MICHIGAN
STATE HIGHWAY DEPARTMENT
Lloyd B. Reid
State Highway Commissioner

DISCOLORATION PHENOMENON IN BEADED REFLECTORIZED HIGHWAY SIGN MATERIALS

By

C.C. Rhodes

Research Project 42 G-19 (2)

Research Laboratory
Testing and Research Division
Report No. 42
January 10, 1943

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W. W. McLaughlin
Testing and Research Engineer
State Building
Lansing, Michigan

Dear Mr. McLaughlin:

For the information of the Maintenance Division there is submitted herewith a report from the Research Laboratory, Testing and Research Division, Michigan State Highway Department, containing a survey and scientific analysis relative to a discoloration phenomenon which has recently appeared throughout a special installation of highway reflectorized signs located on M-78 between Charlotte and Battle Creek.

The investigation discloses the fact that certain types of beaded reflectorized sign materials are capable of sustaining fungus growths under proper conditions of temperature and humidity. This phenomenon is evidently an inherent weakness of the reflectorized materials which, to our knowledge has not been known to exist before, and naturally has not been corrected by appropriate specification requirements pertaining to the reflectorized sign material itself, or to the preparation of the sign base and subsequent installation of the reflectorized sign material to the base.

It is to be noted that although the fungus growths do not materially reduce the effectiveness of the signs at night, they are very

unsightly in the daytime and greatly impair visibility by loss of contrast with the roadside background. Since it is not practical to remove the fungus growth by cleaning methods, the contaminated signs will have to be replaced eventually at an economic loss to the State.

Dr. W. L. Mallman, head of Bacteriology Department at Michigan State College, has collaborated with the Research Laboratory in the study.

In this report we briefly sketch the problem as it exists together with the results of our findings and recommendations for safe guarding against the occurence of fungus growths on future installations of reflectorized highway signs.

Very truly yours,

E. A. Finney
Assistant Testing and Research
Engineer in charge of Research

EAF:EMN

DISCOLORATION PHENOMENON IN BEADED REFLECTORIZED HIGHWAY SIGN MATERIALS

During the month of December 1941, a test section of highway marking signs was established by the Traffic and Safety Division on highway M-78 between Charlotte and Battle Creek. The signs were made of 3/4 inch plywood upon which was mounted a reflectorized sign material called "Scotchlite". A few signs coated with "Prismo" paint and beads were also installed in the same test area for comparative study.

A recent survey conducted in November 1942 has revealed that, almost without exception, the Scotchlite signs in this area have developed dark spots over their entire surface. See Figure 1. The spots, illustrated more closely in Figure 2 part A, and microscopically in parts B and C, are roughly circular in shape, and about 1/16 to 3/16 inches in diameter. The edges of the spots are not sharply defined but shade off gradually from the center. The surface between the spots has also taken on a dark and dirty appearance.

On November 31, 1942 a sample sign was submitted by Mr. G. E. Shuttleworth, Traffic Sign Engineer of the Maintenance Division to the Research Laboratory for analysis and report. The results of the study together with some recommendations for corrective treatments are incorporated in the text which follows.

THE INVESTIGATION

As a preliminary step to aid in the determination of the nature and source of the blemishes, an attempt was made to remove the spots by means of various cleaning methods and chemical reagents. Cleaning the

