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16. ABSTRACT

Introduction

This report describes the durability of the paint systems applied to the Leffingwell and San Simeon Creek Bridges in 1958 and 1959 respectively. These bridges are located in District V on State Sign Route 1 adjacent to the ocean, just north of the town of Cambria.

An article describing the condition of the paints on the Leffingwell Creek Bridge as of May 1961 appeared in the January-February 1962 issue of the California Highways and Public Works magazine. A reprint of this article which describes the location of the paint systems applied and the types of paint used in each is included in this report. Photographs showing the condition of the paints on both bridges as of March 1964 are included in this report along with a copy of the ratings assigned to the various paint systems on the Leffingwell Creek Bridge as of February 20, 1964 by Mr. Albert L. Woods.

Reference to Photographs Nos. 1 to 25 inclusive shows the progress made by the Laboratory and the Bridge Department in producing more durable paint systems when Leffingwell Creek Bridge was repainted in 1958 compared to the poor condition of the average paint system used in the 1952 painting of this bridge as shown in Photograph No. 26. Elapsed time between photographs of the 1952 painting and the 1958 repainting was approximately six years.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

PROGRESS REPORT
RESEARCH ON NEW PAINTS

A STUDY OF VARIOUS PAINT SYSTEMS APPLIED TO LEFFINGWELL AND SAN SIMEON CREEK BRIDGES IN A CORROSIVE MARINE ATMOSPHERE

64-17
DND

APRIL, 1964

State of California
Department of Public Works
Division of Highways

MATERIALS AND RESEARCH DEPARTMENT

April 29, 1964
Project Work
Order 43037R

Mr. J. E. McMahon
Assistant State Highway Engineer
California Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is a Progress

Report on:

A STUDY OF VARIOUS PAINT SYSTEMS APPLIED
TO LEFFINGWELL AND SAN SIMEON CREEK BRIDGES IN
A CORROSIVE MARINE ATMOSPHERE

Study made by .... Technical Section Materials and Research Department and the Bridge Department

Under general direction of .... Donald L. Spellman

Work supervised by .... Herbert A. Rooney and Albert L. Woods

Report prepared by .... Herbert A. Rooney and Albert L. Woods

Very truly yours,

JOHN L. BEATON
Materials & Research Engineer

cc: LRGillis
ELTinney

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A STUDY OF VARIOUS PAINT SYSTEMS APPLIED TO LEFFINGWELL AND SAN SIMEON CREEK BRIDGES IN A CORROSIVE MARINE ATMOSPHERE

INTRODUCTION

This report describes the durability of the paint systems applied to the Leffingwell and San Simeon Creek Bridges in 1958 and 1959 respectively. These bridges are located in District V on State Sign Route 1 adjacent to the ocean, just north of the town of Cambria.

An article describing the condition of the paints on the Leffingwell Creek Bridge as of May 1961 appeared in the January-February 1962 issue of the California Highways and Public Works magazine. A reprint of this article which describes the location of the paint systems applied and the types of paint used in each is included in this report. Photographs showing the condition of the paints on both bridges as of March 1964 are included in this report along with a copy of the ratings assigned to the various paint systems on the Leffingwell Creek Bridge as of February 20, 1964 by Mr. Albert L. Woods.

Reference to Photographs Nos. 1 to 25 inclusive shows the progress made by the Laboratory and the Bridge Department in producing more durable paint systems when Leffingwell Creek Bridge was repainted in 1958 compared to the poor condition of the average paint system used in the 1952 painting of this bridge as shown in Photograph No. 26. Elapsed time between photographs of the 1952 painting and the 1958 repainting was approximately six years.

CONCLUSIONS

All systems are performing better than expected in such a highly corrosive area.

System No. 1 is by far the best. The relative absence of breakdown makes it impossible to accurately estimate how long this system will last since there is no way to determine how much zinc has been lost through sacrificial action. A conservative guess is 6 years longer, or a total of 12 years service-life.

System No. 4 rates second best, and repainting will probably not be necessary for about 4 to 5 years or longer. Service-life will then be 10 years or longer.

More rust exists in areas covered by System No. 2, but it now appears that no replacement of paint in those areas will be necessary for about 2 or 3 more years. It could possibly last longer. This will give a minimum service-life of 8 years or more.

The rust condition along the top flange edges which was discussed at length in previous reports is more or less ignored in this report since it is not typical of that normally encountered. However, it is worth noting that less rust on these edges is found in areas covered by System No. 1. This is probably traceable to galvanic protection afforded by the zinc which tends to inhibit rust penetration or undercutting of sound paint by spreading rust. Results of accelerated tests on scribed sections in laboratory salt-spray cabinets confirm field findings in this respect. Similar results are found in field applications of zinc-rich coatings in both organic and inorganic vehicles although they are less pronounced with the organic. A more extensive use of inorganic zinc silicate coatings on our coastal bridges seems to be economically justified.

LEFFINGWELL CREEK BRIDGE

Paint System No. 3, an epoxy formulation applied in October 1958 on Span 3, was replaced by a Laboratory formulated zinc silicate paint and a vinyl green topcoat, State Specification 61-F-75, in June 1962. The formulation data for the Laboratory inorganic zinc silicate coating, 1R310, is included in this report. The original epoxy system deteriorated so rapidly that severe breakdown was noted within one year after its application. This may be noted by referring to Figure 5 of the reprint from the article in the California Highways and Public Works magazine.

Prior to applying the vinyl green topcoat, State Specification 61-G-75, on Span 3 over the Laboratory formulated inorganic zinc silicate primer 1R310, the excess curing agent used over the inorganic zinc silicate primer was removed by scrubbing with water and wire brushes and a bonding coat of vinyl wash primer applied. In the scrubbing operation, some of the inorganic zinc silicate primer was removed from the steel because of its not having had sufficient time to cure properly in the foggy weather. It is necessary to remove the curing solution to secure adhesion of the vinyl wash primer, State Specification 52-G-52, to the inorganic zinc silicate primer. Despite the inadvertent removal of some of the zinc primer, Span 3 appears to be in excellent condition after almost two years of exposure.

Examination of Photographs 4, 6, 9 and 10 shows the almost perfect condition after nearly six years of the sections of Spans 2, 4 and 5 where coating System No. 1 was used. Reference to the reprint from California Highways and Public Works describes this system which consists of a commercial inorganic zinc silicate paint, a vinyl wash primer bonding coat and a vinyl topcoat. Although the all vinyl, System No. 4, which is known to be an excellent coating in marine atmospheres, shows breakdown on the upper and lower flanges due to underfilm corrosion, very little of this has occurred where the inorganic zinc silicate primer was used under a vinyl topcoat.

The superior protection afforded by the inorganic zinc silicate primer with a vinyl topcoat may be attributed to the galvanic protection provided the steel by the zinc in the primer coating. Salt spray tests in the Laboratory indicate that the inorganic zinc silicate primer provides better protection against corrosion than do hot dip galvanized coatings. The type of inorganic zinc silicate coating used on this bridge which requires the application of a curing agent and its subsequent removal before topcoats can be applied, will no longer be used because of the impracticality and expense incurred by the removal of the curing agent on large complicated structures. The self-curing system of inorganic zinc silicate coatings which require no application of a curing agent will be applied on subsequent experimental work on bridges in marine atmospheres.

SAN SIMEON CREEK BRIDGE

The San Simeon Creek Bridge shows a much greater degree of corrosion than does the Leffingwell Creek Bridge. This may be attributed to the fact that most of the paint applied to sections of the Leffingwell Creek Bridge, except the epoxy and inorganic zinc silicate types, were either the more durable all-vinyl systems, such as System No. 4, or partly-vinyl, such as System No. 2. Although not equal in protection to the inorganic zinc silicate primed system, the all-vinyl system has been noted for its superior performance compared to other organic systems such as those on the San Simeon Creek Bridge.

The three southerly spans of the San Simeon Creek Bridge, Spans 1, 2 and 3, were completely sandblasted and painted with 4 mils of a basic lead silico chromate primer corresponding to Federal Specification TT-P-00615a, Type I, followed by 2 mils of a phenolic iridescent green topcoat, State Specification 58-G-79. The other spans of the bridge were spot sandblasted and spot primed with a red lead primer, State Specification 58-G-53, followed by the application of the phenolic iridescent green topcoat. The photographs are graphic evidence that the basic lead silico chromate priming system is at least equal to that of the red lead priming system in corrosion protection. However, neither of these systems provide the protection equal to that provided by the inorganic zinc silicate or vinyl systems which were applied on the Leffingwell Creek Bridge.

INORGANIC ZINC SILICATE
LABORATORY FORMULA 1R310

Vehicle

Water Glass, 41° Baume	8.5 lbs.
Water	2.3 "
Tamol 731, Rohm & Haas	0.065 "

Pigment

New Jersey Zinc Co., Zinc Dust No. 44	16.3 lbs.
Red Lead, 97% Grade	1.8 "

After the above components were mixed on the job-site, strained through two layers of cheesecloth and sprayed onto the steel, a curing solution of the following composition was applied. This curing solution is allowed to remain on the coating for at least 24 hours before scrubbing it off and applying the Vinyl Wash Primer, State Specification 52-G-52.

Curing Solution

Phosphoric Acid, 85% Grade	25% by weight
Isopropyl Alcohol	75% by weight

1964 Annual Report on Experimental Work
Leffingwell Creek Bridge #49-44
Painted October 1958
Inspection Date February 20, 1964

Ratings are made on an inverse scale of 10 to 0. A rating of 10 would indicate no rust, and lesser ratings indicate more rust.

Span 1 - System No. 4, Total 6 mils.

Ends of several bracing members showing tubercules. Some rust around bearings. A few spots on bottom of bottom flange and on bottom flange edges. Top flange edge rust growing slowly.
Rating: 8

Span 1 - Four mils Red Lead Primer, State Specification 58-G-53, and two mils of State Specification 58-G-79 green topcoat. More rust than on Vinyls in adjacent areas.
Rating: 7

Span 2 - System No. 1, Total 6 mils.

Good shape. Rust or rust stain along top edge of top flange does not appear to be growing much. Bracing good. Light rust on steel slivers has not penetrated steel proper.
Rating: 9+

Span 2 - System No. 2, Total 8 mils.

Considerable rust throughout on webs. Worst area on webs near pier.
Rating: 6.5

Span 3 - Inorganic Zinc Silicate - Laboratory Production. Application too recent to rate properly (1962).

Span 4 - System No. 2, Total 8 mils.

Freckle rust throughout. This system is a "bust" for coastal exposures.
Rating: 6

Span 4 - System No. 1, Total 6 mils.

Only rust is on abrasions and laminations. Excellent shape.
Rating: 9+

Span 5 - System No. 1, Total 6 mils.

Condition similiar to Span 4, System No. 1. Very good.
Rating: 9+

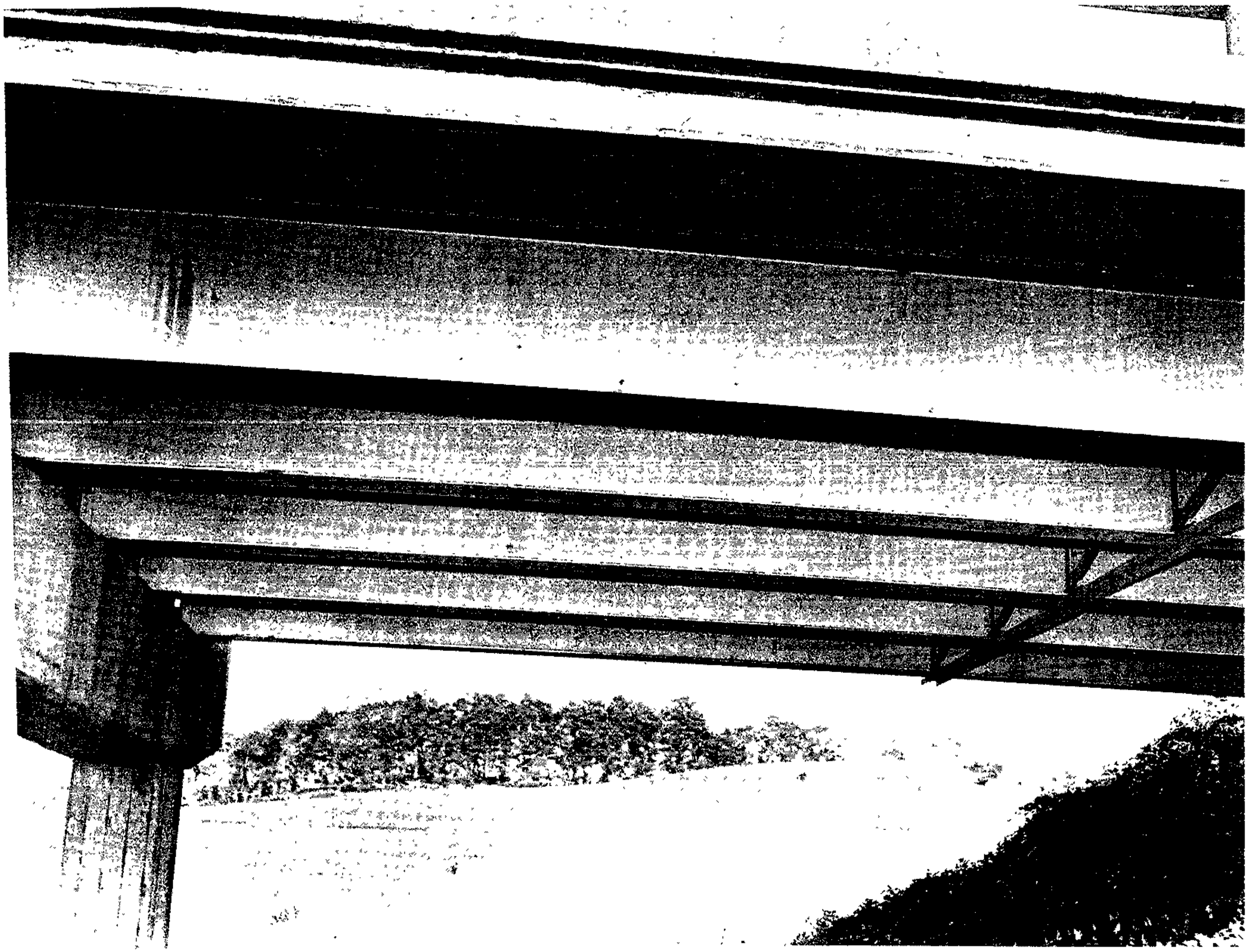
Span 5 - System No. 2, Total 8 mils.

