. Laboratory and field tests, designed to compare durability of standard with proposed concrete highway paints showed that the thermosetting and thermoplastic synthetic resin paints tested had better water, alkali, and abrasion resistance than standard paints. In his conclusion the author states that the baking type paints and the strongly polar thermo-plastic resin paints tested were suitable, satisfactory and superior for concrete highways. (Editors Abstract).

165. "Special Equipment Designed for Painting Highway Center Stripes." Engineering News-Record, v. 134, p. 894, June 28, 1945.
The centerline of roadway is marked with diluted white paint dripping on a bicycle wheel. A truck equipped with an air compressor is used to spray on finished stripe.

166. "Study of White Traffic Lines." Roads & Bridges, v. 83, p. 243, June, 1945.
A resume' of an article by G. Bird and D. J. MacLean, Road Research Laboratory, British Department of Scientific and Industrial Research. The main purpose of the paper was to demonstrate the possibilities of a novel laboratory approach

1945 to the study of traffic markings in general. The studies reported were concerned with the relationships between night visibility and line spacings under blackout conditions.

167. Walz, K. "Examination of Pigment for Traffic Paint." Asphalt u. Teer Strasenbautech, v. 43, pp. 231-245, 1943. (C.A.38:6111). (Nat'l Paint, Varn. & Lacquer Assoc. Abs. Rev. no. 99, p. 6, 1945).

Exhaustive laboratory and road tests made on 12 traffic paint formulations revealed that thermal, hydro, and abrasion resistance tests are the best indicators of the actual behavior of traffic paints. An important variable was the type of surface on which the paint was applied. A diagram and description of the artificial weathering apparatus is included.

1946 168. Cummins, R. P. "Missouri Paints with Narrow Rig." Engineering News, v. 138, p. 211, Feb. 6, 1946.

A 36-ft. long narrow-tread, self-powered machine is used by the Missouri State Highway Department for painting stripes on pavements. It applies the centerline and intermittent no-passing lines at the same time.

169. "Curbs Sandblasted Before Repainting Yellow No-Parking Zones." Roads & Streets, v. 89, p. 71, Aug., 1946.

Colorado Springs, Colorado wanted to remove their yellow "no parking" paint and repaint. The solution worked out was to close off a block at a time on one side of the street and sandblast the curbs clean.

The procedure was to set up a row of stands along the outer edge of the parking lane and rope off that lane early enough in the morning so that parked, locked cars wouldn't hamper the job. Then the outfit came along and speedily blasted the curbs along the block.

170. Lee, R. "Standard White Traffic Marker Used by Oklahoma City." Public Works, v. 77, no. 5, p. 37, May, 1946.

Drawings and specifications for a white traffic marker to be placed on paved narrow streets not wide enough for angle parking. The material consists of white portland cement and white sand, with a mixture of one part cement and two parts sand.

171. Star, D. E. "Special Performance Testing of Paints." Paint Manuf., v. 16, pp. 425-430, 1946; v. 17, pp. 24-5, 1947.

Accelerated weathering and wear resistance of road line paint are discussed.

1947 172. Hafeli, John M. "Traffic Paints. A Study of Typical Formulations." By Gum (Reichold Chemicals, Inc., Detroit, Mich.) v. 18, no. 2, pp. 3-6, 1947.

A short oil, fast drying, modified alkyd and a nonphthalic alkyd with a medium drying rate were compared to standard 20-gal.-oil-length, modified-phenolic, china wood oil varnish in 5 white and in 5 yellow pigment blends commonly used.

173. Hayward, A. T. J. & A. R. Lee. "Plastic and Surface Dressed White Line Road Markings." The Public Works, Roads and Transport Congress, Wed., 23rd. July, 1947, at 3:00 P.M. under the auspices of the Society of Chemical Industry (13): Also, The Surveyor (London) Vol. 106, no. 2896, August 8, 1947.

A review of the wartime development of plastic line and surface dressed white lines. Plastic lines have proved most successful. Surface dressed lines have been successful under proper experimental conditions but have not yet been developed commercially. Under proper control both types are more economical than paint because of longer service. Further improvement in the plastic line can be expected.

174. "Highway Traffic Striping." Engineering News-Record, v. 138, no. 6, pp. 80-83, Feb. 6, 1947.

Details are presented on traffic striping equipment used in New York, Virginia and Missouri. Broken dot and dash marking is made automatic by a cam arrangement that opens and closes the spray gun at regular intervals.