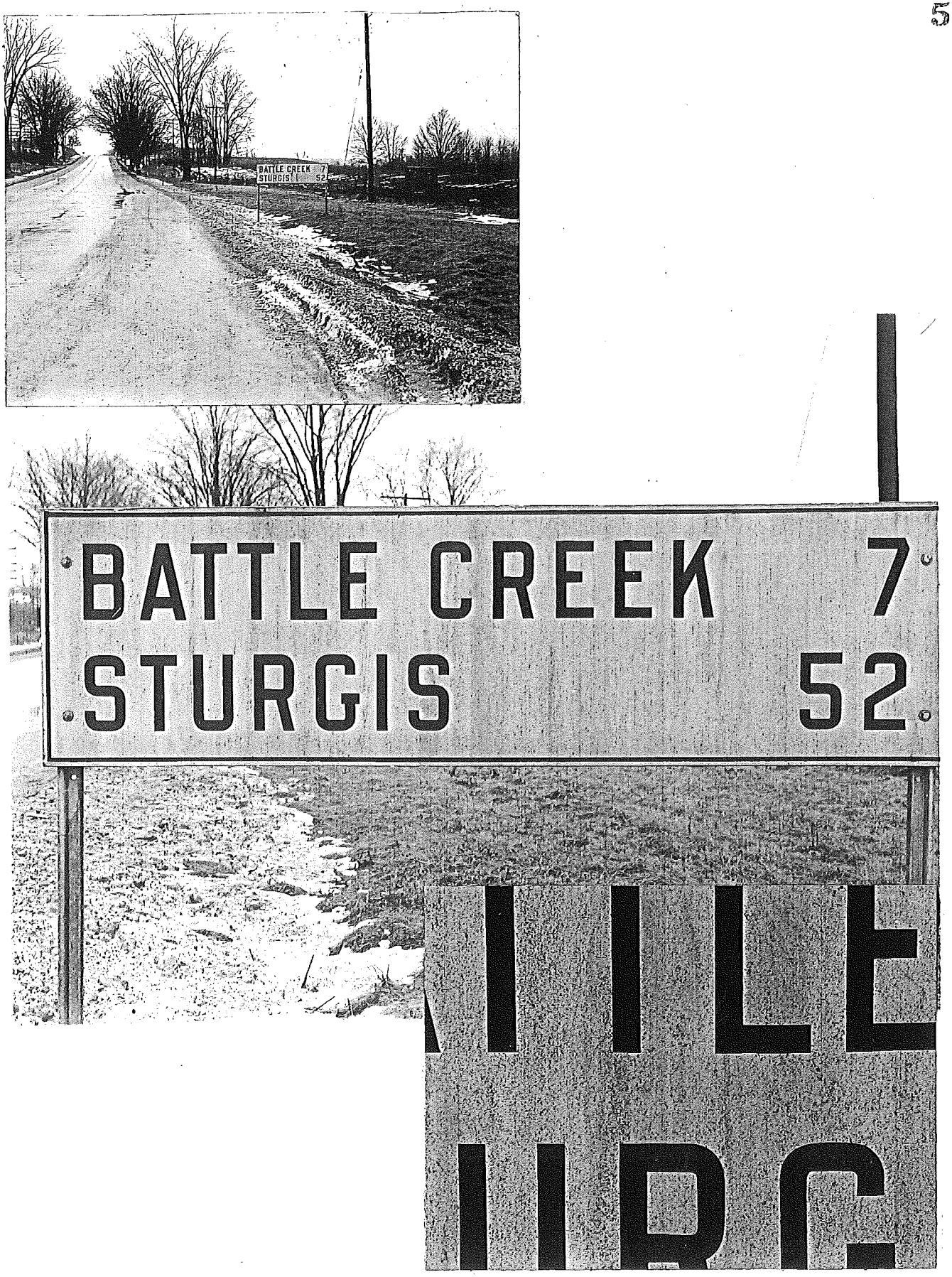


FIGURE 1

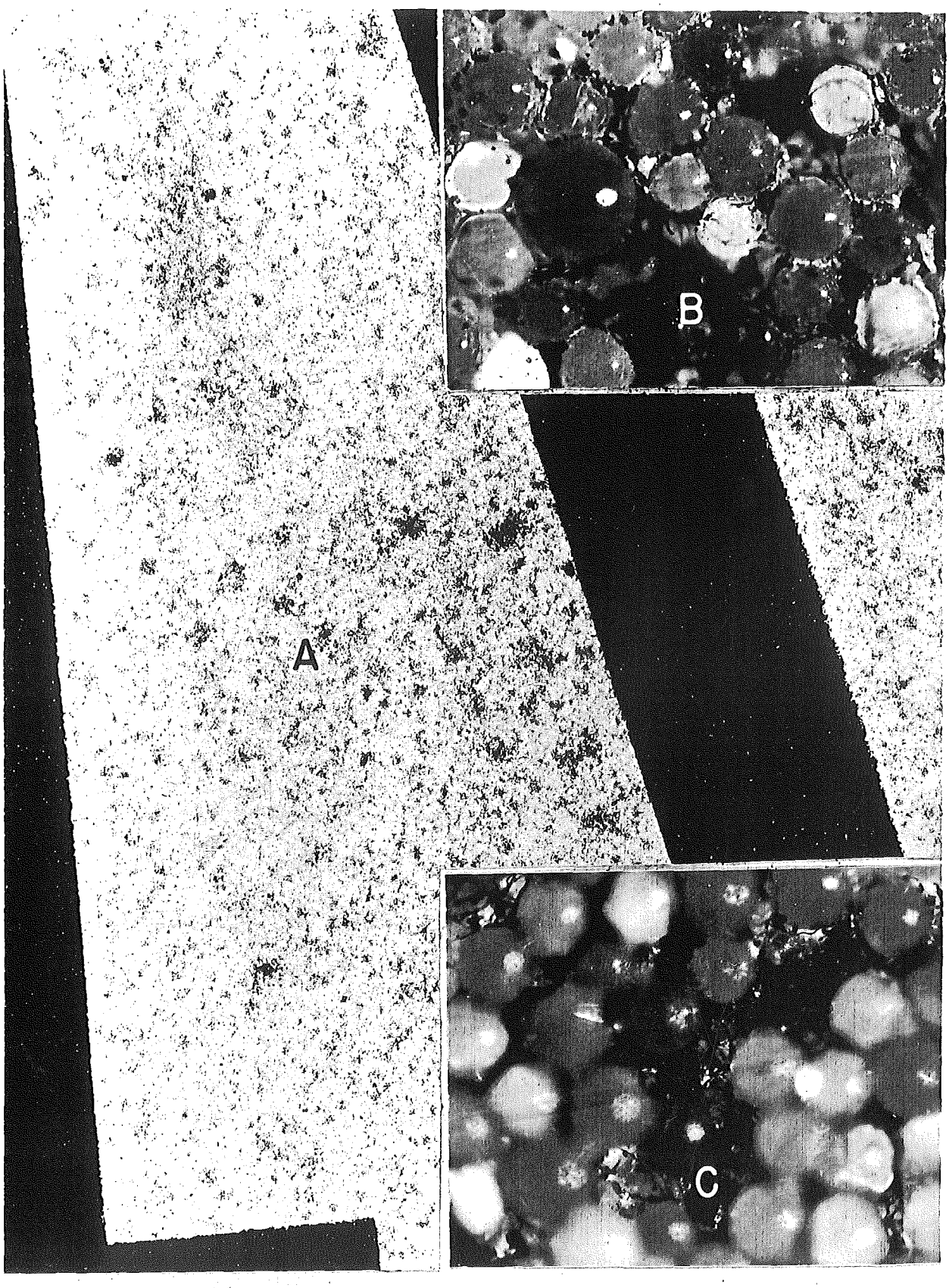


FIGURE 2

surface with soap and water lightened the background but did not remove the spots. Cleaning agents like tri-sodium phosphate and scrubbing with soda and Bon Ami, also the use of various organic solvents including kerosene, acetone, xylol, and alcohol failed to remove the discoloration. Too long application of solvents or persistent scrubbing with soda and Bon Ami not only removed the spots, but also most of the glass beads.

Some of the darker areas were treated with concentrated nitric acid, which lightened the spots somewhat. When observed under the microscope at a magnification of 80 diameters, the foreign material appeared to consist of a network of rootlike fine stringy threads of cell structure, evidently plant growth. (See Figure 2, B and C.) Since the material of such growth is essentially cellulose and lignin, an oxidizing treatment was indicated. By using a solution of potassium permanganate alternated with application of sodium acid sulphate the spots were removed. However, this treatment also loosened quite a number of glass beads, which means that such a cleaning method would necessarily require close control in order to avoid excessive deterioration of the bonding material. Another oxidizing treatment, suggested subsequently, and which was also carried out in this laboratory, will be discussed later.

Having established the fact that the spots were the result of some kind of mold growth, samples of the material were submitted to the Bacteriological Department of Michigan State College for culture to determine the particular variety or varieties of fungus present. The result was highly interesting and photographs of two representative