Better shape than same system in other spans. Some rust on bottom and top flanges and on flange edges.
Rating: 7.5

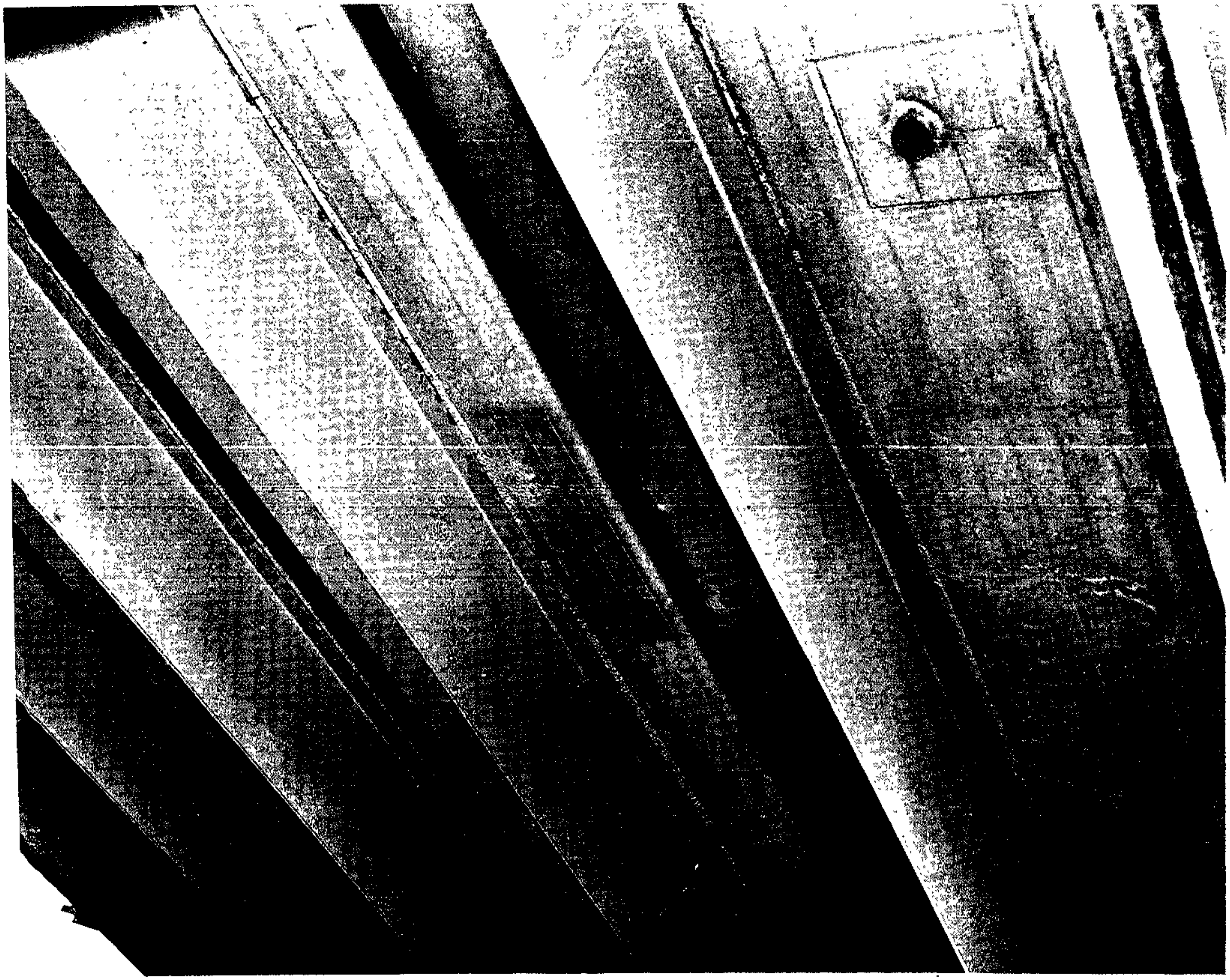
Spans 6, 7, 8 - System No. 4, Total 6 mils.

Very good shape for 6 years exposure. Light rust scattered throughout mainly on flange edges, bracing member edges and ends and around bearings.
Rating: 8

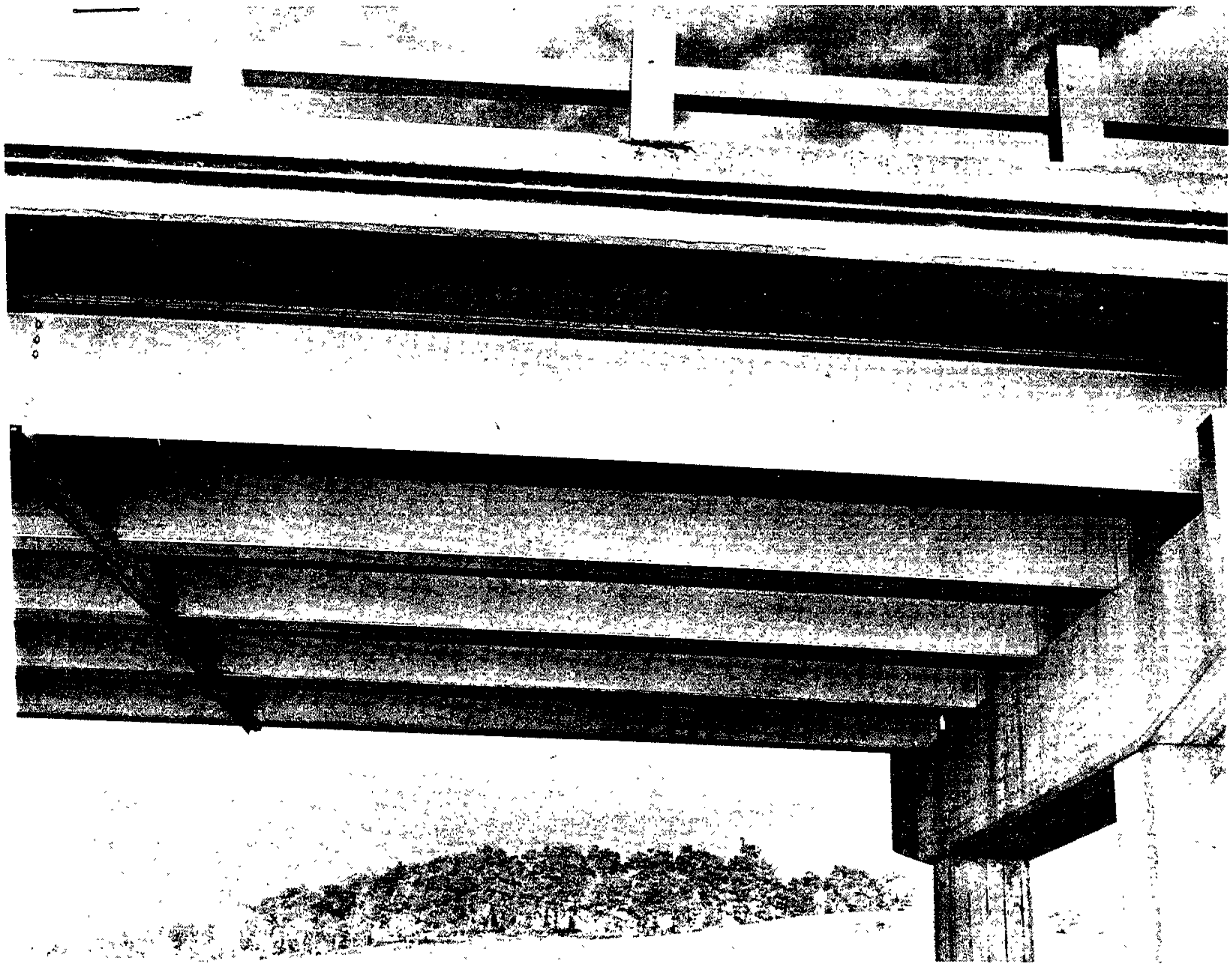
Photograph No. 1. Leffingwell Creek Bridge. Span 1, South Section System No. 4. Painted October 1958 - Photographed March 2, 1964.



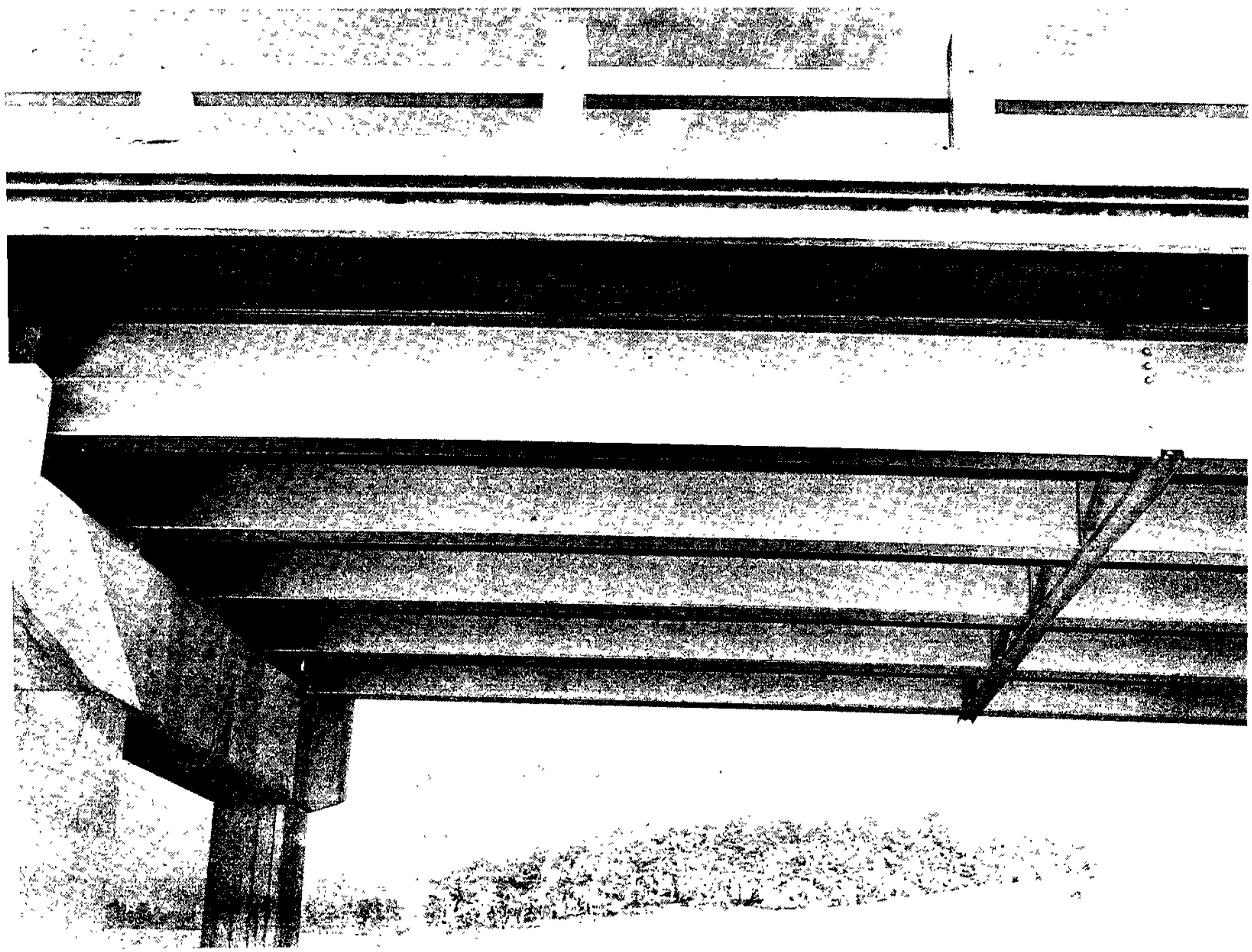
Photograph No. 2. Leffingwell Creek Bridge. Span 1, North Section System No. 4 (except front beam which is System No. 5). Painted October 1958 - Photographed March 2, 1964.