1947 175. Leech, C. B., Jr. "Standard Truck Serves Virginia." Engineering News-Record, v. 138, p. 210, Feb. 6, 1947.

Machine used to paint traffic lines on Virginia Highways permits one stripe to be added alone or two lines to be painted simultaneously with either line made solid or intermittent.

176. "New Jersey's Singing Highway: Route No. 6." Am. City, v. 62, p. 133, Dec., 1947.

A 2-ft. wide space is left between lanes for the full depth of slab. This space is filled with regular grey concrete covered with an inch of corrugated white concrete. This lane marking has been found to be both permanent and economical.

177. "New Paint Process Proves Economical." Mich. Municipal Review, v. 20, no. 12, p. 137, Dec., 1947.

Working closely with manufacturers of paint and glass beads, the Highway Department has adopted a formula of six pounds of beads per gallon of paint. Tests prove that this mixture is satisfactory for one year of wear on heavily-travelled truck-lines.

Reflectorized paint lasts two to three times as long as ordinary paint. This saving on labor and equipment cost due to the greater durability of the paint made the total yearly cost very little higher than the total yearly cost for ordinary paint.

178. Nicholson, Frank. "Semi-Permanent White Line Pavement Markers (Rubber)." Roads & Road Constr., v. 25, no. 300, pp. 458, Dec., 1947.

A description of a patented rubber marker - 18 in. x 5 in. ridged with hip ends. Vulcanized to the under surface is a sheet of strong, untreated, cloth fabric which extends 2 in. beyond the sides and end for fixing to the pavement surface. The details of the fastening process are given. This consists mainly of painting the surface with a bituminous emulsion and covering the fabric with a bituminous grit. A 3-in. twist screw is driven through the marker into the road surface at each corner. Cost data are given. The expected life is 10 years.

179. O'Brien, M. A. "Traffic Striping Developments." California Highways & Public Works, May-June, 1947.

The development of standards for traffic marking, specifications for materials, as well as equipment used has been given much attention during the last 20 years. California experience with the dashed line has been very satisfactory, as it provides good visibility under varying conditions at a 60 percent reduction in material costs. The requirements for traffic paint include such items as quick drying, long life, good adherence to various surfaces without serious discoloration, and bead retention. Changes in standard markings have caused many changes in equipment. The operator must be able to make the following transitions in sequence of work without stopping the machine: 1. Place a single broken stripe; 2. Place a double stripe consisting of a broken stripe on the left and a solid stripe on the right; 3. Place double solid stripes; 4. Place double stripes consisting of a broken stripe on the right and a solid stripe on the left. A bead dispenser is described, and photographs of an improved striping machine are included.

180. "Pavement Striping Methods." Roads and Streets, v. 90, no. 4, pp. 78, 80, 82, 84, 88, April, 1947.

There is a wide variety of special equipment being employed by different state highway departments. These are discussed, along with the use of reflector beads. The paint shortage is being gradually overcome.

181. "Ribbed White Concrete Markers Guide Traffic Day and Night." Constr. Methods, v. 29, no. 10, pp. 88-90, Oct., 1947.

Highway slabs are 10-in. deep and 12-ft. wide, and were poured so as to leave a two foot space between parallel lanes. After road forms were stripped, this 2-ft. strip was filled with a 9-in. layer of ordinary concrete topped with 1-in. of Atlas white cement mortar to act as a permanent lane separator, or marker. These white strips were scored with a hand tool to make a shallow saw-toot surface.

1947 182. "Traffic Paint Performance." Am. City, p. 133, April, 1947.
Simple tests have been devised for determining the resistance to abrasion, the drying time, and the resistance to road service of traffic paint. These tests are described in this article.

183. "Traffic Striper - News Article." Engineering News-Record, v. 138, p. 338, Feb. 27, 1947.
This traffic striper was built by Carl Sohmer of Tacoma, Washington. Operated by three men, the machine uses about 80-gal. of paint to line about 12 blocks, moving at a speed of a block a minute.

184. Waters, C. R. "Dash Line Road Striping Made Easy." Engineering News-Record, v. 138, p. 208-210, Feb. 6, 1947.
Controls for paint spraying have recently been developed by the State Public Works Department in western New York to mark traffic lines on pavements, so that the length of dash lines may be varied and so that the paint may be started at any place to duplicate dash lines previously placed on pavements.