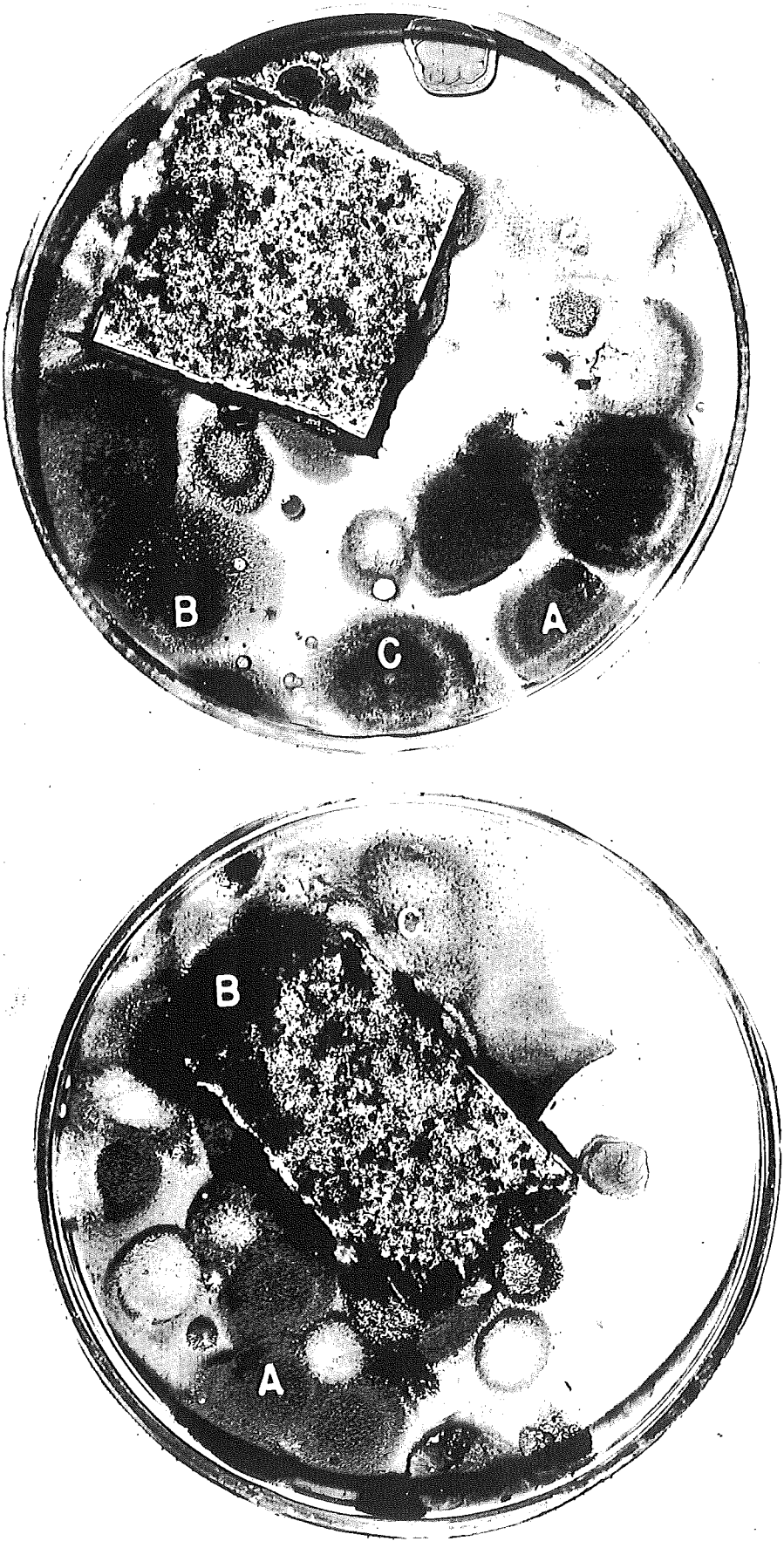


FIGURE 3

substrate, they first secrete enzymes into the substance to dissolve it. Many types are thus capable of breaking down and dissolving such compounds as proteins, starch or cellulose. Some forms require only an organic source of carbon, but growth in any case is impossible without a substrate which is at least partially organic.

These considerations immediately suggested a closer scrutiny of the environment in which our molds were found. Further inquiry into the history of this particular group of signs brought to light several pertinent and highly significant facts. As mentioned earlier, the base of these signs consisted of regular 3/4 inch plywood. This material was not pretreated in any way although the glue was of the "waterproof" type such as has been used in more recent installations. The usual treatment of the plywood base prior to mounting the beaded material consists of a light prime coat of white lead paint and turpentine followed by a heavy application of black paint (M.S.H.D. specification 17-B). Due to lack of time for proper preparation, these signs were installed with only the light prime coat under the reflectorized fabric. It should be noted too, that the beaded material was cut right to the edges of the plywood backing without being sealed, instead of leaving a margin between fabric and base for sealing with transparent resin. Signs which have received standard treatment and installed in other locations throughout the State of Michigan were found during a recent survey to be in good condition.

Examination of the beaded material itself indicates that it is composed of a kind of paper, sized and painted, upon which is superimposed a thin layer of transparent resin, which in turn serves as a

matrix or bed for the small glass beads. The back of the fabric is coated with an adhesive for permanently attaching it to the base material of the sign.

On the other hand, "Prismo" signs are made by simply lacquering the painted or enameled face of the sign and sprinkling the glass beads over the surface before the lacquer dries. In this case the clear lacquer serves as a bonding material for the beads. Prismo signs were apparently free of contamination in the test area.

In order to determine the relative availability of the various sign materials as a fungus nutrient, a further series of cultures was made. The specimens for this test consisted of reflectorized material both unmounted and mounted on metal strips, thus eliminating any effect due to the wood base of the sign. Prismo and Decal types were mounted on metal only. After dusting with mold spores, the specimens were stored under favorable conditions of temperature and humidity for approximately two weeks. The photographs, designated by figures 4 to 10 inclusive, represent the state of fungus growth at the end of the two week period. The dark and shadowy areas in the photographs represent fungus growths. The different materials are identified as follows:

Figure 4--1-A	Scotchlite	White	Steel, mounted
Figure 5--1-B	Scotchlite	Silver	Unmounted
Figure 6--1-C	Scotchlite	White	Unmounted
Figure 7--1-D	Scotchlite	Yellow	Steel, mounted
Figure 8--2-A	Prismo	White	Steel, mounted
Figure 9--3-A	Decal	White	Steel, mounted
Figure 10--3-B	Decal	Yellow	Steel, mounted