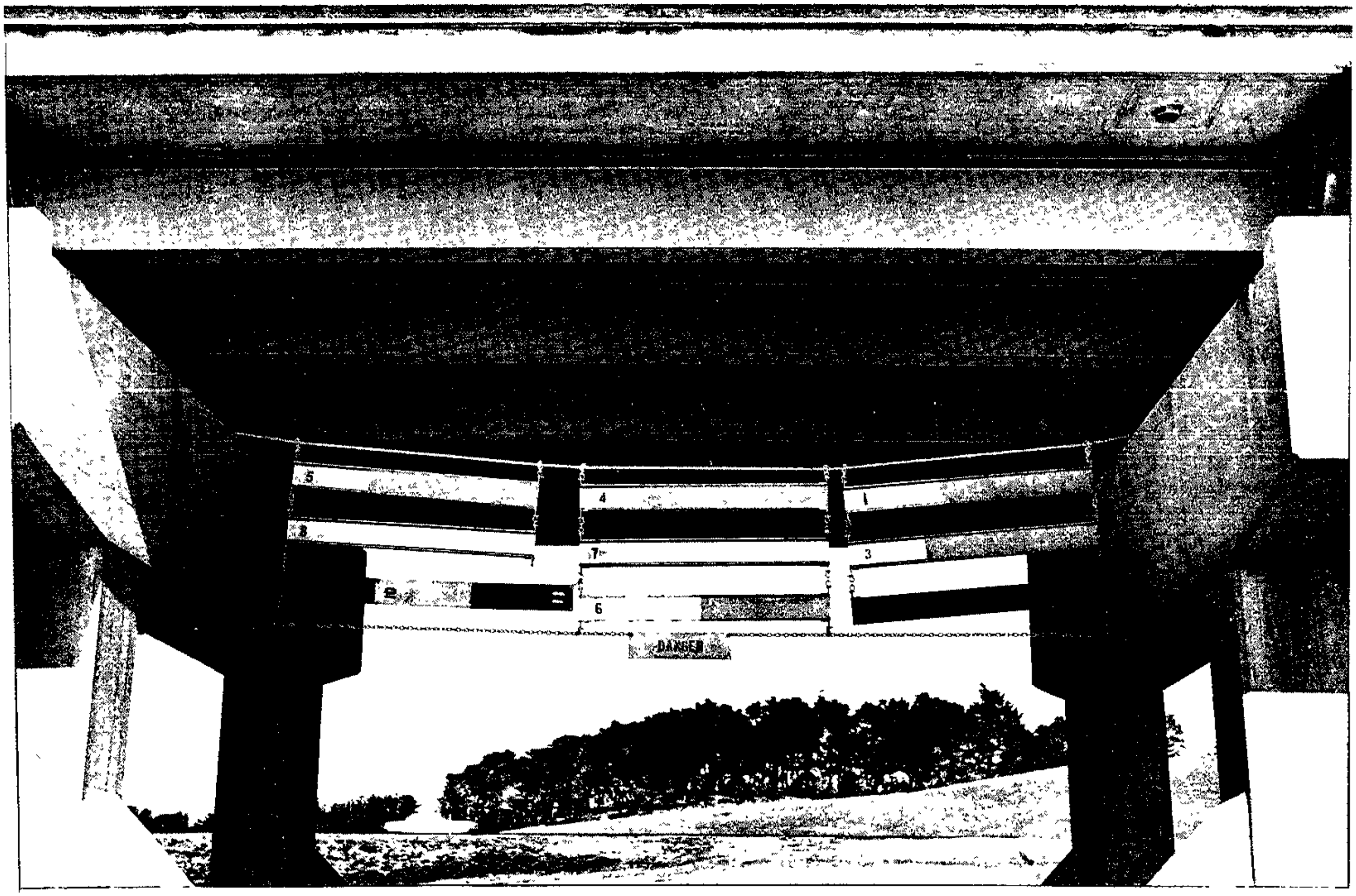
Photograph No. 3. Leffingwell Creek Bridge. Span 1, North Section (close-up picture) System No. 4 (except front beam which is System No. 5). Painted October 1958 - Photographed March 2, 1964.



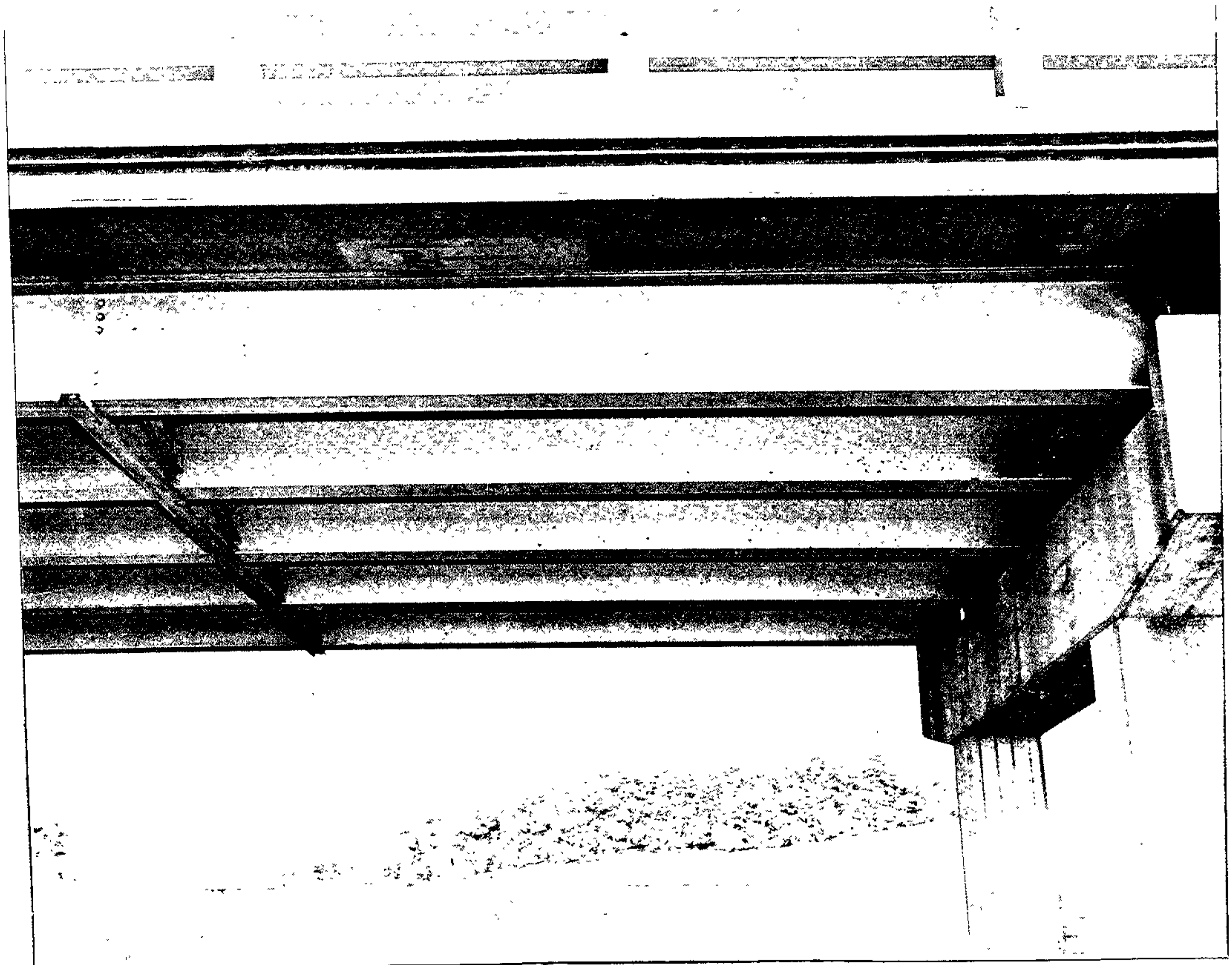
Photograph No. 4. Leffingwell Creek Bridge. Span 2, South Section System No. 1. Painted October 1958 - Photographed March 2, 1964.



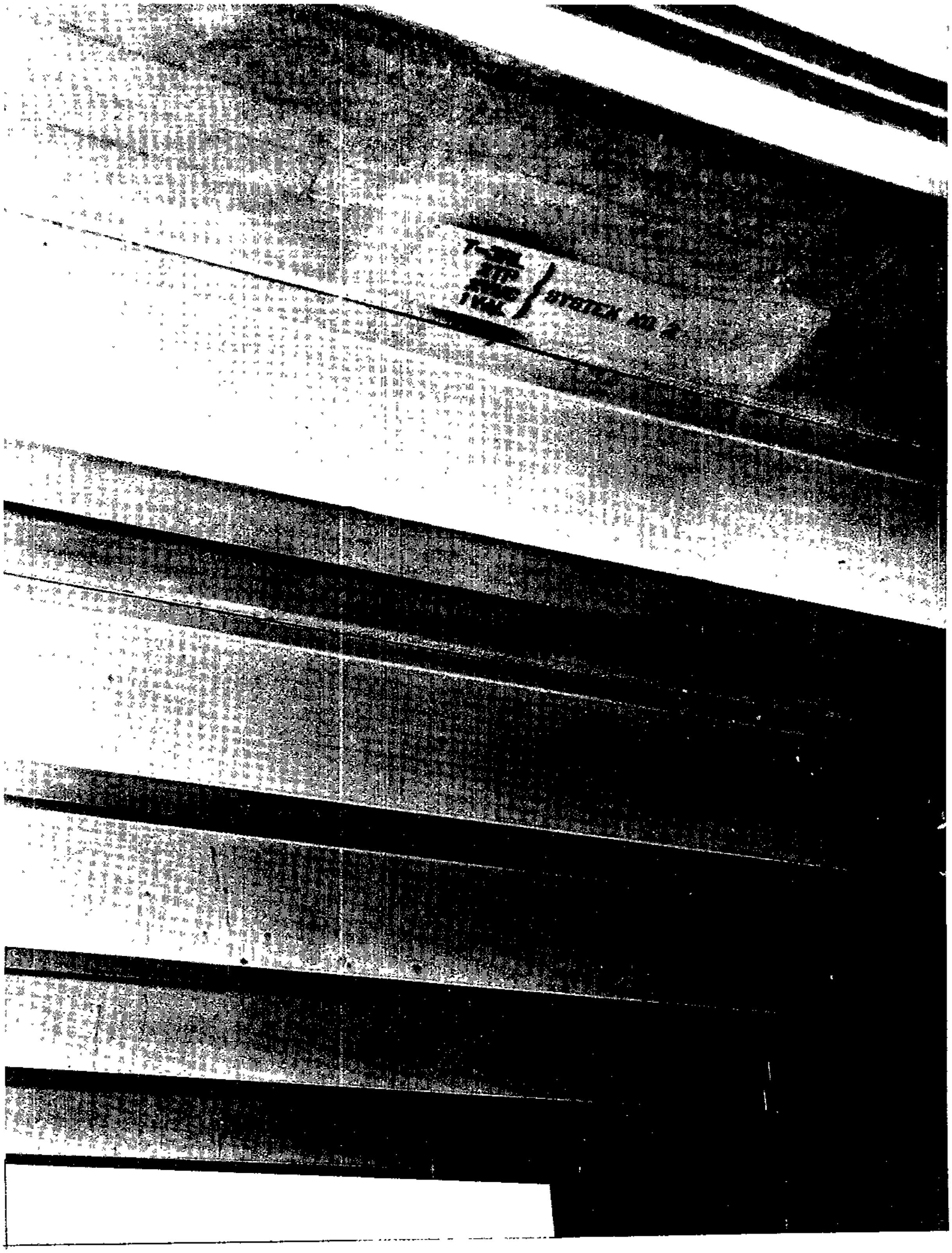
Photograph No. 5. Leffingwell Creek Bridge. Span 2, North Section System No. 2. Painted October 1958 - Photographed March 2, 1964.