185. Ziegler, C. M. "Reflector Beads Widely Used in Michigan's Pavement Marking Program." Roads & Streets, v. 90, p. 71-74, Jan. 1947.
This article gives details of the extensive use of reflectorizing beads and an excellent explanation of the underlying principle that has brought reflectorizing materials to the fore.

1948 186. Allen, J. H. "Jacksonville's Life Saving Traffic Markings." Am. City, v. 63, p. 151, April, 1948.
Traffic fatalities have decreased 69 percent since the application of a new traffic marking system. Now in use is a 4-in. continuous white center line covered with glass beads. The cost of reflectorization is 6½ cents per sq. ft.

187. "California Traffic Markers Paint a Variety of Lines Automatically." Western Construction News, v. 23, no. 7, p. 99, July, 1948.
Refinements and improvements in Division of Highway traffic markers enable operators to paint many types of striping without stopping the machine for adjustments. The machine and its operation are described.

188. Crabtree, W. O. "Traffic Paint." Am. Paint Journal, v. 32, p. 43, 1948.
The important properties of traffic paints are reviewed and discussed; also the use of reflectorizing beads. It is concluded that white paint gives better visibility than yellow paint.

189. "Marking Highways for Safety; Calif. Traffic Striper Uses Compressed Air." Comp. Air Mag., v. 53, pp. 116-118, May, 1948.
This is the latest California traffic striper. All parts are exposed for easy adjustment, cleaning and removal. It is pushed by a truck. Broken or continuous lines may be painted. An attachment for dropping reflector beads is on the machine.

190. "New Traffic Paint." Roads & Streets, v. 91, no. 8, p. 105, Aug., 1948.
"Oncrete for Concrete" traffic paint marketed by Lowebco, Inc., of Chicago, made in yellow, white and black.

191. "These Improved Traffic Striping Machines are 100 Percent Air Operated." Roads & Streets, v. 91, no. 5, p. 96, May, 1948.
Two excellent examples of recent traffic striping machines are pictured here. Both are operated by compressed air. Either will paint or positively retrace a single broken stripe, a double white stripe consisting of a broken stripe on the left and a solid stripe on the right, or a double white stripe and a double white stripe consisting of a broken stripe on right and a solid stripe on left.

192. "Traffic Paints - A Report on Their Formulation." Am. Gum Importers Laboratories, Inc., Natural Resin Series No. 8, Oct., 1948.
The American Gum Importers have for the past 10-yrs. been experimenting

1948 with traffic paints. The unique properties of certain natural resins to give the maximum in adhesion and toughness seemed to point directly to their use in traffic paints. These traffic paint studies were separated into 3 main branches of investigation: (1) the cold-cut vehicles which were alcohol and Ketone soluble; (2) the cold-cut vehicles which were petroleum thinner and coal tar soluble; and (3) the series based on cooked varnish.

193. Tremper, Bailey and Minor, C. E. "Experience with Reflectorized Traffic Paints." Proc. Highway Research Board, v. 28, p. 262, 1948.

Glass beads increase the night visibility of painted traffic stripes to a greater degree than other available material. Smaller beads offer advantages in economy and service life over the larger sizes formerly used.

Beads were originally applied by gravity to the fresh surface of the stripe. This method, called "over-lay", has been succeeded by a "premix" method in which the beads are mixed with the paint just prior to application. The "fog-coat" method may be used as an alternative for the "pre-mix." In this method, beads are placed by over-lay in a second light application.

Data are given on the use of the "pre-mix" and "fog-coat" methods.

1949 194. "Bleeding Tests for Traffic Paints." Better Roads, v. 19, p. 10, Oct., 1949.

The direct cause of bleeding is the solution of the bitumens that are soluble in the vehicle of the paint. Tests run by the Michigan State Highway Dept. indicated that tar-surfaced roads bleed much more severely than do asphaltic surfaces. No traffic paint tested, except water soluble types, was found to be 100 percent bleed resistant over a tar surface.

195. Byerly, Fred S. "Laboratory Testing of Resistance of Traffic Paints to Bleeding." ASTM Bulletin, no. 160, pp. 52-6, Sept., 1949.

This article outlines some work done by group IV, Subcommittee IV, Committee D-1, ASTM leading to the development of ASTM standards on bleeding of traffic paints.