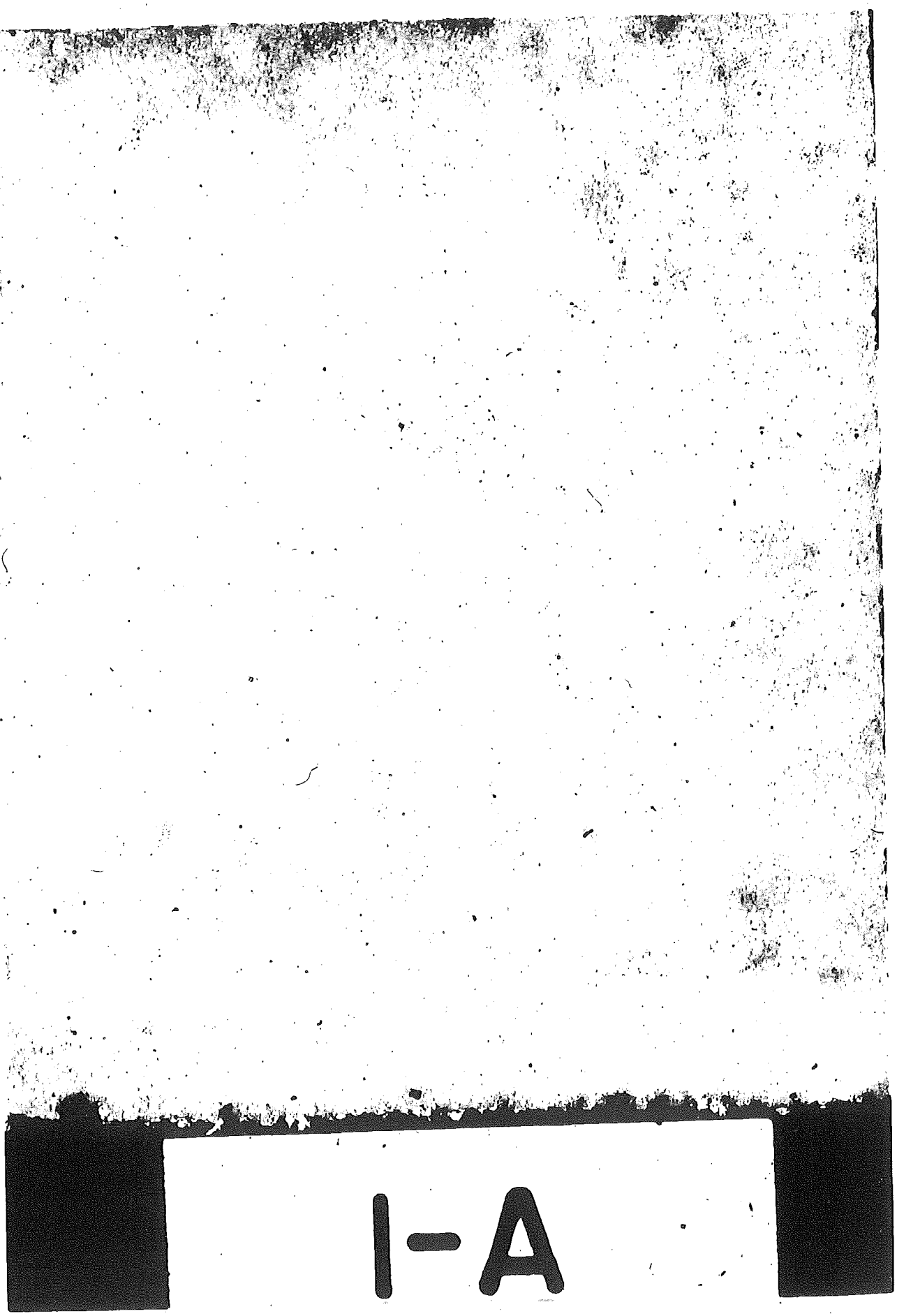


FIGURE 4

