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**16. ABSTRACT**

California's traffic paint program- the development and placing of that broken white line which guides you along the highway-- is maintained at an annual cost of approximately $700,000. The evolution of that line from city crosswalk delineation through the solid line of the highway to the reflectorized broken line of today is probably familiar to most motorists. The technology and compositional factors associated with the development are not so well known, although many of our highway personnel are aware of California's pioneering in the field. They will remember also the introduction of the "California Formula" which was developed by the late G.H.P. Lichthardt of the Materials and Research Department of the Division of Highways.

This "California Formula" was used successfully in California for many years and had widespread use in several other states for a time. It encountered disfavor in the East in later years, partly because of the inconvenience experienced in its manufacture and partly because of its limited durability in those areas. In California, however, it gave good service on asphaltic pavements as recently as 1951. Except for the emergence of national shortages which forced us into other formulations, we would perhaps still be using this formula, though its relatively slow drying properties would render it very annoying under present day traffic volume. The temporary shortages made necessary some makeshift substitutions for the emergency, then a program designed to stabilize and improve our position in this field was begun. Perhaps one should say the program was intensified rather than begun, for experimentation has been in progress continuously since the adoption of the traffic line as a fixed part of the highway program.

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Reprint from California Highways and Public Works, March-April, 1953

# Traffic Paint

## Its Development in California Makes an Interesting Story

By E. D. BOTTS, Senior Chemical Testing Engineer

CALIFORNIA'S traffic paint program—the development and placing of that broken white line which guides you along the highway—is maintained at an annual cost of approximately $700,000. The evolution of that line from city crosswalk delineation through the solid line of the highway to the reflectorized broken line of today is probably familiar to most motorists. The technology and compositional factors associated with the development are not so well known, although many of our highway personnel are aware of California's pioneering in the field. They will remember also the introduction of the "California Formula" which was developed by the late G. H. P. Lichthardt of the Materials and Research Department of the Division of Highways.

#### California Formula

This "California Formula" was used successfully in California for many years and had widespread use in several other states for a time. It encountered disfavor in the East in later years, partly because of the inconvenience experienced in its manufacture and partly because of its limited durability in those areas. In California, however, it gave good service on asphaltic pavements as recently as 1951. Except for the emergence of national shortages which forced us into other formulations, we would perhaps still be using this formula, though its relatively slow drying properties would render it very annoying under present day traffic volume. The temporary shortages made necessary some make-shift substitutions for the emergency, then a program designed to stabilize and improve our position in this field was begun. Perhaps one should say the program was intensified rather than begun, for experimentation has been in progress continuously since the adoption of the traffic line as a fixed part of the highway program.

#### Abrasion Apparatus

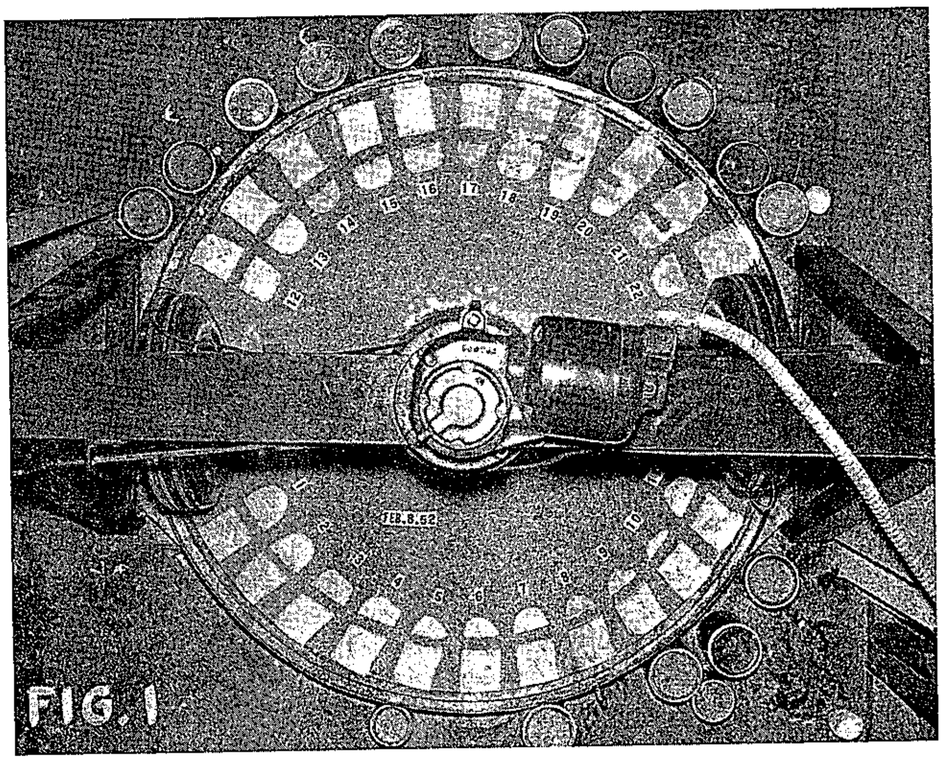
Preliminary experimentation with a large number of formulations on transverse traffic lines led to the selection of a few of them for large scale trial. An abrasion apparatus based on a design developed by the Los Angeles City Bureau of Standards was used as an accessory in some of this work. This apparatus consists of a three-quarter-inch plate glass, four feet in diameter, which acts as a track for anchorage of traffic stripes. The stripes .015 inch thick when wet, are drawn with a doctor blade and allowed to cure for a minimum of 72 hours. Weighted rubber-tired wheels set at a 2-degree bias are then driven over the lines in a dry condition for a definite number of passes. A similar treatment is then applied to the lines under wet conditions.