Photographic standards are given for evaluating the degree of resistance of traffic paints to bleeding. These pictorial references consist of four photographs illustrating the following degrees of bleed resistance:

No. 8 (Slight bleeding) No. 6 (Moderate bleeding)
No. 4 (Bad bleeding) No. 2 (Very bad bleeding)

This article describes the work which resulted in writing ASTM Method D969-48T. Coal tars bleed much more severely than do asphalts.

196. "Centerline Marking Units Added to Step Up This Major Service." Missouri Highway News, v. 7, no. 6, p. 1, 3, Aug., 1949.

Small replica of large 34-ft. overall machine is now being dispatched to each of various divisions. These machines, designed by Maintenance Bureau and constructed by Equipment Bureau's headquarters garage personnel, will expedite marking process.

197. "Center Striping of Highways and Municipal and Industrial Plant Roadways." Nat. Safety News, v. 59, pp. 39-40, 42, April, 1949.

Description of types of equipment used for application and renewal of pavement markings.

198. Custer, H. R. and Zimmerman, E. K. "Field Evaluation of Traffic Paints of Known Composition." Proc. Highway Research Board, pp. 274-281, 1949.

This report is a summary of progress made on a cooperative project between the Penn. Dept. of Highways and the Titanium Pigment Corp.

Traffic paints of known composition are evaluated and developed from field service tests. For comparative evaluation, each paint must be applied in the same manner, with equipment similar to that normally used by highway departments.

It has been possible to develop traffic paint formulations of merit, and to indicate improvements for the future.

1949 199. "Experience with Reflectorized Traffic Paint." Public Works, v. 80, no. 22, p. 40, July, 1949.

A study has been made by the State Department of Highways of Washington on reflectorized traffic paint as it has been used by the Department on its roads. From this it has been concluded that glass beads increase the night visibility of traffic paints to a greater degree than any other available material.

200. "A Further Report on the Formulation of Traffic Paints." Am. Gum Importers Laboratories, Inc., Natural Resin Series No. 10, Sept. 1949.

Additional exposure evaluations have been made. These exposures, involving variations in pigmentation and adjustments in vehicle preparation, attempt to discover more effective traffic paints. Both cooked and cold-cut vehicles were again studied and their performances compared with the best of those experiments discussed in the previous traffic paint paper.

Considerable thought was given to pigmentation changes in this latter series. Attempts were made to answer questions as to the relative merits of various extenders. Mica, Magnesium Silicate and pumice were among those chosen for study.

201. Hank, R. S. and Bennett, F. E. "Highway Striping." Pacific Road Builder & Engineering Review, v. 73, no. 2, pp. 22-23, Aug., 1949.

Cooperative field study program carried out by Texas Highway Department and Goodyear Tire & Rubber Co. Primary purpose of study is to attempt to correlate factors of weather, cleanliness of surface, rate of application, and type of road surface with durability of specification paints.

202. Hank, R. S. and Bennett, F. E. "What Lowers Traffic Paint Durability?" Am. City, v. 64, p. 173, Sept., 1949.

Texas has developed a new traffic paint calling for Pliolite S-5, a paint resin manufactured by the Goodyear Tire & Rubber Co. The new formulation is called "YP-3." The vehicle is based on materials new to the traffic paint field. The pigmentation selected included diatomaceous silica.

203. Hill, John M. & Ecker, Howard A. "A Direct Reading Portable Photoelectric Photometer for Determining Reflectance of Highway Centerline." ASTM Bulletin No. 159, pp. 69-72, July, 1949.

The development of a reflective centerline material required a means of evaluating properly the reflection obtained with various beaded materials as compared to conventional highway striping paints.

The photometer described here may be used on the highway in daylight for evaluating night brightness of highway centerline stripes. An unskilled operator obtains the reflectance value from a meter in less than 2 seconds.

The instrument is calibrated in terms of a perfectly diffused white surface of 100 percent diffusing-reflecting factor.

204. Lyon, V. H. and Robinson, D. L. "A Study of Glass Beads for Reflectorizing Traffic Paint." Proc. Highway Research Board, pp. 245-273, 1949.

The Missouri Highway Dept. reports on a study of the physical and chemical properties of glass beads, in an attempt to evaluate the available products and arrive at satisfactory specifications.

Eight different glass beads grading from No. 20 to No. 100 sieve were applied by gravity to fresh Missouri specification yellow traffic paint. Of the eight beads studied, two composed of glass of normal silica content performed satisfactorily, and two with low silica content looked promising.