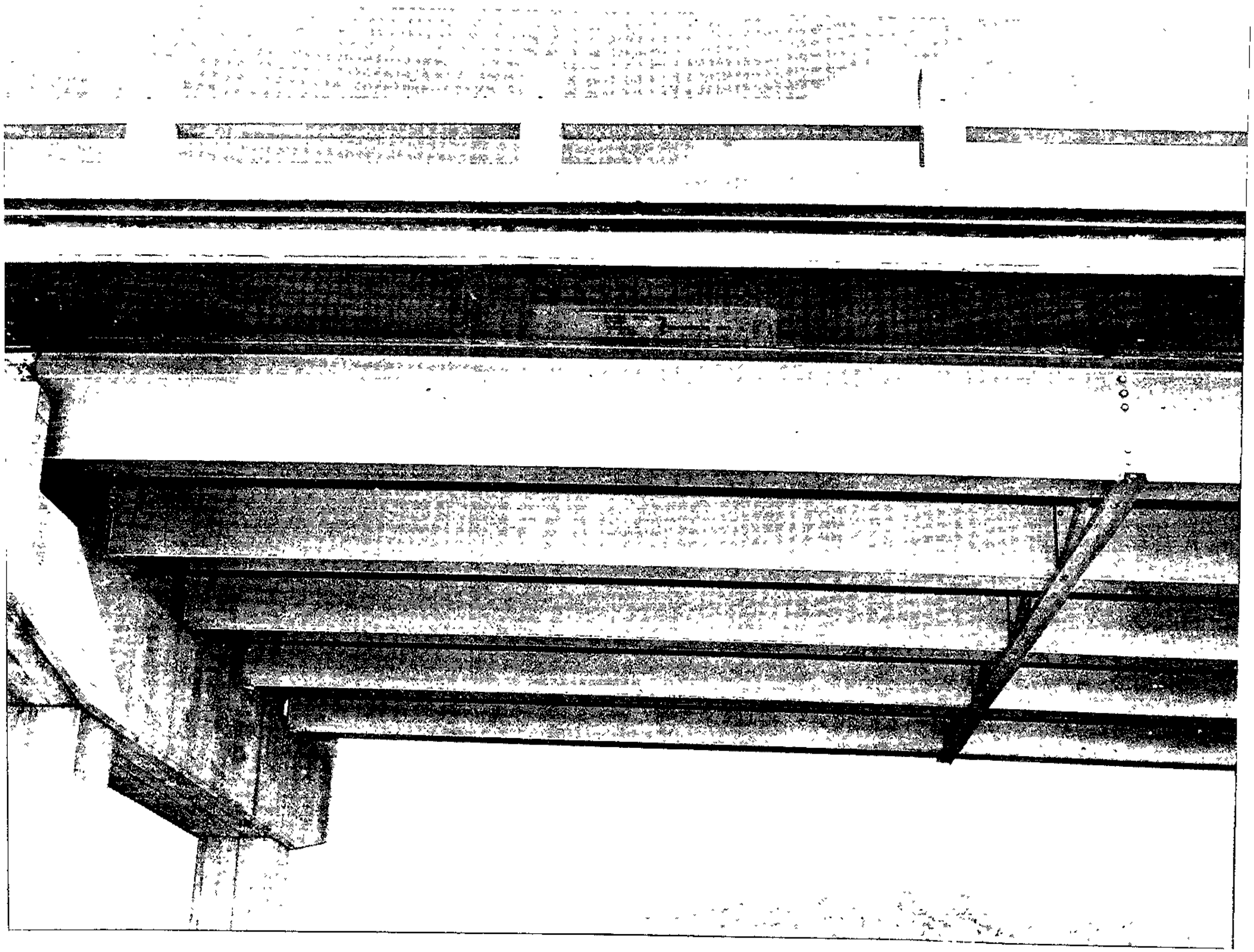
Photograph No. 6. Leffingwell Creek Bridge. Span 3. Originally painted in October 1958 with System No. 3. Repainted in June 1962 with Laboratory Formulated Inorganic Zinc Silicate, Formula 1R310, and Vinyl Green Topcoat, State Specification 61-G-75. Original System No. 3, an epoxy system failed within a few months after application. Photographed March 2, 1964.



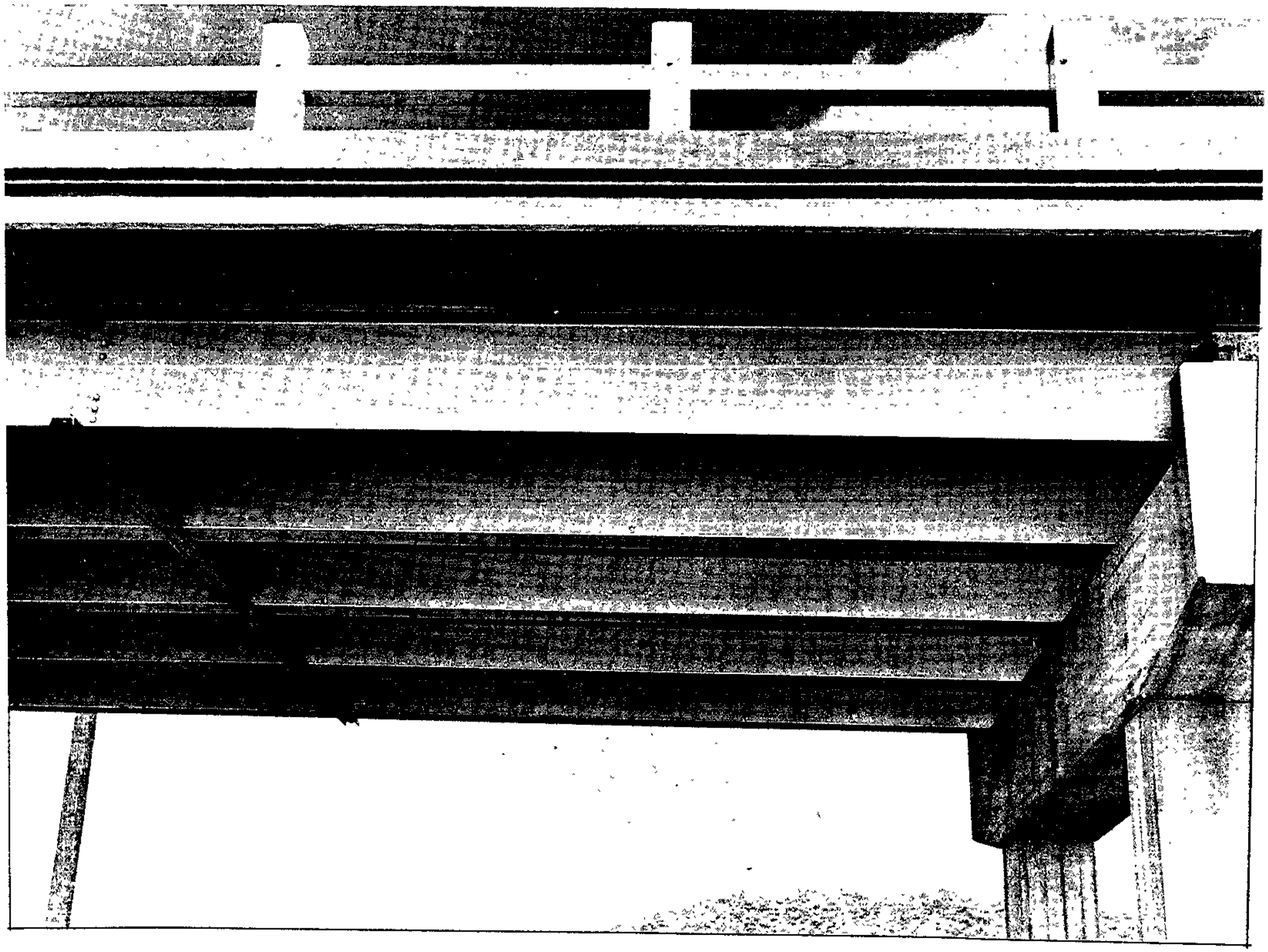
Photograph No. 7. Leffingwell Creek Bridge. Span 4, South Section System No. 2. Painted October 1958 - Photographed March 2, 1964.



Photograph No. 8. Leffingwell Creek Bridge. Span 4, South Section (close-up picture) System No. 2. Painted October 1958 - Photographed March 2, 1964.

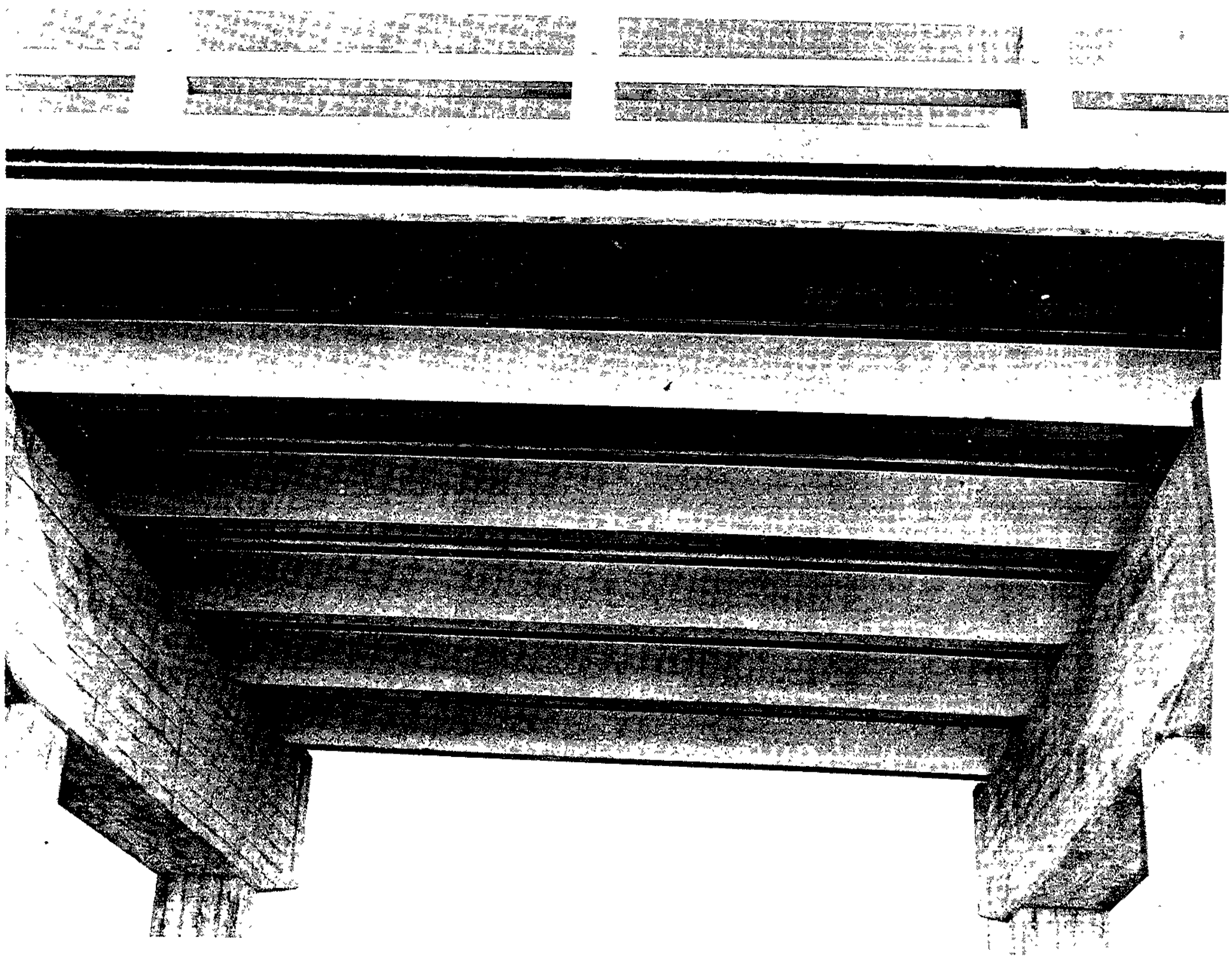


Photograph No. 9. Leffingwell Creek Bridge. Span 4, North Section System No. 1. Painted October 1958 - Photographed March 2, 1964.