*Figure 1* shows the results of a typical test of this kind on the apparatus in use in the Materials and Research Department. In this instance the apparatus was run until virtually all samples failed. It would be superfluous to identify each of the lines and its composition in an article of this kind.

#### Results of Tests

It should be pointed out, however, that the correlation of such tests with practical service tests is not as good as was hoped for. The test is exclusively a measure of the resistance of a film to abrasion. The lack of correlation between tests on this apparatus and those on a highway is not due to

*Apparatus used to compare the abrasion resistance of paint films*



improper comparative measurement of abrasion but rather to the fact that many other factors are involved in making a satisfactory traffic line. Highway pavements are of concrete or asphaltic mixtures and there is no complete correlation between transverse line performance tests on the highway if the tests are widely separated with respect to location or time of application. Indeed there is no complete correlation of the performance of the traffic lines throughout the State even under comparable traffic conditions. The laboratory tests do give valuable information however, and point the way for establishing large scale tests, which, after all, are the real criteria by which we must be guided, both as to feasibility of manufacture and use.

#### Bids on Five Types of Paint

Following this premise (that large-scale tests under service conditions provide the best criteria for traffic stripe performance), we issued invitations for bids in 1950 on five differ-

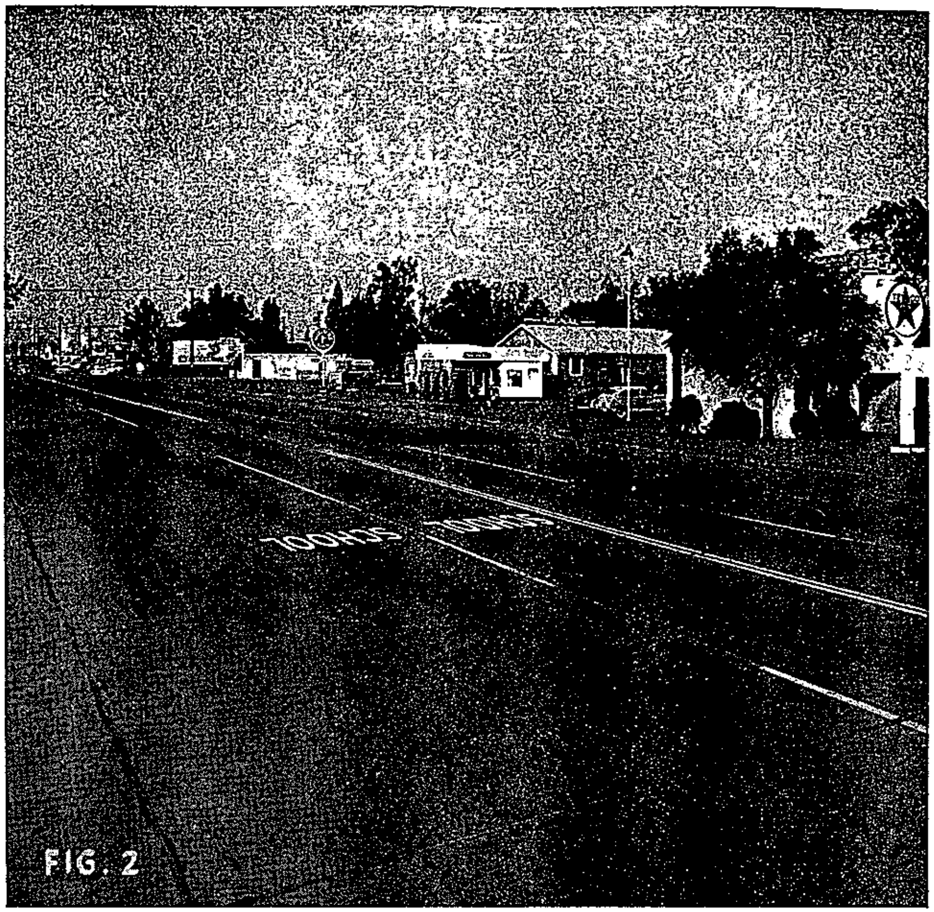


FIG. 2

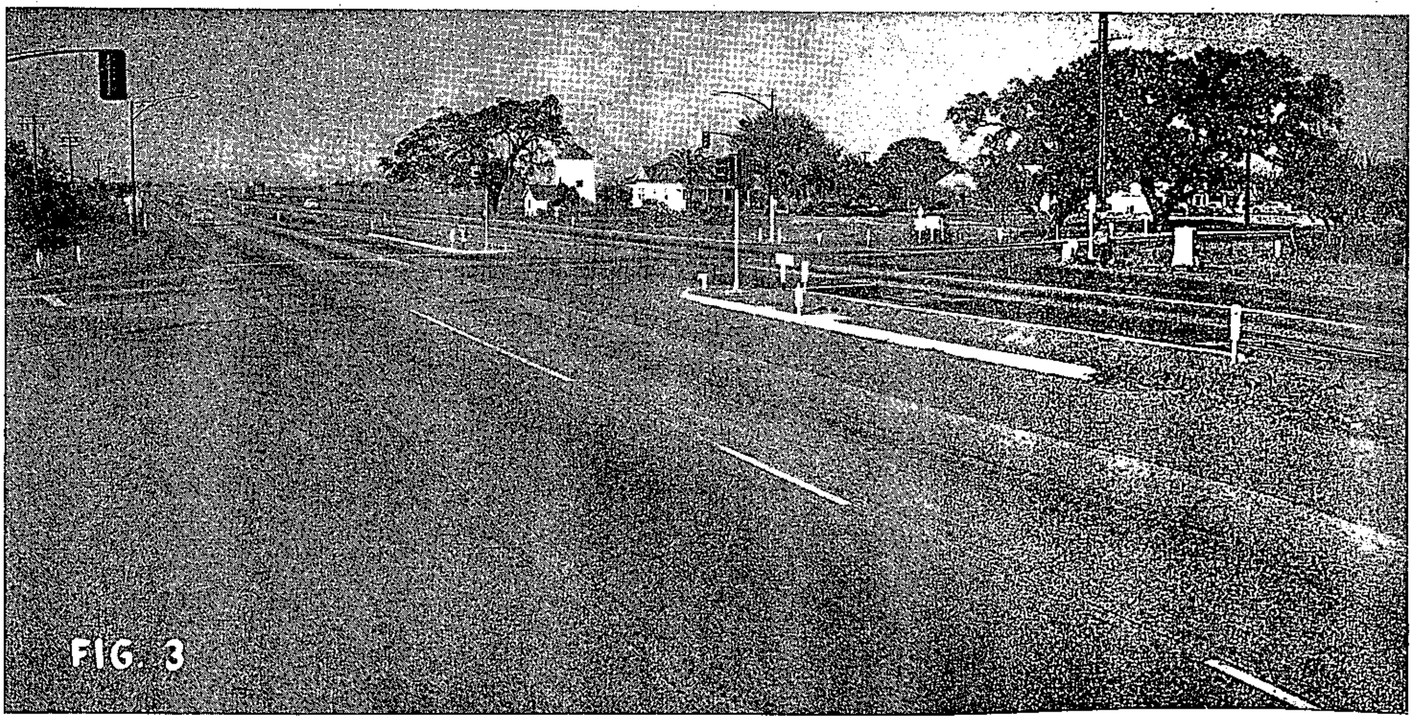


FIG. 3

*These two photos show California Type II (Alkyd) pavement marking near an intersection after seven months of service. UPPER—Lodi on U. S. 99; LOWER—On Stockton By-pass, U. S. 99.*