205. Mummery, J. R. "Oleo-casein Paint." New Zealand J. Sci. Technol, 308, pp. 297-309, 1949.

During the war years when materials for paint manufacture were restricted, an oleo-casein paint consisting of linseed oil in a water emulsion stabilized by casein solution and mixed with a pigment blend of lithophone, whiting, and barytes gave satisfactory results as a traffic-line and general road-side paint.

206. Neal, Harry E. "Ohio Pavement Striping Equipment." Traffic Engineering, v. 20, no. 1, p. 17-18, 37, Oct., 1949.

Techniques of mechanization and mass production are being applied to the

1949 business of striping State highways. The newest unit for pavement striping on Ohio highways is built on 5-ton chassis with 105-in. wheelbases. It can apply two colors and three lines simultaneously where passing is restricted in each direction. It is capable of laying pavement markings at 10-12 mph.

207. "Standard Method of Conducting Road Service Tests on Traffic Paint." ASTM D 713-46, 1949 Book of ASTM Standards, Part 4, pp. 395-6.
This method of test is intended for determining the relative values of service of traffic or pavement marking paints under actual road conditions. Samples of the paint being tested are compared under prescribed conditions and periodic observations are made as to the relative performance characteristics as a basis of comparison.

208. "Standard Method of Evaluating Degree of Resistance of Traffic Paint to Abrasion, Erosion, or a Combination of Both, in Road Service Tests." ASTM D 821-47 1949 Book of ASTM Standards, Part 4, pp. 376-9.
The failure described by these reference standards is that condition manifested in traffic paint by more or less gradual surface disappearance, thinning of the film, and exposure of the substrate because of abrasion, erosion or a combination of both. The degree of failure is judged by the amount of substrate that is visible.

209. "Standard Method of Evaluating Degree of Resistance of Traffic Paint to Bleeding." ASTM D 868-48 1949 Book of ASTM Standards, Part 4, pp. 380-1.
The bleeding characteristics described are that condition of discoloration manifested in traffic paint when applied to tar or asphaltic type roads. The number assigned to evaluate the degree of bleeding failure represents in these reference standards a measure of the contrast between the color of a dry film on a non-bleeding surface and the color of the dry film on test surface.

210. "Standard Method of Test for Dry to No-Pick-Up Time of Traffic Paint." ASTM D 711-48,1949 Book of ASTM Standards, Part 4, pp. 388-9.
This method describes a laboratory test to determine the length of drying time after application for no-pick-up of traffic or pavement marking paint by the tires of an automobile.

211. "Standard Method of Test for Evaluating Degree of Settling of Traffic Paint." ASTM D 869-48, 1949 Book of ASTM Standards, Part 4, pp. 397-8.
This method of test is intended for determining the degree of pigment suspension and ease of remixing a shelf-aged sample of traffic paint to a homogeneous paint suitable for use in the manner intended.

212. "Standard Method of Test for Light Sensitivity of Traffic Paint." ASTM D 712-47, 1949 Book of ASTM Standards, Part 4, pp. 390-1.
This method of test is intended for determining the color change produced by sunlight on paint material intended for use as traffic or pavement marking paint.

213. "Tentative Method of Test for Night Visibility of Traffic Paints." ASTM D 1011-49T, 1949 Book of ASTM Standards, Part 4, pp. 392-4.
This method is intended for testing traffic paint surfaces for luminous directional reflectance, using directions of illumination and view similar to those of night traffic.

214. "Tentative Method of Evaluating Degree of Resistance of Traffic Paint to Chipping." ASTM D 913-47T, 1949 Book of ASTM Standards, Part 4, pp. 384-7.
The failure described by these reference standards is that condition manifested in traffic paint by actual detachment of entire sections of the film usually in small pieces, either from the substrate or from paint previously applied. The degree of resistance to failure is judged by the amount of substrate that is covered.

1949 215. "Tentative Method of Laboratory Test for Degree of Resistance of Traffic Paint to Bleeding." ASTM D 969-48T, 1949 Book of ASTM Standards, Part 4, pp. 382-3.

The method covers a laboratory procedure for determining the degree of resistance to bleeding of traffic paints in which the test panel is cut from "15-lb., coal-tar saturated asbestos or rag felt."

216. Tremper, Bailey and Minor, C. E. "Glass Beaded Traffic Paint." Am. City, v. 64, no. 6, p. 141, June, 1949.

With small beads the range in types of suitable paints is greatly extended since the quality of high capillary rise is of less importance.