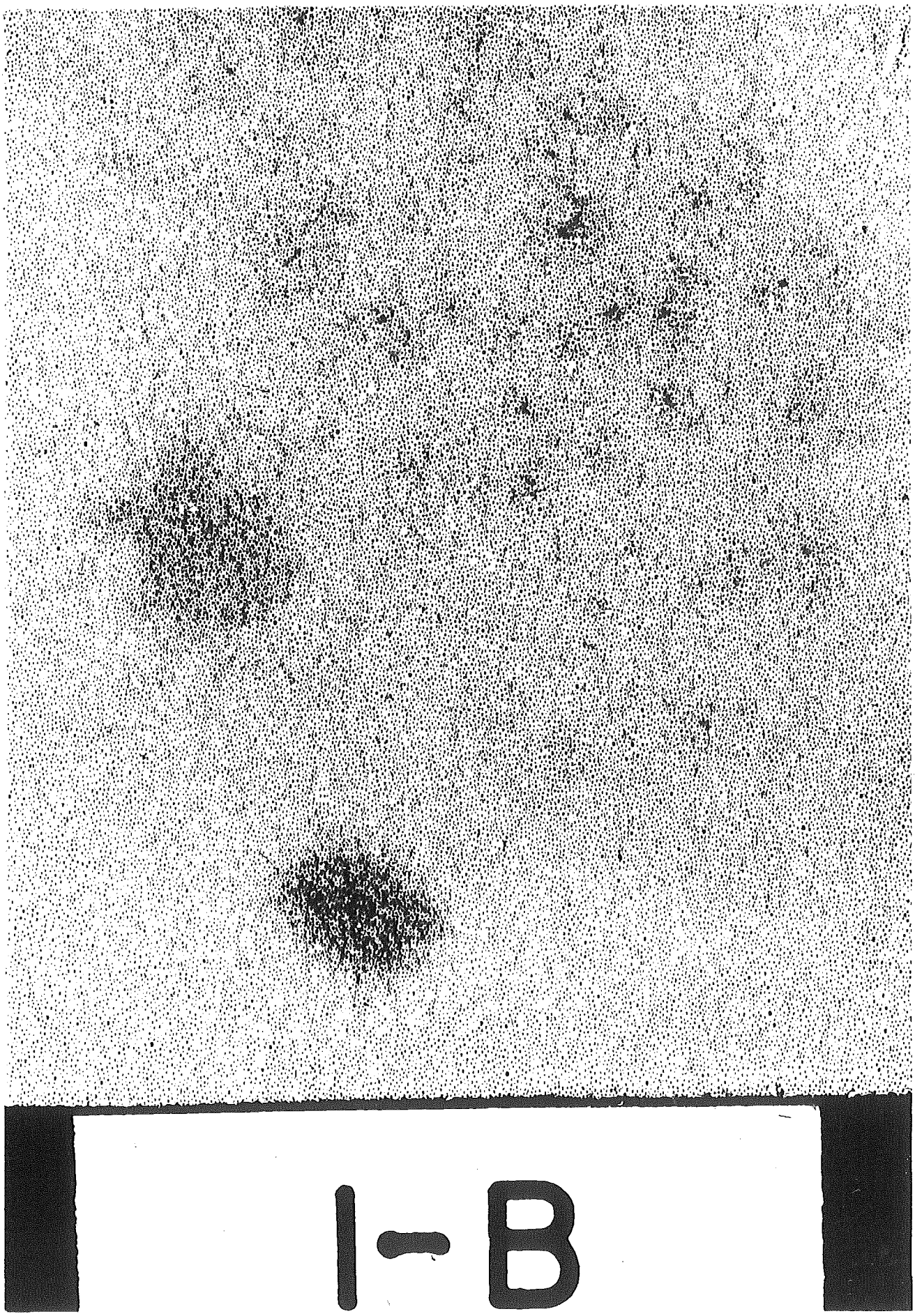
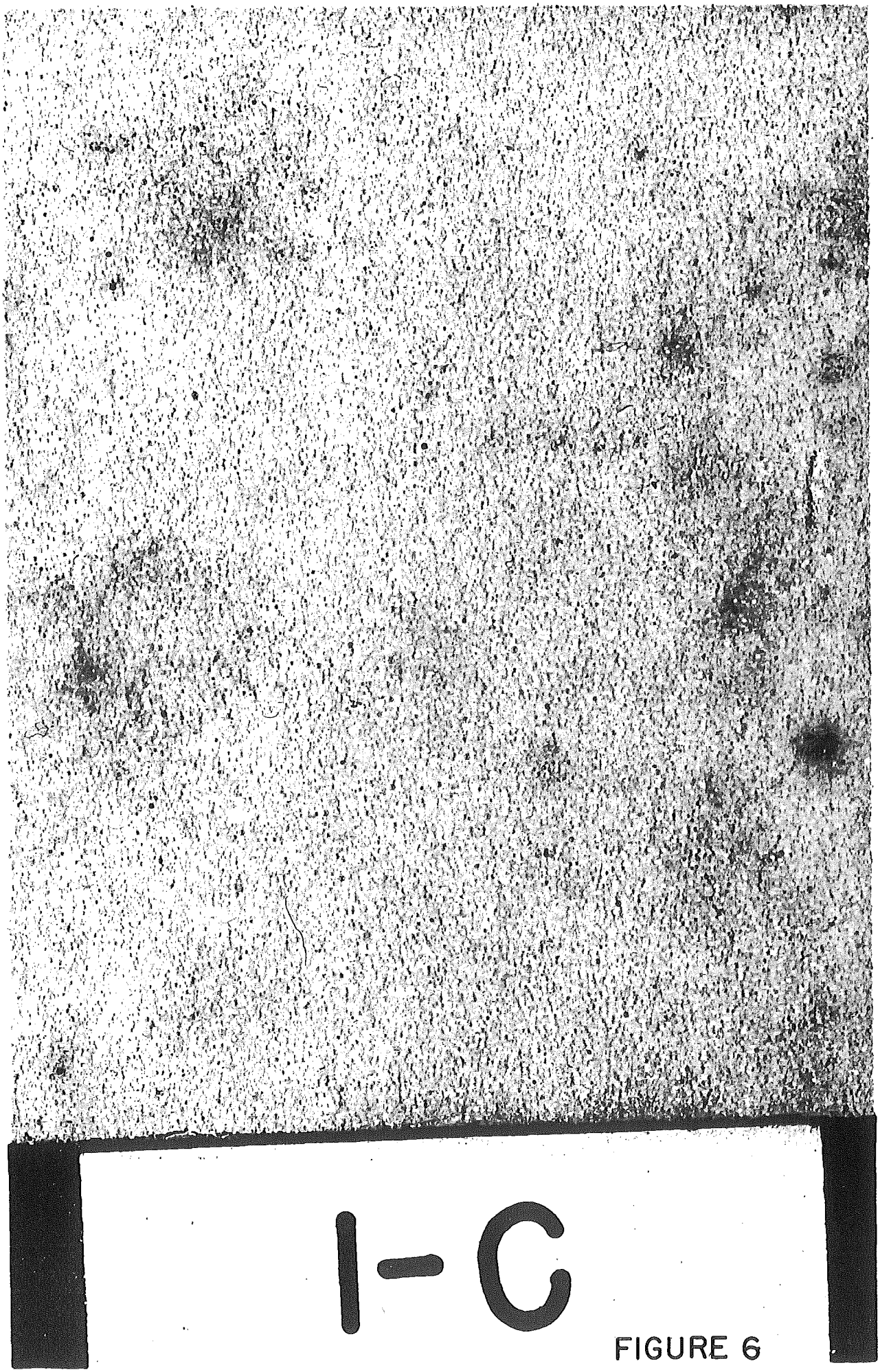