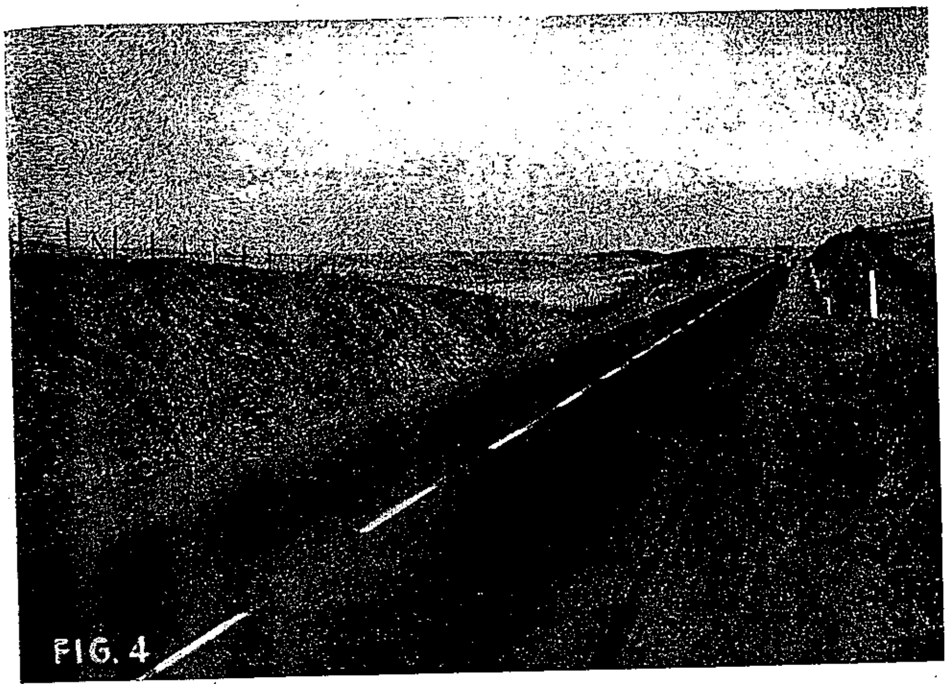


FIG. 4

ent vehicular types of traffic paint. These types were:

I–The D. B. B. Manila resin and chinawood oil–the "California Formula."

II–Alkyd.

III–Dispersion resin.

IV–Chinawood oil–pentalyn varnish–chlorinated rubber.

V–Modified phenolic resin, castor oil, chlorinated rubber.

The pigmentation was left to the discretion of the manufacturer with the proviso that covering capacity should be 200 square feet per gallon as a minimum.

*UPPER—Single line in foreground is California's Experimental Type III in background. On U. S. 50 section change just east of Folsom. LOWER—California Standard Type IV traffic stripe after eight months' service.*