The best method of applying these beads has been found to be "overlay" method. The beads are mixed with the paint just prior to application.

217. Vannoy, W. G. "Traffic Paint Tests." Proc. of the First Pacific Area National Meeting of ASTM, p. 47, Oct. 10-14, 1949.

Traffic paint testing procedures are reviewed in an attempt to determine which tests might be considered as standard. Certain laboratory control tests together with small scale road tests are given as the most effective means available at the present time for evaluating traffic paints.

All of the tests listed herein and considered standard are beneficial and helpful as control tests for traffic paint compositions. This would include the laboratory control tests and the small scale road tests. Such tests are considered important by many consumers.

218. Zimmerman, E. K. "Traffic Paint Studies - Progress Report No. 1", Official Digest, Federation of Paint & Varnish Production Clubs, No. 293, pp. 353-67, 1949.

Tests involving 217 paints were made under cooperative program between Highway Dept. Lab. of the Commonwealth of Pennsylvania and the Titanium Pigment Corp. Satisfactory traffic paints produce satisfactory reflectance or "signal value" at all times and satisfactory durability. "Signal value" is dependent on brightness and reflectance. Traffic paints to be used in concrete pavements must be "textured" by incorporating large-particle-size extenders such as coarse pumice to enhance signal value at night. The necessary high brightness of these paints is achieved through the use of titanium dioxide. Drying and durability requirements indicate an optimum pigment volume concentration of 50 percent with alkyd or oleoresinous vehicles. A zinc oxide content of 20 percent based on pigment weight will give a paint with improved hardness and dry. For bituminous highways, 4 to 6 gal. length varnishes at 50 percent PVC are used with rutile titanium-calcium pigment and no extenders.

1950 219. Corder, Leon W. "Missouri's Big Traffic Striper Has a Litter of Pups." Better Roads, v. 20, no. 8, p. 29, August, 1950.

Ten divisional traffic-line markers now employed by state highway maintenance forces to meet conditions created by expanded mileage of bituminous surfacing. Striping units easily mounted on and removed from half-ton trucks; smaller models incorporate working principles time-tested in large machine operating on statewide basis. Dispersal of work makes quality control more difficult.

220. Hadert, Hans. "Road-Marking Paints." Farbe u. Lack, 56, pp. 497-8, 1950.

A review with formulas.

221. "The Payoff." Engineering News-Record, v. 145, no. 5, Aug. 3, 1950.

Virginia's continuing tests of highway marking paints saved $88,000 last year. Eleven different kinds of plain white and reflectorized paints were studied under varying conditions on six highways.

222. "Plastic Discs Used for Traffic Markers." Roads & Construction, p. 84, March, 1950.

Known as "Dur-o-line" traffic markers the discs are 4½ in. in diameter and are furnished in either white or yellow. The markers have a convex top and a flat bottom with waffle-type ribbing, and are applied by means of a special adhesive and a metal pin in the top center of the disc. A two-man crew can lay a hundred of the discs in an hour without holding up traffic.

1950 223. Talen, H. W. and Brunt, N. A. "Testing the Resistance to Wear of Paints." Verfkroniek, v. 23, pp. 236-8, 1950.

Eight paint samples containing the same pigments but different vehicles were exposed to traffic in a wear test. The paint did not wear off layer by layer, but wore straight through to the base coat. The chemically drying paints were noticeably more resistant than the physically drying. Paints applied by spraying wore better than those applied by brush.

224. "Traffic Line Paints." Public Works, p. 65, May, 1950.

The following conclusions resulted from the reported study:

1. Different types of paint should be specified for concrete and bituminous.
2. While some reflectorizing paints give high night reflectances, some are no better than ordinary paints.
3. The size of bead has an effect on the night reflectance.
4. Field service test is an entirely satisfactory method of evaluating paints.

225. Walter, John. "Research Carried out in Ontario-Highway Problems." Roads and Construction, p. 122, March, 1950.

Problems:

1. Paints have had a wide range of consistency. Thin paint causes excessive fogging, while thick paint causes handling and loading difficulties.
2. Settlement of paint in storage has caused mixing and loading problems.
3. Problems in application due to use of glass beads.
4. Field performance, such as discoloration, bleeding on bituminous pavements, and traffic abrasion.