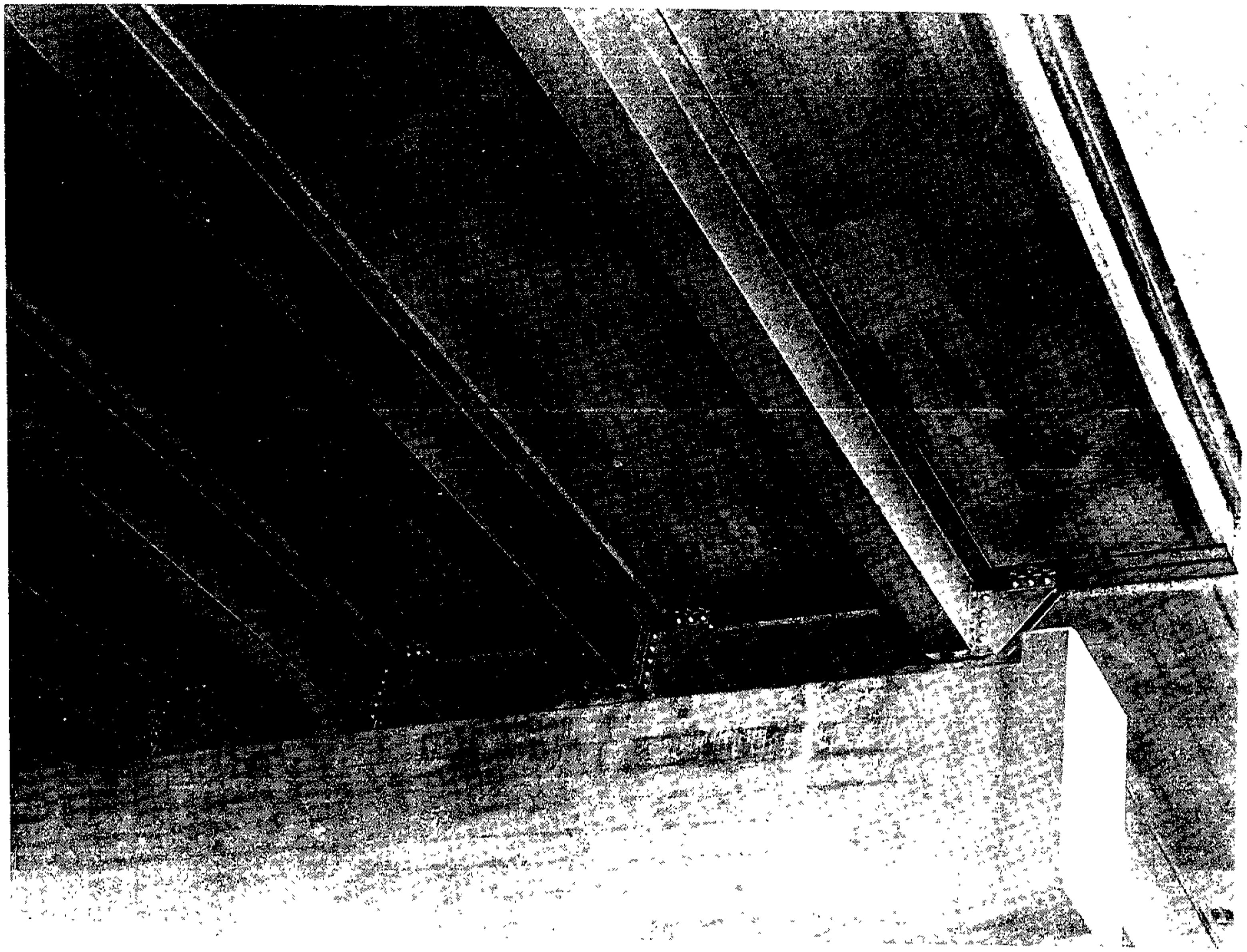


Photograph No. 10. Leffingwell Creek Bridge. Span 5, South Section
System No. 1. Painted October 1958 - Photographed March 2, 1964.

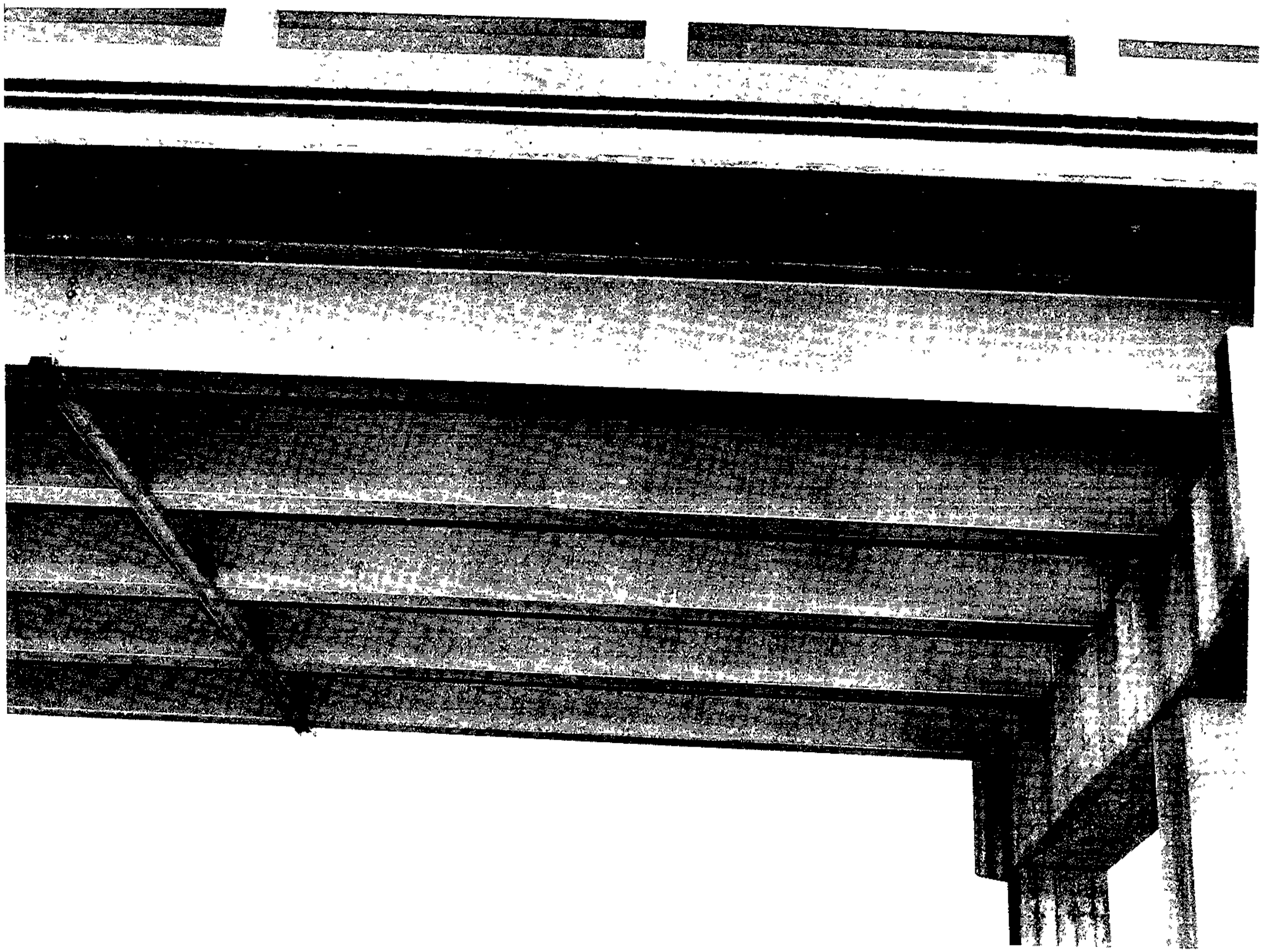
Photograph No. 11. Leffingwell Creek Bridge. Span 5, North Section System No. 2. Painted October 1958 - Photographed March 2, 1964.



Photograph No. 12. Leffingwell Creek Bridge. Span 6, System No. 4.
Painted October 1958 - Photographed March 2, 1964.

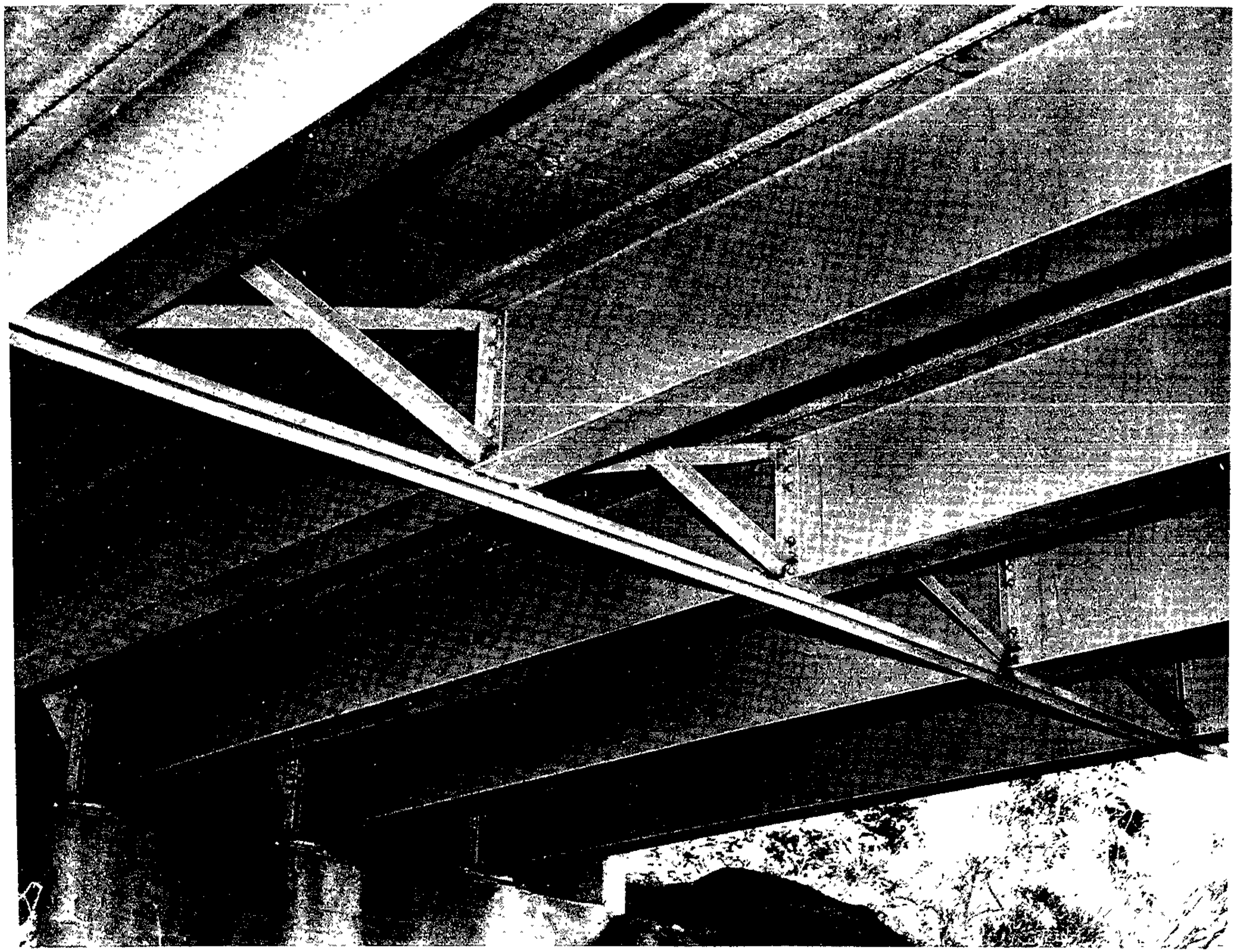


Photograph No. 13. Leffingwell Creek Bridge. Span 6 (close-up picture) System No. 4. Painted October 1958 - Photographed March 2, 1964.

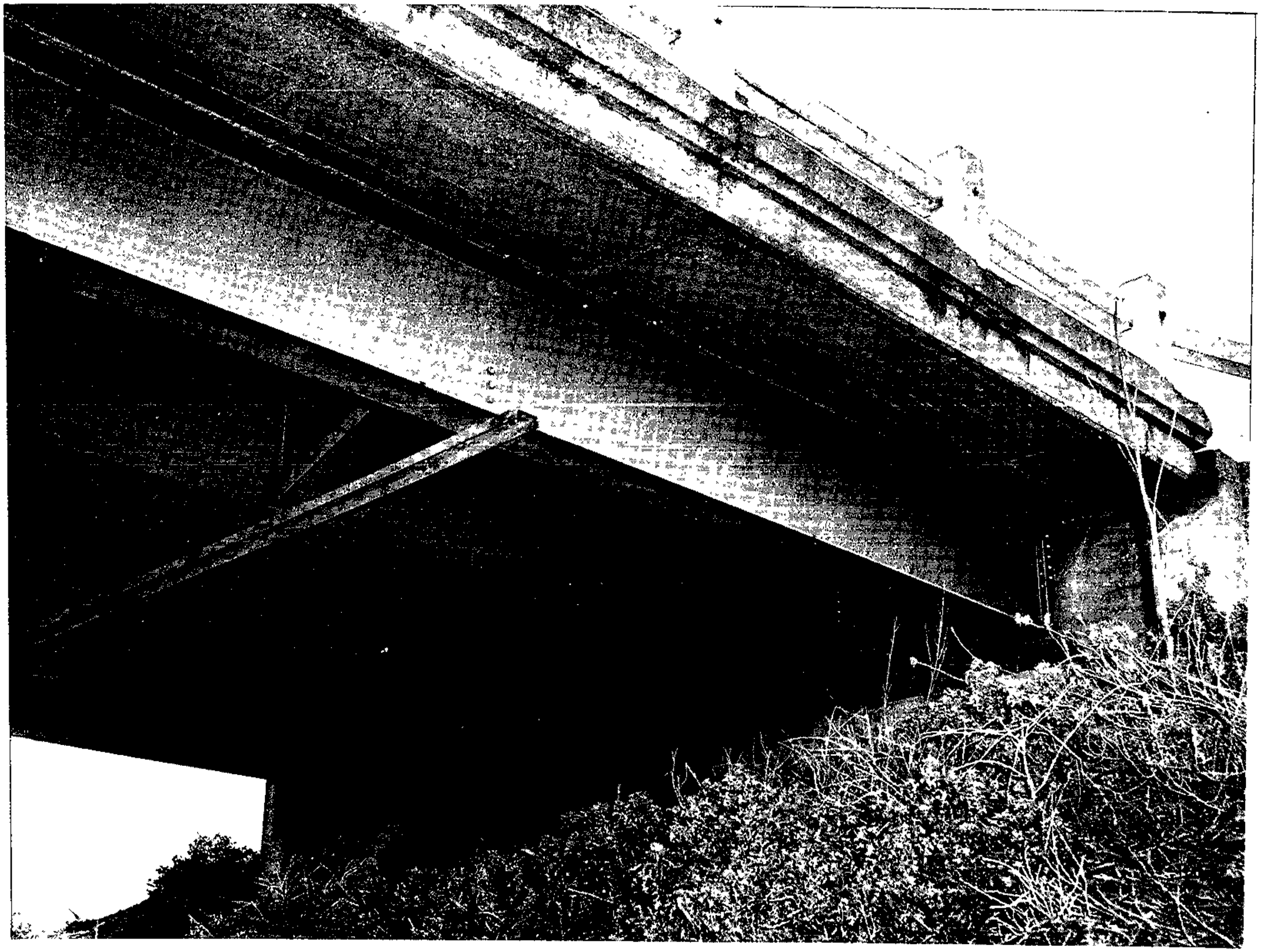


Photograph No. 14. Leffingwell Creek Bridge. Span 7, South Section
System No. 4. Painted October 1958 - Photographed March 2, 1964.