FIGURE 5



I-C

FIGURE 6

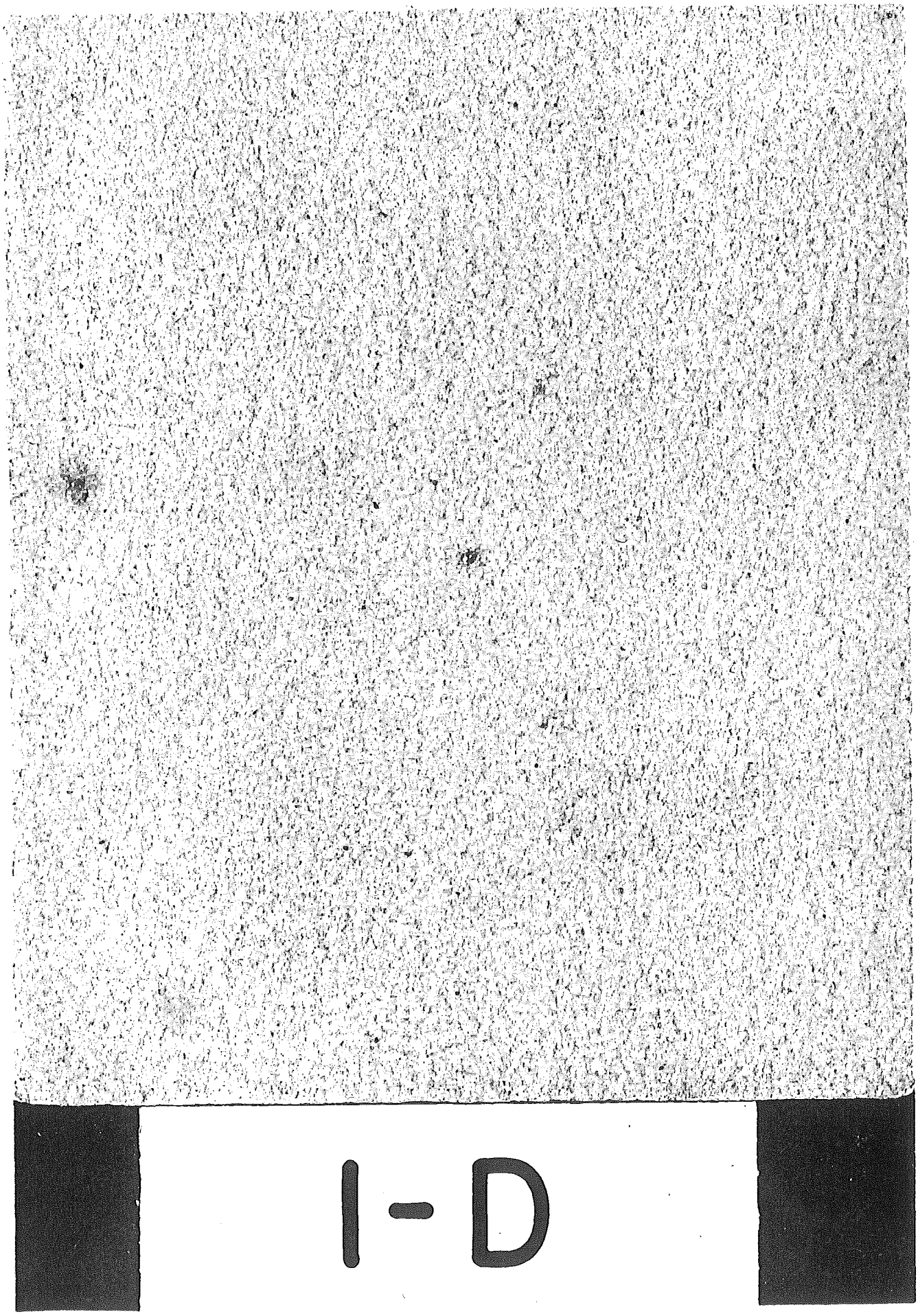
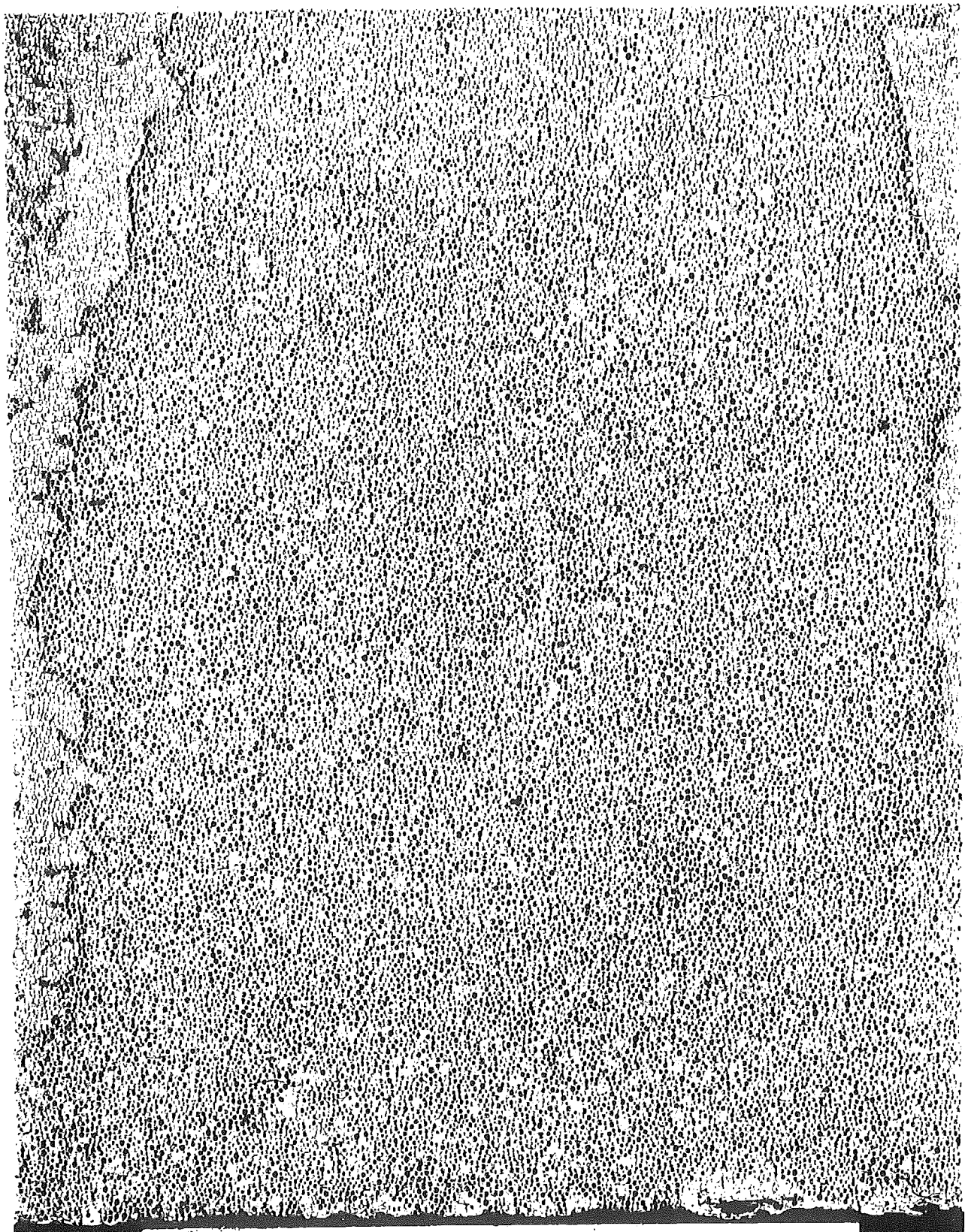
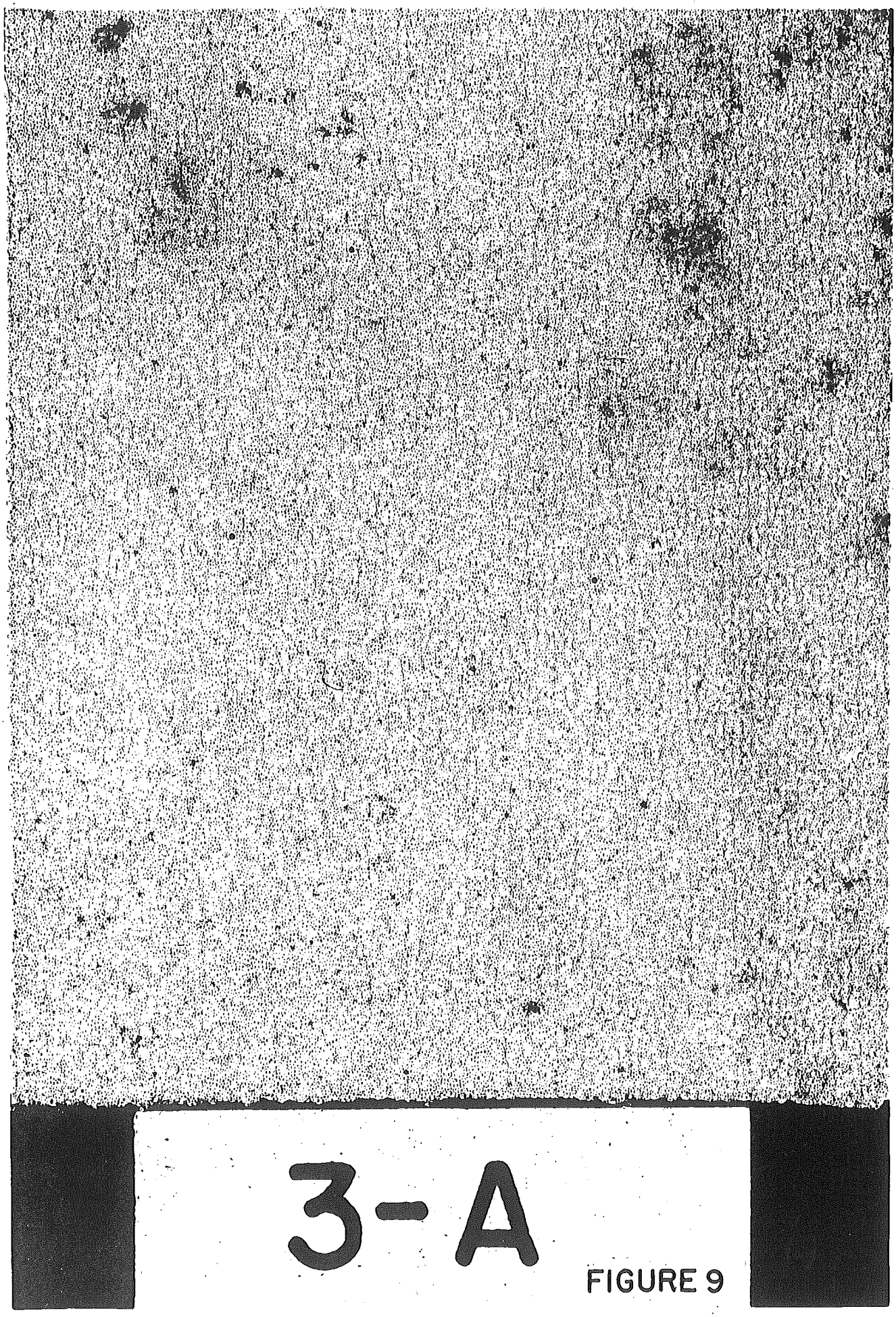