Observations:

1. Different types of paints are needed for bituminous and concrete pavements.
2. The night reflectances of some reflectorized paints are little or no better than ordinary paints.
3. The size of beads has an effect upon the night reflectance, but further study is necessary.
4. The field service test is entirely satisfactory.

226. Wieman, Don. "Traffic Striping." California Highways and Public Works, v. 29, nos. 3, 4, p. 52, March-April, 1950.

New idea for laying out highway traffic stripes which uses a transit sighting on a light truck moving toward the transit, the truck is equipped with a spotting gun and is driven in zig-zag manner across the centerline. The spotting gun is operated electrically by the truck driver on receiving a light signal from the transit man.

1951 227. "Analysis of Plastic White Line Compositions." Road Research Technical Paper No. 23, Road Research Laboratory, Dept. of Sci. and Indust. Research, 1951 (Great Britain).

Satisfactory plastic white lines are composed of mineral aggregate, filler and pigment with a fluxed rosin binder. Durability of line is dependent upon nature and amount of binder. Method of analysis for determining proportions of binder, mineral aggregate and pigment, and for subsequent examination of binder are presented.

228. Ashman, G. W. "Present Preferences for Traffic Paint." Highway Research Board Bulletin no. 36, Pavement Marking, May, 1951.

The results of a survey on traffic paint completed in 1950 are discussed. Replies to questionnaires received from 34 states and 175 paint manufactures indicated a great increase in the use of reflective road markings.

In 1949 and 1950, the ratio of white to yellow traffic paint used was 7 to 3. Preferences on vehicle types remained unchanged. First choice was alkyd resins, second choice was phenolic resins, third was phenolic varnish-dispersion resin type.

229. Byerby, F. S., Baumann, F. H. Diefenderfer, H. H. and Ashman, G. W. "A Laboratory Method of Test for No-Dirt-Retention Time of Traffic Paints." ASTM Bulletin, no. 176, pp. 44-46, Sept., 1951.

A progress report of cooperative tests conducted by a working group of

1951 Subcommittee IV of ASTM. Results indicate several hours additional drying time may be necessary between the stage of no-paint-pickup by tires and stage of no-dirt-pickup from the tires. The apparatus required in the proposed tentative method is that used in the ASTM Standard Method of Test for Dry to No-Pick-Up Time for Traffic Paint (D 711-48).

230. "Marble with Styrene Binder." Modern Plastics, v. 29, no. 4, p. 94, Dec., 1951.
New marker developed by Perma-Line Corp., New York, N. Y. is made of ground marble with a styrene binder. Mixture is placed in prepared grooves in asphalt, concrete or other road surfaces.

231. "Plastic Road Line Markers Tried in Nassau, Queens." Engineering News-Record, v. 146, no. 16, p. 44, April 19, 1951.
Traffic Lines, Inc. of New York on low bid of $4,900 are to install 3.36 mi. of white plastic traffic line markers in Nassau and Queens Counties (N. Y.) by grooving pavement ½ in. deep and 4 in. wide to receive thermoplastic material, 60 to 72 in. long, with placement by rolling material into groove at 425 deg. F.

232. "Recommendation for Plastic White Line Markings." Road Note No. 9, Road Research Laboratory, Dept. of Sci. and Indust. Research, 1951 (Great Britain).
Constituents commonly used are gum rosin fluxed with mineral oil for binder, pigmented with titanium dioxide, and filled with white silica sand or crushed calcite. Materials must be heated to 130 deg. C but prolonged heating at this temperature should not be permitted.

233. Shelburne, Tilton E. "Comparison of Reflectance Readings of Traffic Paints." ASTM Bulletin, no. 173, p. 44, April, 1951.
The reflectance values of plain, beads-on-paint, and beads-in-paint lines, placed longitudinally and diagonally to traffic and under no-traffic-conditions, were measured by means of the Hunter instrument and the Minnesota Mining Co. instrument and the results correlated.

234. Waters, Charles R. "Methods and Application Procedures for Pavement Marking." Highway Research Board, Bulletin no. 36, Pavement Marking, May, 1951. Roads and Eng. Construction, v.89, no. 9, p. 82, Sept., 1951 (Synopsis).
A report of findings determined by questionnaire sent to all states and several foreign provinces and countries. Questionnaire contained more than 70 items relating to types of paint, costs, methods of application, methods of protecting a fresh line, drying time, mixing of beads, and other aspects of pavement striping. The data are presented in tabular form and discussion is included of pertinent information.