Photograph No. 15. Leffingwell Creek Bridge. Span 7, North Section
System No. 4. Painted October 1958 - Photographed March 2, 1964.

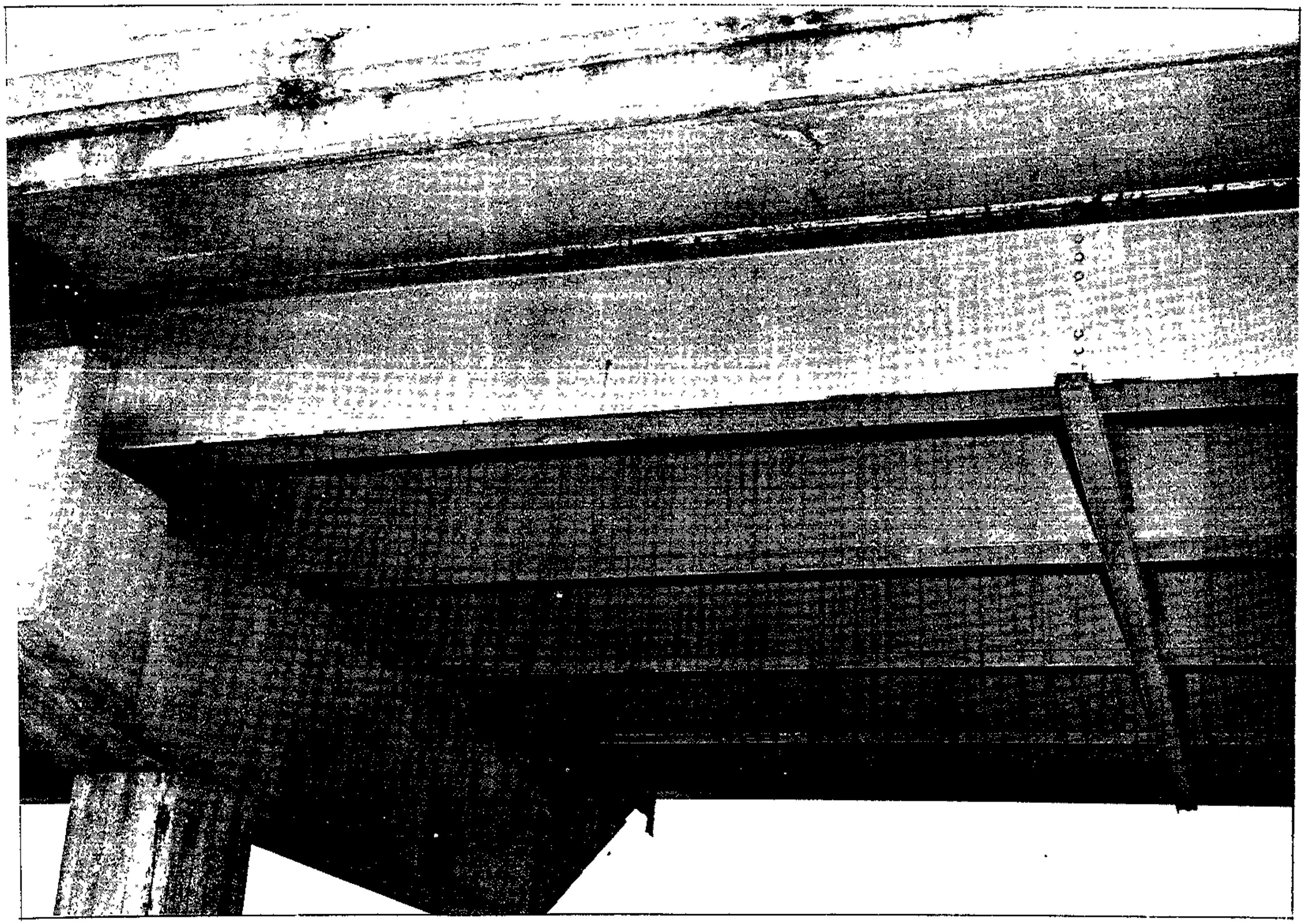


Photograph No. 16. Leffingwell Creek Bridge. Span 8 (close-up picture) System No. 4. Painted October 1958 - Photographed March 2, 1964.



Photograph No. 17. San Simeon Creek Bridge. South End, Span 1. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.

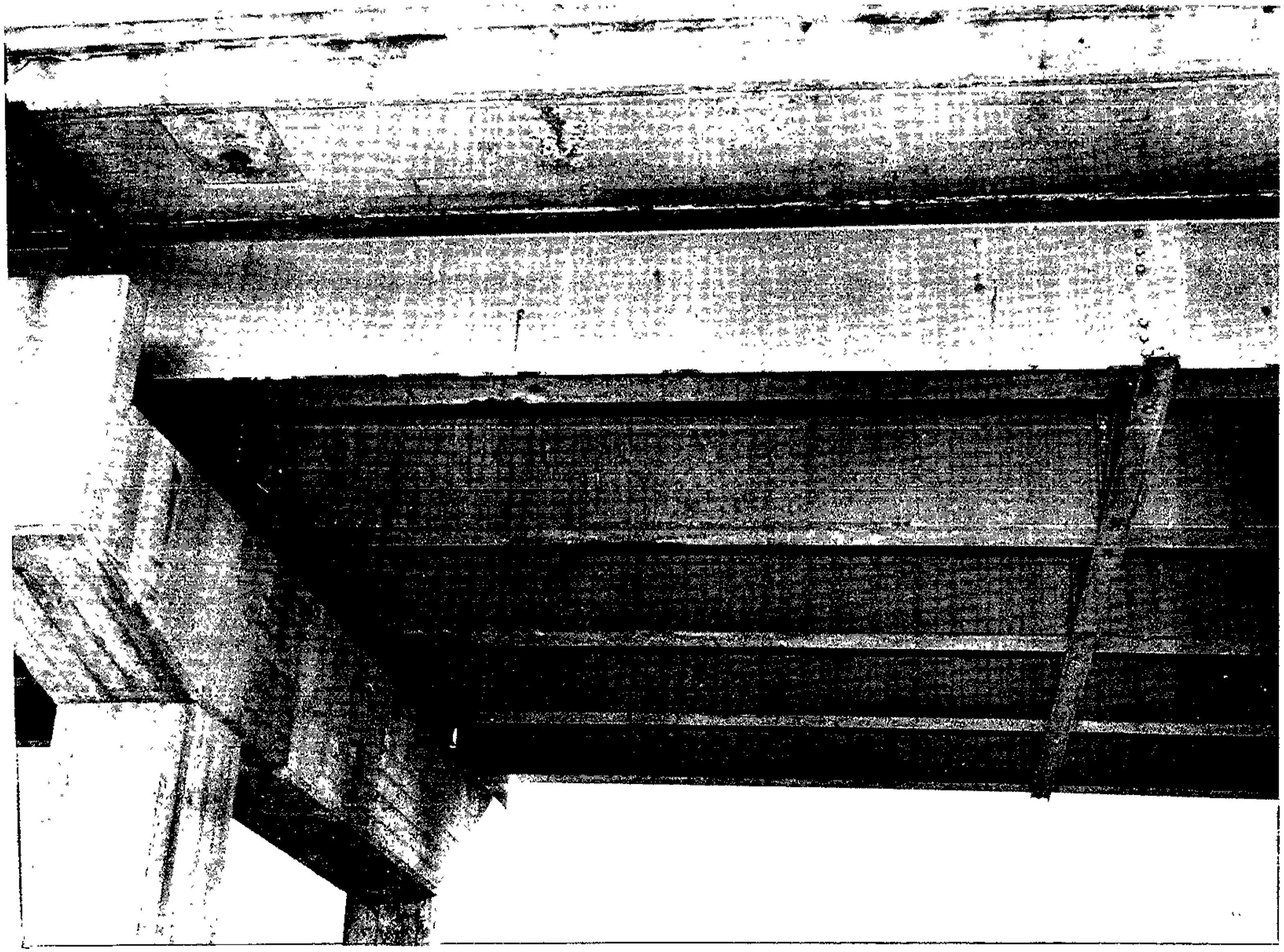
Photograph No. 18. San Simeon Creek Bridge. Span 1, Section 2. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.



Photograph No. 19. San Simeon Creek Bridge. Span 1, Section 3. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.

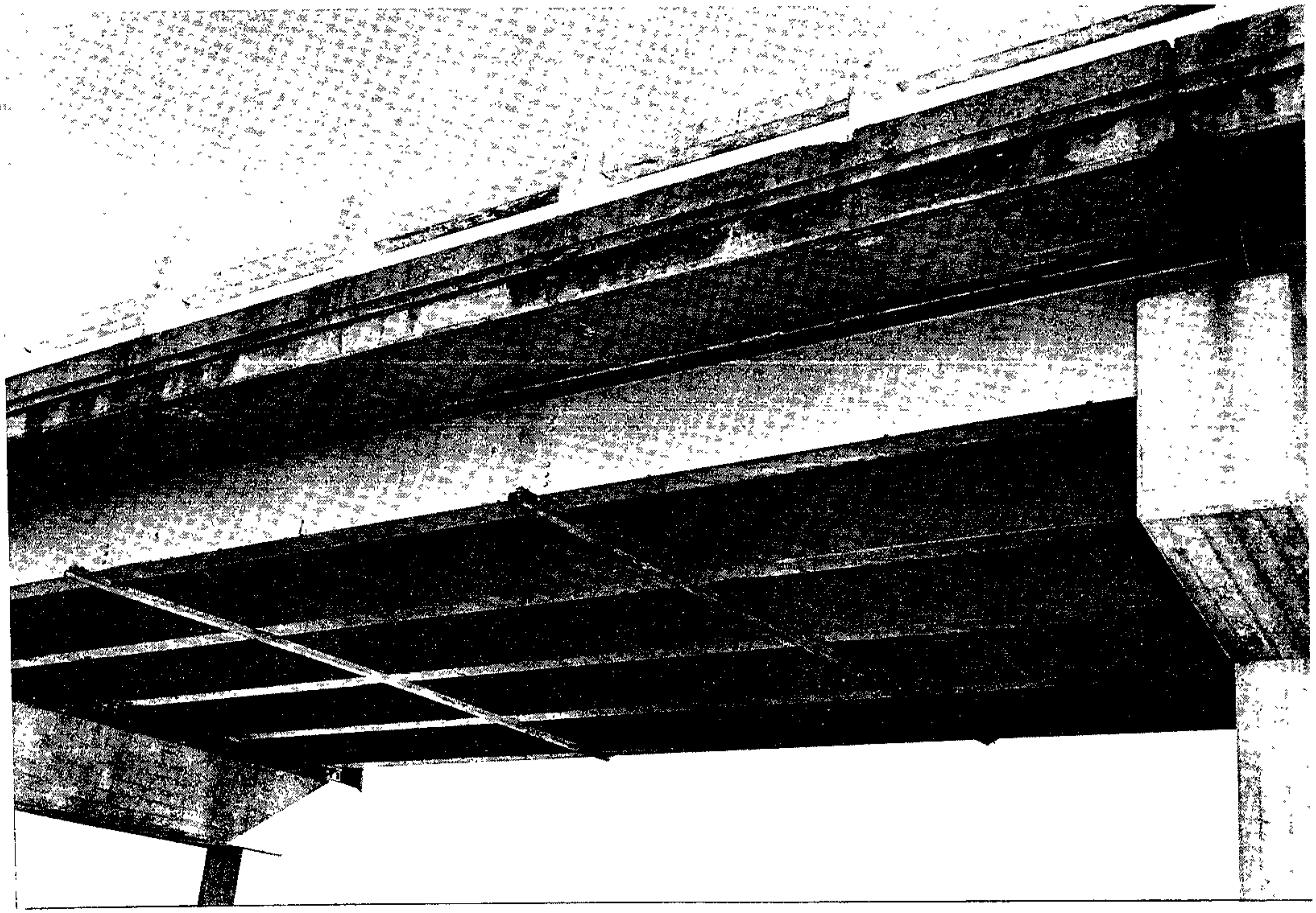
Photograph No. 20. San Simeon Creek Bridge. Span 2, Section 1. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.