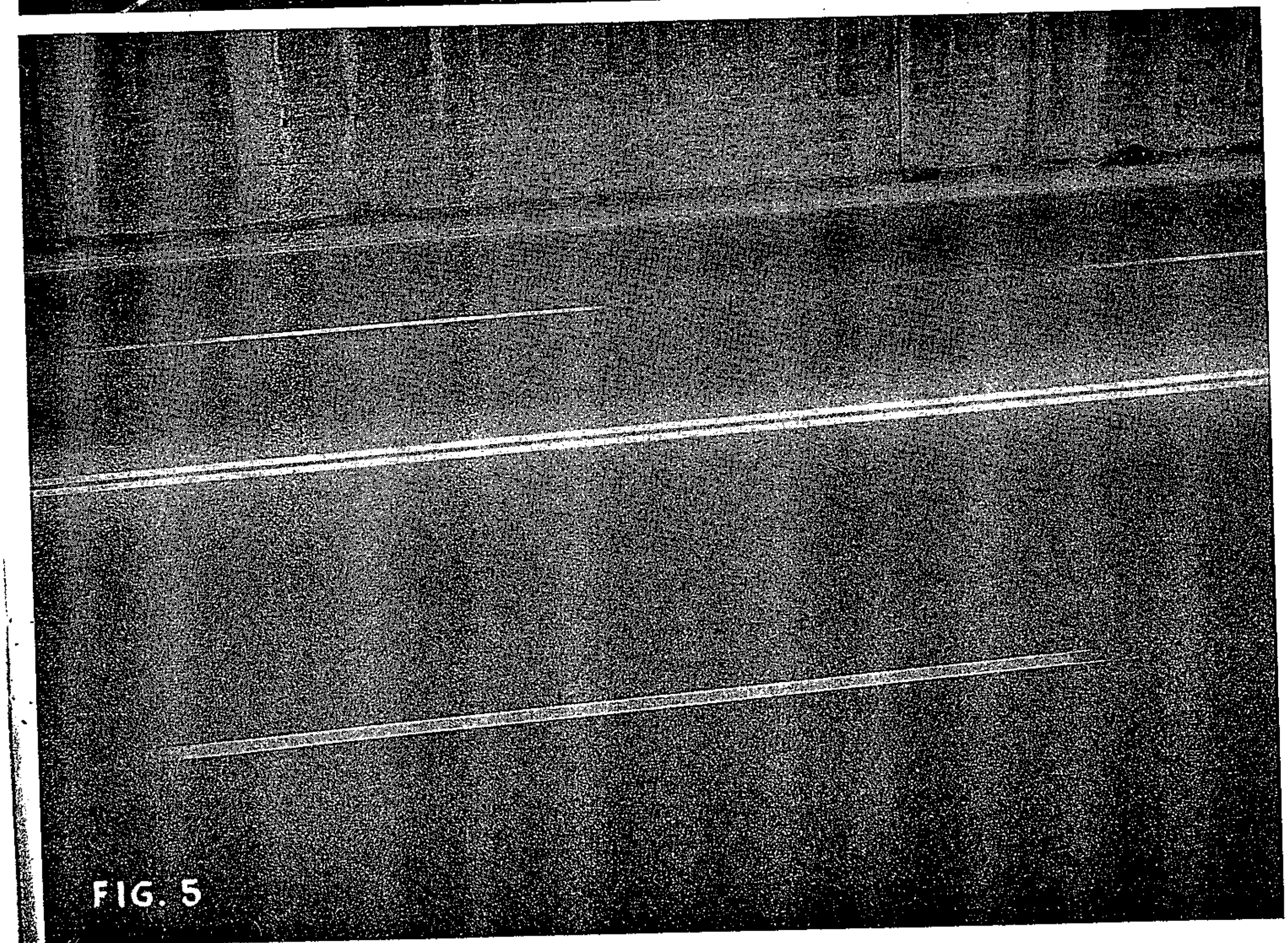


FIG. 5

California had used Type I for many years so we knew what to expect of it. Type II had also been used at times and something of its over-all performance was known. The durability of the alkyd in general paint formulations is well known among paint technologists. It is most commonly tabbed by the layman as a "synthetic" which of course is in a sense applicable to all paints. Properly adapted to traffic line requirements this alkyd type gives excellent service in many locations. The 50,000 gallons acquired in this instance performed well on surfaces in the interior section of the State. On the coastal areas or in an environment of high humidity it failed quickly. In one instance, a line of this type practically disappeared within 10 days after application. A heavy rain had fallen a few hours after it was applied. This condition, combined with heavy traffic, practically obliterated the line in a very short time. Other locations where traffic was equally severe were well marked by this same paint for several months. *See Figs. 2 and 3.*

#### Type III Not So Good

Type III conformed approximately to one of the federal specifications for traffic paint. In general it gave good service but it was rather vigorously criticized by the paint crews as having "no body" and spattering excessively during application even though its viscosity, pigment, and nonvolatile content were correct. That this criticism was justified to some degree is apparent in *Fig. 4*. In the immediate foreground is a single line of Type I. Type III lines with the frayed edges are in the background. Some adjustment of this formulation could render it quite acceptable, but we have abandoned it for the present.

#### Type IV Adopted as Standard

Type IV out-performed the other formulations and has been adopted by the State as our current standard traffic paint. Some modifications have been necessary at times to meet conditions prevailing in the raw materials market. The current specification calls for a definite and detailed formulation. The key substance of this formulation is chlorinated natural rubber, sold under the trade name of Parlon. This material controls the character of the film to a marked degree and aids greatly in reducing the initial drying time—that is the time to reach the state of what we call "no pick-up." Combined with the chinawood oil—pentalyn varnish—it offers a tough film of good durability and abrasion-resisting character.

The greatest deficiency of Parlon as a component of paint films is its incompatibility with many frequently used materials. This particular pentalyn varnish is one of the few vehicles known to afford compatibility sufficient to assure complete package stability for a reasonable length of time. Even in this formulation a certain degree of incompatibility results as the volatile content of the paint evaporates. The same phenomenon existed to a degree in the old "California Formula." It is probably a desirable feature in that it provides a film permeable to water vapor which may form under the paint. Otherwise certain conditions would cause blistering and early failure.