FIGURE 7



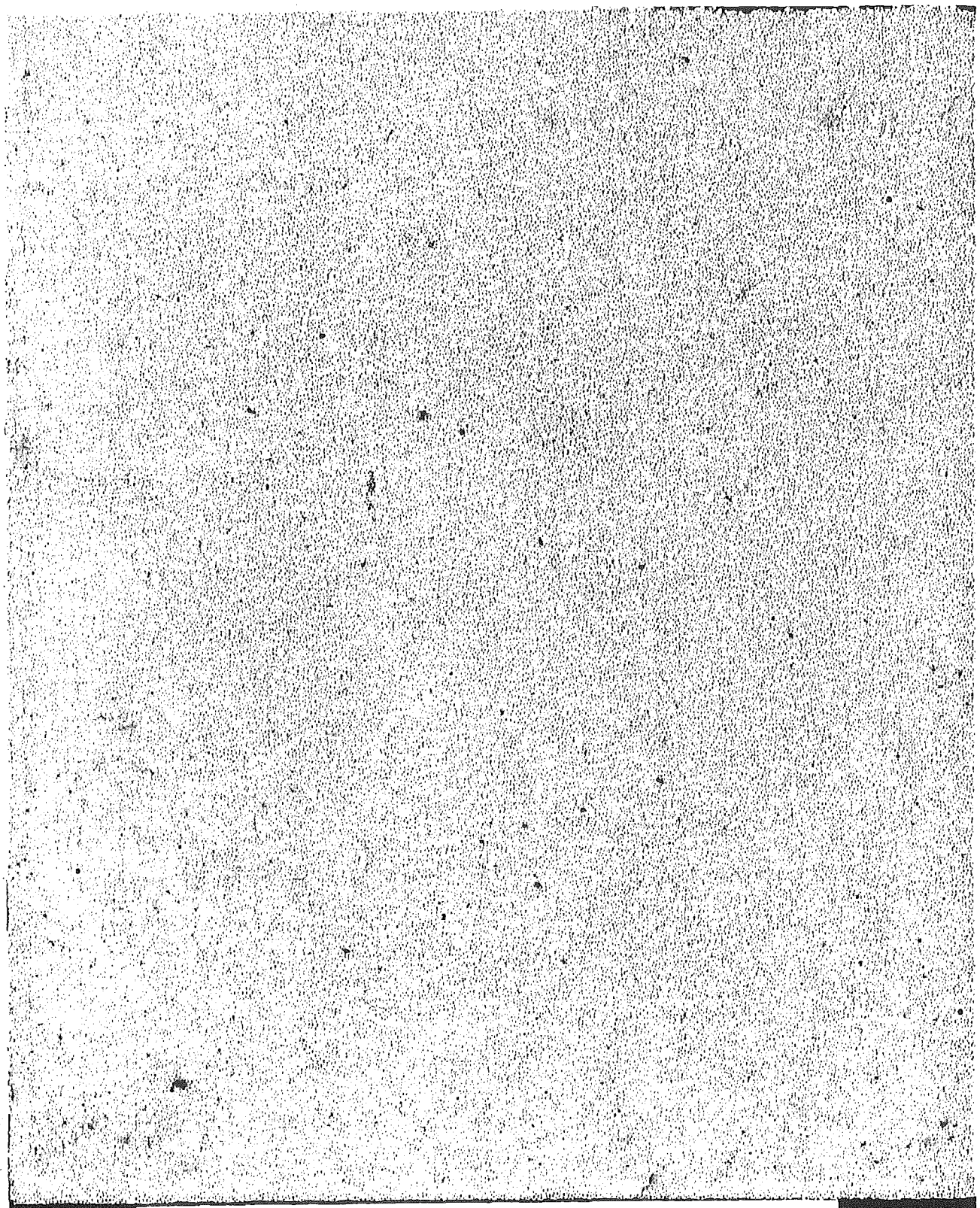
2-A

FIGURE 8



3-A

FIGURE 9



3-B

FIGURE 10

The significant fact to be noted from this study is that the Scotchlite fabric, both mounted and unmounted, is favorable to fungus growth. Characteristic spots have developed over the surface similar to those found in the field, while the Prismo material is apparently untouched. Mold growth is also present on the Decal samples thereby indicating the possibility of contamination in the field. The nutrient of the fungus, then, is provided by the material of the beaded fabric itself, and is independent of the type of base employed.

Since moisture is the other prime requisite of growth, the type of base material and its pretreatment, (priming, painting, etc.), is undoubtedly of critical importance in this case. Metal does not absorb and retain amounts of water sufficient to maintain optimum conditions for fungus growth. Wood which is properly treated prior to installation, that is, thoroughly primed and painted to prevent infiltration of moisture, may also be a suitable material, since it has been found that signs so treated have resisted invasion by the mold thus far.

CLEANING METHODS

Once the sign has become overgrown and spotted with mold, it is very difficult to restore it by ordinary cleaning methods. Oxidizing treatments remove the spots, but do not offer a satisfactory service cleaning method for two reasons, the first of which is the danger of excessive deterioration of background material since the reagent attacks the substance of the fabric as well as the mold. The second objection is that prolonged saturation is necessary to completely eradicate the blemishes and this method is not feasible in ordinary shop practice. A series of tests was performed using Chlorox as the oxidizing agent applied

for various periods of time.

Photographs of the cleaned specimens are shown in figure 1), wherein A designates the original material, while B, C, and D show the result of 3, 30 and 60 minute applications respectively by immersing specimen in a Chlorox solution. It is evident that applications for periods under one hour failed to do the job completely, although the material was brightened appreciably, and such a treatment may be worthwhile as an emergency measure pending replacement of the signs. It is of prime importance, therefore, that attention be given to preventive, rather than corrective measures.

PREVENTATIVE MEASURES

Although, from experience so far, it appears that a good paint job on the plywood base may be adequate to prevent recurrence of this phenomenon, it is our opinion that some inhibiting fungicide should be incorporated in both the prefabricated reflectorized material and the plywood. There are quite a number of fungicides available commercially at the present time. These may be divided broadly into two classes, (1) the water-soluble metallic salts, mostly zinc and copper compounds and (2), oil-soluble organic compounds, usually phenol derivatives. The latter group are to be preferred for our work, since their use does not require a drying or seasoning period for the wood following impregnation, and the oil or oil-like solvents used as a vehicle not only promote more rapid penetration of the active ingredients, but also resist leaching and aid considerably in waterproofing the wood. They are all safe to handle and leave a clean, paintable surface.