Photograph No. 21. San Simeon Creek Bridge. Span 2, Section 2. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.

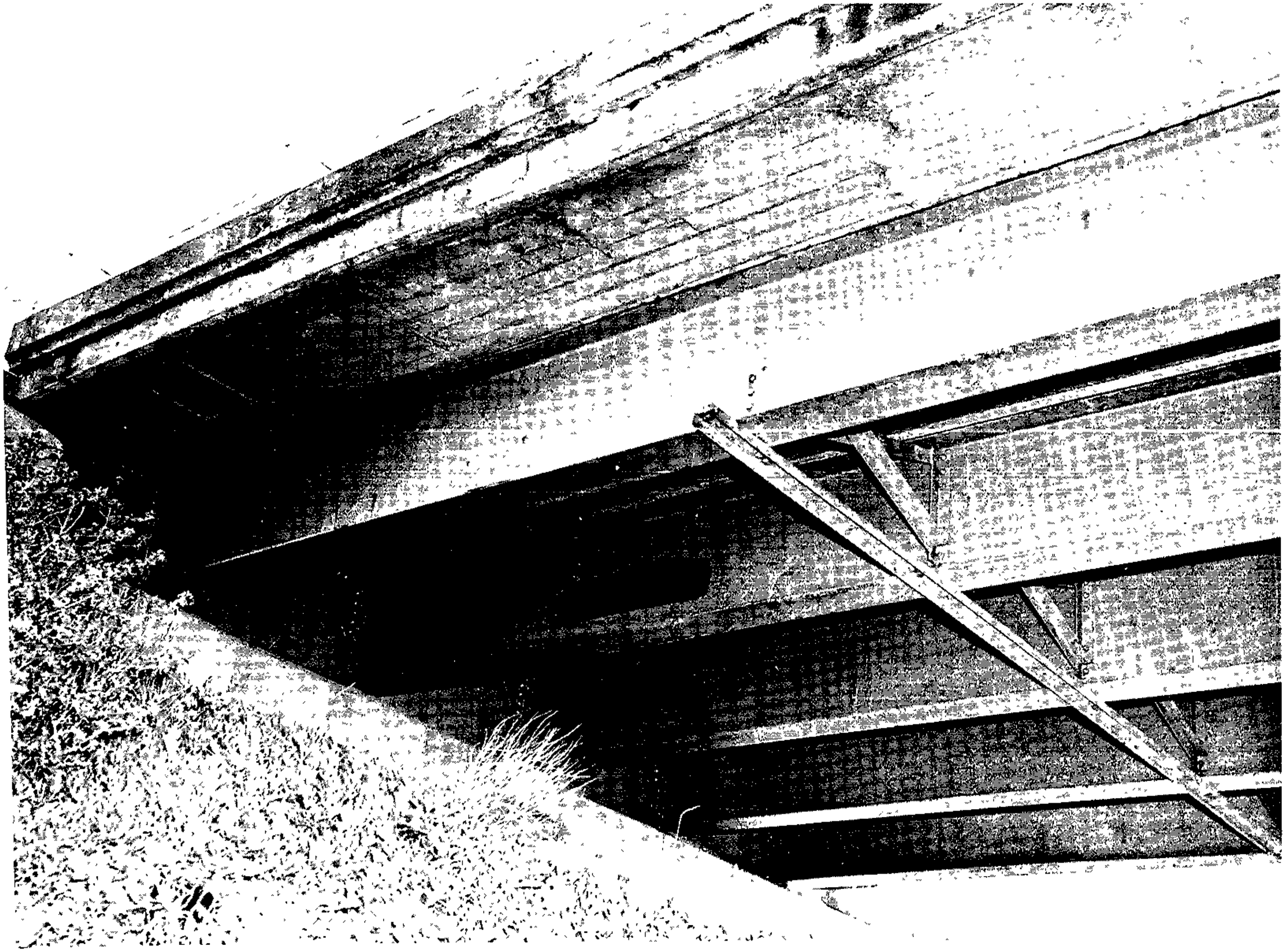


Photograph No. 22. San Simeon Creek Bridge. Span 2, Section 3. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.

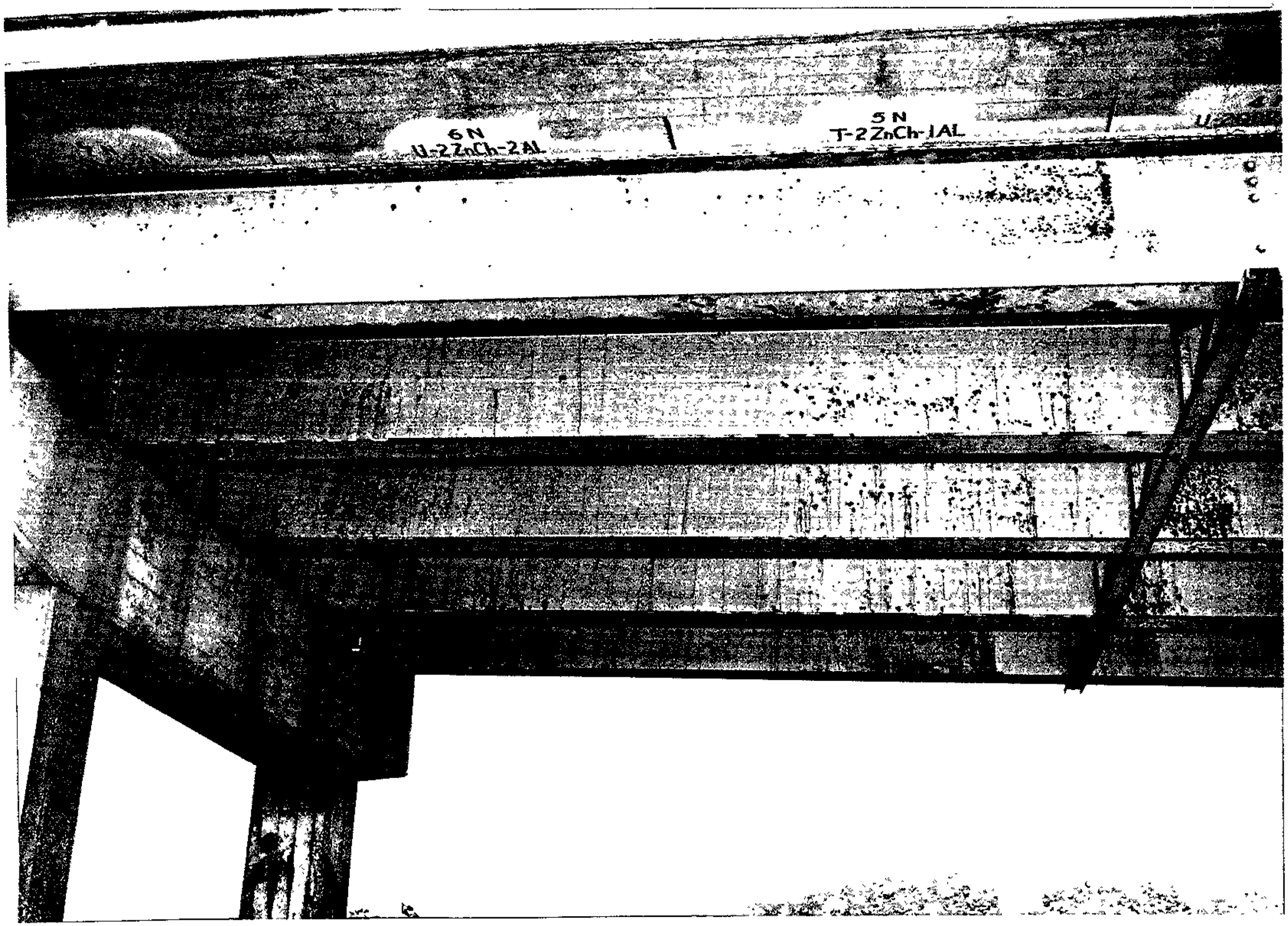
Photograph No. 23. San Simeon Creek Bridge. Span 3. 4 mils Basic Lead Silico Chromate, Federal Specification TT-P-00615a, Type I, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.



Photograph No. 24. San Simeon Creek Bridge. Span 4. 4 mils Red Lead Primer, State Specification 58-G-53, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.



Photograph No. 25. San Simeon Creek Bridge. North End Abutment Span. 4 mils Red Lead Primer, State Specification 58-G-53, and 2 mils Phenolic Iridescent Green, State Specification 58-G-79. Painted June-October 1959 - Photographed March 3, 1964.



Photograph No. 26. Condition of the average paint system applied to Leffingwell Creek Bridge in 1952 as of October 1958.

Experimental Paint

Corrosion Resistance Tested On Leffingwell Creek Bridge

By HERBERT A. ROONEY, Senior Chemical Testing Engineer, and
A. L. WOODS, Bridge Paint Inspector

In accordance with the continuing research program of the Technical Section of the Materials and Research Department concerning the development and application of improved corrosion resistant paints this report describes the experimental paint systems applied to the Leffingwell Creek Bridge in October 1958, and the results observed as of May 1961, after an exposure period of 2½ years.

The Leffingwell Creek Bridge is situated just north of the town of Cambria on Road V-SLO-56-B (State Sign Route 1) in San Luis Obispo County and is close to the shoreline of the ocean as shown in Figure 2. It is a low level structure containing eight steel stringer spans with a concrete deck supported on concrete piers and abutments. The 24-foot wide concrete deck shields the steel girders to a limited extent from rain thereby allowing salt to accumulate in heavier deposits than would occur if the steel were more exposed as in a superstructure. This bridge and several others similarly situated with respect to the ocean present an ideal location where protective coatings may be tested in a very corrosive environment.

Poor Correlation

Although accelerated laboratory corrosion tests to determine the protective quality of paints are often made in salt spray cabinets, there is frequently poor correlation between laboratory tests of this type and actual corrosion observed when the paints are applied in a natural corrosive environment. This is true for many reasons. Panels exposed in a salt spray cabinet are normally painted under ideal atmospheric conditions in the

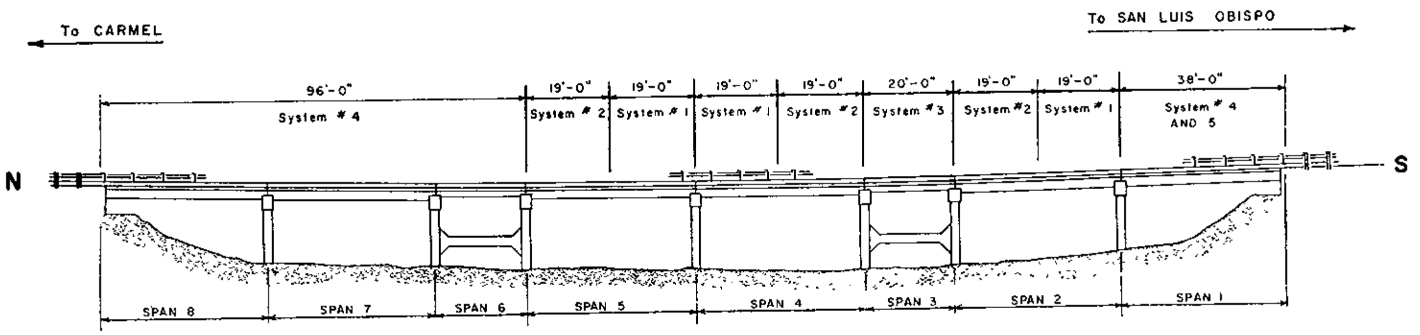


FIGURE 1—A diagram of the Leffingwell Creek Bridge on State Sign Route 1 in San Luis Obispo County showing the location on the structure of the various systems of painting discussed in this article.