#### Service Life of Lines

The general serviceability of this Type IV paint is apparent in *Figs. 5, 6 and 7*. The lines shown here are all on concrete and in a location where the traffic count approximates 30,000 vehicles daily. Even on the curves where abrasion and shear are excessive the lines show up well. Although these photographs were taken eight months after application, the lines were in good enough condition to withstand six months more of the heavy wear before being repainted. It should be pointed out that this is an exceptional case, just as failure after two or three months is likewise unusual. The average effective service life of this Type IV line is from 6 to 10 months, the actual life depending upon the location and time of year it is applied. Weather cycles exert a certain if not a definite influence on the service life of the lines. Heavy rains following a long period of high temperature and ultra-violet radiation seem to accelerate failures of many organic films. Naturally the shock and abrasive influence of heavily weighted tires do not lessen the effectiveness of these factors, so traffic lines undergoing such a series of attack will generally show early failure.

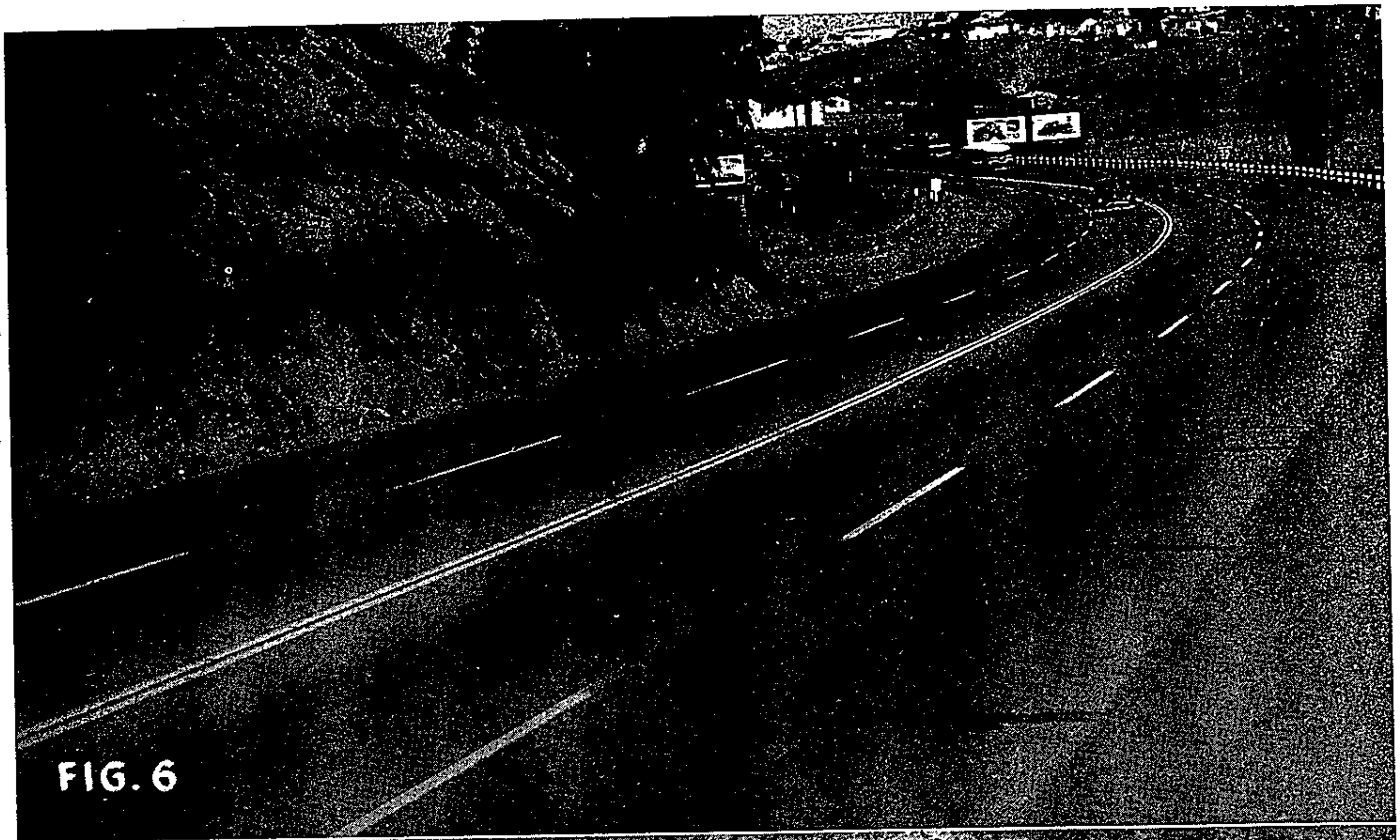
#### Type V Abandoned

Type V formulation had to be abandoned because of compatibility difficulties. This case exemplifies the necessity for large-scale experimentation in manufacture. No difficulties had been encountered in the preliminary small-scale preparation of this paint, but in large-scale production discrepant features were quickly detected. This formulation was replaced by another type of composition in which we attempted to exploit the characteristics of Parlon at a reduced cost of finished product.