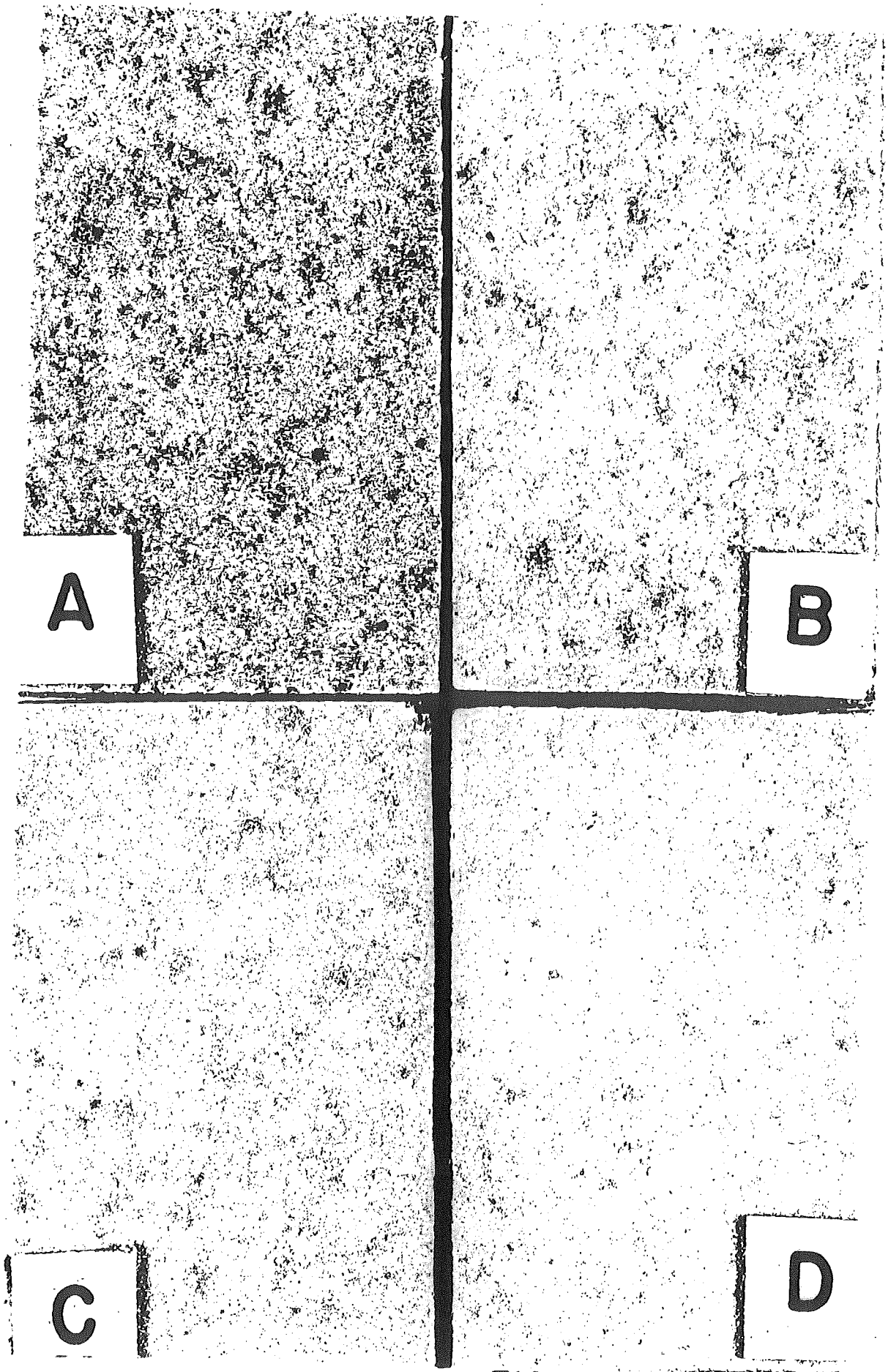


FIGURE II

Fungicides of this type may be obtained either in a ready-mixed form as a proprietary product, such as "Wood Life" of the Protection Products Company of Kalamazoo, Michigan, or as a dry powder or flake to be made up into solution as required. The "Dowicides" of the Dow Chemical Company, "Dowicide G" being particularly recommended, are examples of the latter and may be made up according to several different "Permatol" formulas developed by the Western Pine Association. These formulas may be used without royalty or license and specify the various quantities of of the dry material to be dissolved in given amounts of penetrant and spreader solvents.

The solution may be applied by spraying, brushing or dipping, although the first two methods give only a superficial treatment. The method of application depends upon the degree of penetration required, but for best results should consist in immersion of the wood in the fungicide solution for a period of from three to thirty minutes. The dip may be hot or cold, but the temperature range is limited to about 100°F because of the comparatively low flash point of the solvents employed.

In some instances it may be possible to purchase pretreated plywood material. Most lumber companies now apply preservatives of this type to exposed millwork. If so, a simple method may be to spray or brush the solution upon the cut edges of such material in our own shops before applying the paint coats.

Specifications governing the method of treating, depth of penetration, and quantity of toxicant absorbed by the wood product are equally necessary in order that sufficient preservative may be

incorporated uniformly to the required depth in the various products so treated. An excellant preservative may be made ineffective by hurried or improper treatment, resulting in shallow penetration and light absorption which, in turn, give inadequate protection to the treated wood.

The prefabricated reflectorized material itself should be impregnated with a suitable fungicide during the manufacturing process, and the proper treatment of such materials is a problem which must be solved by their respective manufacturers.

SUMMARY AND RECOMMENDATION

The salient points in the foregoing discussion may now be briefly summarized:

1. The blemishes on beaded reflectorized signs, in service for one year, which were submitted by the Maintenance Division, are the result of fungus growth or mold.
2. Of the two types of beaded material installed in the test area, the prefabricated material "Scotchlite" only was affected.
3. Two conditions prevalent in highway signs essential for fungus growth, are, nutrient and moisture.
4. Scotchlite supplies nutrient, Prismo does not.
5. Insufficiently protected wood supplies, moisture, metal and properly painted wood apparently do not.
6. Ordinary cleaning methods cannot be used to restore the signs, and oxidizing treatments are not feasible

as a routine service method.

The following recommendations are submitted as a guide in the future installation of reflectorized signs.

1. Waterproof glue should be used in the fabrication of the plywood.
2. When plywood is used as a base, the entire sign should be subjected to a preservative treatment with a fungicide solution prior to painting and mounting of the reflectorized material.
3. In addition to the preservative treatment the plywood base should be well primed and painted to prevent absorption and retention of moisture.
4. Beaded reflectorized material should be mounted in such a way that a margin of at least 1/8 inch remains between the edge of the material and that of the plywood base for the purpose of sealing.
5. Prefabricated reflectorized material should be impregnated with a suitable fungicide during the manufacturing process irrespective of what preservative treatment the sign base may receive or of what material the sign base may consist.
6. All existing reflectorized highway signs made with plywood should be periodically inspected and painted to prevent abnormal deterioration.
7. It may be argued that the signs on M-78 have failed primarily because of improper installation practice

and thus a similar failure will not occur elsewhere. Such opinion is based on the fact that similar failure has not occurred in other installations in Michigan which, it is understood, have received adequate painting treatment prior to applying the reflectorized material. However, we must not overlook the fact that these other installations with wood bases have been in service less than a year and therefore we have no positive assurance that they will continue to a normal service life without contamination of this character. Consequently, in view of the facts set forth above we believe that the several precautionary measures outlined above are justified and should be carried out on all future sign installations in which a prefabricated reflectorized sign material is used.