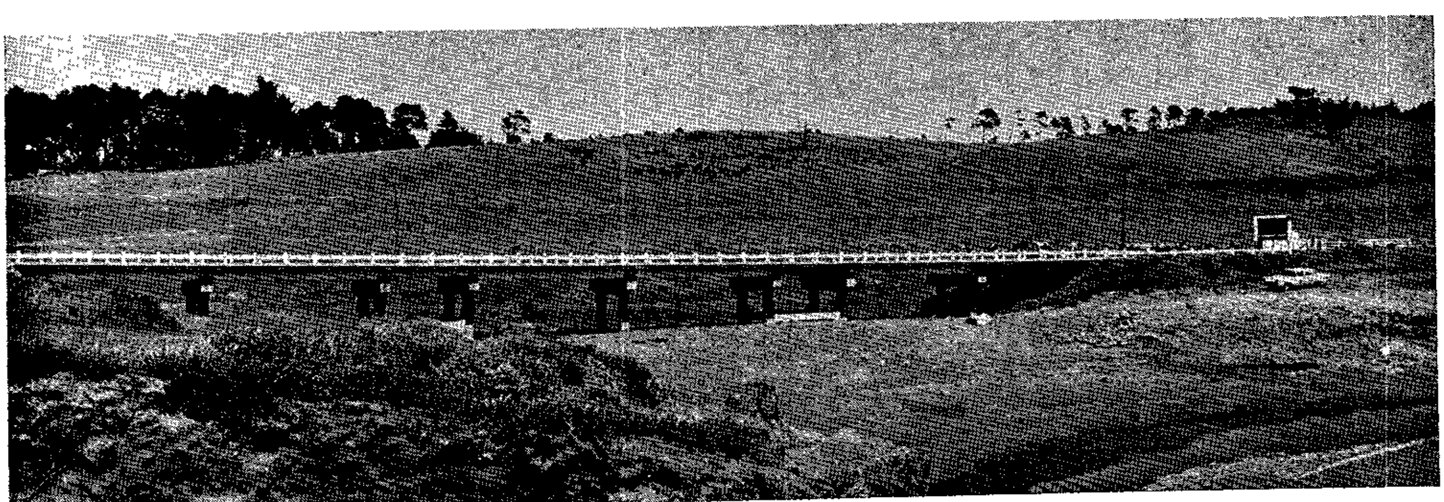


FIGURE 2—A photograph of the actual bridge shown in the diagram above. Note the beach and surf line in the lower right corner.

Reprint from *California Highways and Public Works*, January-February 1962

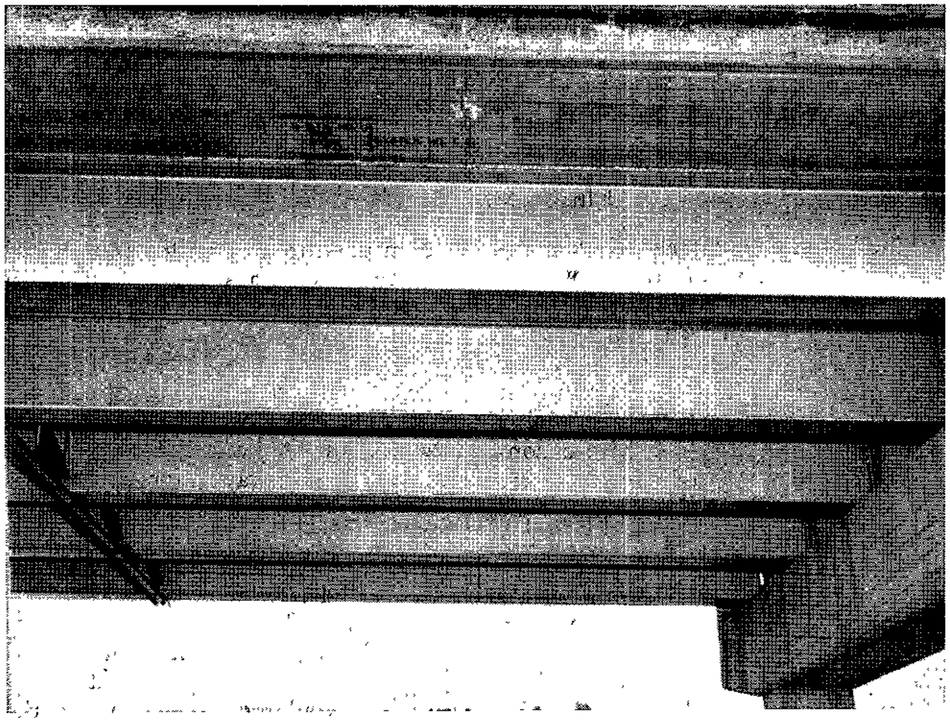


FIGURE 3—Under view of the south portion of Span 2 on which Painting System No. 1 was used.

laboratory before they are placed in the cabinet. Paint is applied to structures like the Leffingwell Creek Bridge and bridges in similar areas along the coast where the humidity is frequently in the range of 70-80% and above and the air temperature seldom greater than 60°F. The solvents in the paint cause moisture from the humid atmosphere to be carried into the paint film during application due to the cooling effect produced by the vaporization of the solvents.

Even if paint could be applied under ideal conditions to structures in this coastal zone, discrepancies between salt spray cabinet tests and field testing would still be evident since weather cycles cannot be duplicated in a salt spray apparatus. Both the composition of the salt and the nature of the exposure do not reproduce conditions occurring in the natural environment. However, salt spray cabinet and weatherometer tests do have some value in their ability to separate the very poor from the better types of corrosion resistant paints.

Description of Coatings

Figure 1 is a drawing of the Leffingwell Creek Bridge showing where each paint system was applied and Table I is a description of the coatings comprising each system. Figures 3 to 6 show the conditions of these various coating systems as of May 10, 1961.

As of the date of May 10, 1961, the best system appeared to be No. 1 (Figure 3), the inorganic chemically cured zinc coating with the complete vinyl System No. 4 (Figure 6) almost equivalent to System No. 1 in durability. The greatest failure occurred in the 100% solids epoxy coating represented by System No. 3 and as shown in Figure No. 5. It may be of significance that the application of System No. 3 was not preceded by a vinyl wash treatment. It has not been customary to use this treatment in advance of epoxy coatings.

Because of the prevailing winds and topography, the southern half of the bridge presents the most severe corrosive conditions. All systems were used in this portion of the bridge to give comparative data under conditions of an equally severe corrosive environment.

No Definite Conclusions

This report is a progress report and no definite conclusions, other than the complete failure of the epoxy coating represented by System No. 3, can be drawn for another two or three years.

The decreasing order of durability of these Systems as of the date of this report is:

System	Order
1	1
4	2
2	3
3	4

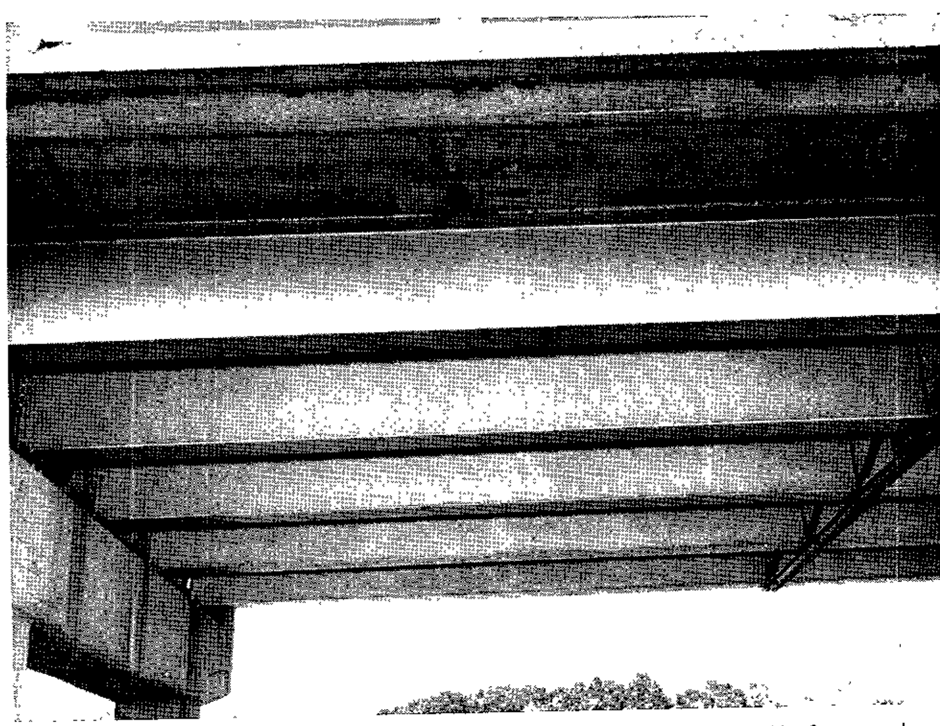


FIGURE 4—Under view of the north portion of Span 2 on which Painting System No. 2 was used.

FIGURE 5—Under view of Span 3 on which Painting System No. 3 was used.

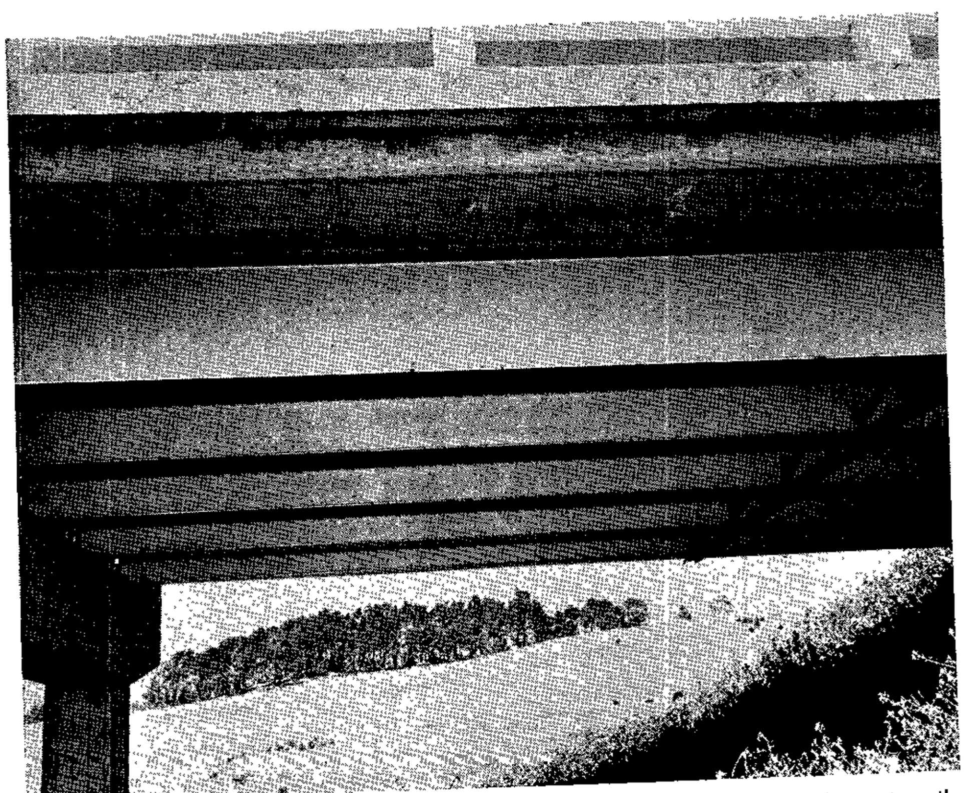


FIGURE 6—Under view of the north portion of Span 1. Painting System No. 4 was used except on the stringer in the foreground on which System No. 5 was used.

A rating of System No. 5 is not justified because of the relatively small area to which this system was applied.

Acknowledgment

Sincere appreciation is due Robert Souza of the Materials and Research Department for the excellent photographs he took for this report and to Mr. F. N. Hveem, Materials and Research Engineer and Head of the Materials and Research Department, for his suggestions and interest in the promotion of research relative to corrosion.

TABLE I

COATINGS

System No. 1

3 mils of inorganic zinc pigment-silicate binder cured with a phosphoric acid solution, Curing Agent scrubbed off with water, Vinyl Wash Primer, State Specification 52-G-52, applied followed by 2 mils of Vinyls, State Specifications T58-G-40 and T58-G-41 in alternating coats and a final coat of 1 mil of State Specification T58-G-49, Vinyl Paint, Aluminum Finish Coat.

Total film thickness, 6 mils.

System No. 2

Vinyl Wash Primer, State Specification 52-G-52; 3 mils of Semi-Quick Drying Red Lead Primer, State Specification 58-G-53; 2 mils of White Traffic Paint, State Specification 55-G-95; 2 mils of Vinyl Paints, State Specification T58-G-40 and T58-G-41 in alternating coats; 1 mil of State Specification T58-G-49, Vinyl Paint, Aluminum Finish Coat.

Total film thickness, 8 mils.

System No. 3

Epoxy Paint, 100 percent solids, made with an epoxy resin of viscosity 40-100 poise at 25°C and an epoxide equivalent of 180-195, 20 percent TiO_2 and 5 percent Cr_2O_3 cured with an epoxy amine adduct and applied by hot spray 15-20 mils thick.

System No. 4

Vinyl Wash Primer, State Specification 52-G-52; 4 mils of Vinyl Paints, State Specifications T58-G-40 and T58-G-41 in alternating coats; 2 mils of Vinyl Paint, Aluminum Finish Coat, State Specification T58-G-49.

Total film thickness, 6 mils.

System No. 5

Vinyl Wash Primer, State Specification 52-G-52; 4 mils of Semi-Quick Drying Red Lead Primer, State Specification 58-G-53; 2 mils of Phenolic Iridescent Green, State Specification 58-G-79.

Total film thickness, 6 mils.

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