About 5,000 gallons of the new formulation was produced and used in various locations over the State. It worked well in general and gave good service as a traffic stripe. However, one of our striping crews turned up a characteristic in the paint which caused it to be dropped from further consideration. The crew placed 80 gallons of the paint in each of two reservoirs on the truck and started laying a stripe one morning. While the paint was being used from one tank the other was being agitated. When the switch-over was made to the second tank the paint was found to be of a consistency of thick mayonnaise and could not be used in the spray at all. This phenomenon could not be reproduced in small scale operations in the laboratory. The manufacturer could do it by agitation in a 500-gallon mixing vat. Such are the anomalies one finds in paint technology and manufacture.

#### Durability Requisite

Returning again to durability as one of the prime requisites of a traffic stripe, it is well known that portland cement concrete pavement is a much more difficult surface on which to maintain a properly marked traffic stripe than is asphalt pavement. There is a wide variation among paints with respect to durability on similar surfaces, but practically all of those developed up to this time will do better on asphalt than on portland cement. *See Fig 8*. There are several reasons for this difference, the chief one being lack of adhesion of the film to a concrete surface. Concrete is alkaline and tends to saponify the oils and resins in many films. Moisture carrying a salt content creeps through the concrete and under the paint film. For this reason the film must necessarily "breathe," that is, be pervious to water vapor, or it will be pushed off the pavement. It must also possess a degree of plasticity to prevent cracking and chipping as temperature





*UPPER—California Standard Type IV traffic stripe after eight months' service on U. S. 40 west of Carquinez Bridge. LOWER—Same type after eight months' service on U. S. 40 at west city limits of Rodeo.*

...ges and compressions of the film ... place under traffic.

...iving a film all of these and other ...acteristics does not compensate ... the moderate solvent action that ...ch paint exerts on asphalt to bind ... two surfaces together. Common ... solvents have no perceptible ...t on concrete so the adhesion of paint film to this type of pavement largely a physical phenomenon.

#### Experiments

The Materials and Research Depart...ment has done some extensive experi...mentation in seeking ways to increase this bond and thus extend the service life of a traffic stripe. *Figs. 9 and 10* show a series of transverse traffic stripes which were all placed on the same day on adjoining sections of concrete. The lines bearing the same number in each photograph are composed of identical paints and were sprayed successively from the same can. For example, line *6A in Fig 9* was placed within two minutes of the laying of *6A in Fig 10.* The only difference between the two sections was in a pretreatment of the concrete under the lines shown in *Fig. 10.*

The pretreatment consisted of spraying the concrete on which lines were to be placed with a dilute alcoholic solution of phosphoric acid. The lines were placed about 20 minutes following the acid treatment. This particular acid is ideal for the purpose because it neutralizes any alkali on the surface and leaves a thin film of insoluble calcium phosphate as an anchor for the paint film. The effectiveness of the treatment is obvious from the photographs. At the time the photographs were taken the lines had been exposed for six months on a highway having an average daily traffic of about 30,000 cars. *Line No. 8* is California's standard stripe now in use.

#### Question Not Determined

It would be nice if we could assume that this practice would show equally well at all locations under all traffic conditions. Unfortunately, where there is sand and gravel on the road, as is often the case at intersections, the phosphoric acid does not seem to do any good. The sand and mud carried onto the pavement by the tires of vehicles entering the highway are too


*UPPER—Comparative serviceability of traffic line paint on asphalt (foreground) and concrete (background). CENTER—Experimental transverse traffic lines on bare concrete after six months' exposure. Traffic 30,000 vehicles daily. LOWER—Same as center except that concrete had been pre-treated with phosphoric acid.*

effective as a grinding agent, especially during wet conditions. On the other hand, on curves where the shear and wear by tires are excessive, the wearing qualities of the stripe are somewhat extended beyond the normal by this pretreatment. Whether or not the pretreatment of concrete for traffic striping is economically defensible is still to be determined.

#### Lines on Curves

One of the factors involved in the apparent lack of correlation of the observed service life of traffic stripes is the design of the highway. A narrow two-lane highway which causes a driver to veer from the shoulder towards the center line will invariably show stripe failure earlier than a wide four-lane highway where the tires contact the line less frequently. Likewise the line on a curve is much more attractive to all of us as drivers than the shoulder or edge of the pavement. A glance at the lines on a straightaway and those on curves will tell the story. The line on a curve will rarely last as long as that on the straight stretches. The only remedy for this situation is to eliminate the curves or modify them. That, of course, is impractical on many roads and probably can not be achieved in any substantial measure on many others. Because of these factors we try to use a paint that has a high over-all performance rating as well as one which meets other requisites of present day traffic conditions.

#### Drying Time of Paint

One of the more important additional requirements is the drying time of the paint—the time of "no pick up" when traffic runs over the line. Our present formulation meets this condition in seven to ten minutes, while specifications demand a maximum of 15 minutes. In spite of this short time, careless motorists ruin a considerable portion of the traffic line by running over it before the line has "set." Probably most drivers have noticed stripes with tangential faint lines extending into the center of the traffic lane. Each of these is due to a careless or indifferent motorist who has crossed the stripe within seven or eight minutes of its placement. Such maneuvers not only create an unsightly highway but ruin the portion of line where the wheels cross it. So far no one has developed a traffic paint that will "set" instantaneously upon being placed on the pavement.

**Pending such development the cooperation of the motoring public is required to maintain a neat serviceable traffic stripe.**

Some research men, notably the English, have reported excellent results from the use of hot mixes as traffic lines. These mixes are not thought to be practicable for use in California.

#### Performance Specification

It might be said in passing that some vendors are very anxious for the State to adopt a performance specification for traffic paints. This would be desirable certainly if we could devise a test which could be performed quickly and would be a guarantee of the performance of the paint on the highway. As has been indicated in the foregoing, no such test has been devised up to now, so far as we know. A specification involving a few performance tests combined with composition requirements seems to be the best method of securing a uniform product that will perform in accordance with previously established standards.

Most of this discussion has been centered around the vehicle of the traffic paint. It is probably the most important part of the paint in so far as durability, drying time, etc., are concerned. The pigment, nevertheless, is of great importance and plays its role in most of the characteristics displayed by a paint. Of prime importance in any paint is the relative volume of the pigment and nonvolatile vehicle. This factor is known to the trade as pigment volume concentration or "P. V. C." and is usually expressed as percentage. The optimum value must be determined by experiment for each vehicle and the use to which the paint is to be put must be considered in this respect. Our traffic paint specification calls for about 45 percent P. V. C. This value is a compromise among the requirements for good visibility, durability and the ability of the vehicle to hold small glass spheres or "beads" used to reflectorize the line to increase night visibility. Where "beads" are not used, a somewhat higher P. V. C. is generally desirable.

#### Reflectorized Lines

The effect of the reflectorized lines is not realized by many motorists. It has not escaped the observing driver, however. Many people have asked what caused the line to "come up at you" at night and to point out how much better some lines show at night than others. Some people have even noticed how the night line has appeared white and clean while in daylight it has has been dirty and somewhat discolored. That, of course, is because we see at night the reflected surface of that portion of paint under the beads. It has been protected from dust and surface wear and consequently is clean.

The failure of such lines to function satisfactorily in rain or when pavements are wet is the greatest deficiency in the traffic striping program. Water disperses light effectively, so instead of getting a reflection from our headlights, we get nothing that is distinctive. It is an unfortunate fact from the Highway Engineer's viewpoint because during such weather conditions a line is needed more than during good weather. Some compensation may be realized in the fact that fog is not so efficient in the dispersion process and a line may be followed reasonably well if the fog is not too dense.

#### Rainy Weather Failure

The discoloration and unsightly appearance that a "beaded" line acquires after a few months exposure is due largely to traffic dust, although certain constituents of the paint vehicles may be part of the trouble. Overcoming this is another problem. It is not insoluble, for the surface could be washed if conditions would warrant such procedure. I fear, however, the rainy weather failure will remain with us indefinitely. It is impossible to repeal the laws of physics, but an answer to the difficulty may lie in a completely different approach. The man who accomplishes the feat of developing an applicable and practical solution to the problem will have earned his niche in the hall of Highway Engineering Fame.

There are numerous other details involved in the traffic paint program—too many, in fact, to attempt to describe them completely. The factors of prime consideration which guide the program may be listed in an approximate order of importance as applicability, durability, visibility, drying time and cost. Interchange of some of the listed properties would not be disturbing.

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