The holes with one exception were bored directly on the centre line. This exception was at the eastern end where the rock was exceptionally seamy, and a couple of bad caves resulted. The second one developed an opening completely through the rock, letting in a considerable flood of water and earth from above; not, however, before the caving was visible on the surface 70 ft. above.

Some hesitation was felt about driving a hole through this shaky roof, and fortunately one of the large water worn cavities before mentioned was found here extending some 4 ft. off line of the tunnel. The pouring hole was accordingly driven here without the loosening of any further rock from the roof. Considerable water was coming through the roof in this section and was collected on a sheet-iron roof and run to wooden troughs along the side and carried beyond the concreting in progress.

For the final stage of pouring at this section, a 2-in. pipe was run through the concrete bulkhead and extended upward to near the upper surface of the rock, some 12 or 14 ft. above the roof line of the tunnel. When ready for concreting the wooden troughs were plugged and the compartment allowed to fill with water. When this was completed the concrete was poured into the still water down the pipe. Shortly after commencing the concreting, water began to discharge through the 2-in. pipe leading through the bulkhead. Finally grout began to appear discoloring the water; then the pipe was closed. Concrete was poured into this hole until it finally appeared in the cave-in previously mentioned above the centre of the tunnel.

Twenty-three holes in all were bored, the total cost of well boring, casings, temporary trestle over river and segregation prevention being less than $2.50 per cubic yard of concrete. Experience indicates that at least one-third of these holes might have been omitted. Where a 60-ft. head is obtainable the holes may be safely spaced at 80 ft. and with a certainty that all of the cavities will be thoroughly filled.—From "Enginering News-Record," New York.

PROTECTING IRON AND STEEL STANDPIPES FROM CORROSION

IN an attempt to bring together such information as may be obtainable, relative to actual experience with standpipe paints, Metcalf & Eddy, consulting engineers, of Boston, Mass., sent inquiries to water works in the northern and eastern parts of the United States where iron or steel standpipes are in use, requesting information as to the dates of painting, kind of paint used, preparation of the surface for painting, and other significant data. In general, the water works superintendents were generous with their responses, which were received during the winter of 1916-17, but in a disappointingly large number of cases the responses were, in effect—"The writer has been here but a short time. The former superintendent left no records and I do not know what paint was used or when it was applied."

The significant data received in response to this inquiry, together with some information available from other sources, were given in a paper read last week by C. W. Sherman, of the firm of Metcalf & Eddy, at the convention of the New England Water Works Association. Mr. Sherman's data cannot be summarized or averaged. In a few cases the standpipe had not been painted since erection. There are doubtless cases in which the quality of the water is such that it protects rather than corrodes the metal; such cases are, however, rare and experience seems to indicate that as a rule an iron or steel standpipe should be thoroughly cleaned and painted inside at least as often as once in four or five years, says Mr. Sherman. Perhaps, however, if the cleaning were as thorough as would be accomplished by means of the sand blast, and if a protective coating where then properly applied, the interval between paintings could be materially extended.

A. H. Kneen, of Philadelphia, painted two standpipes with vertical stripes of different kinds of paint, and observed the conditions after two or three years of service. The only paints which gave reasonably good service were a red oxide of iron paint, and red lead. Most of the paints used were undoubtedly proprietary articles, and although one red oxide of iron paint showed "good" or "very good" results, several others characterized the same way in Mr. Kneen's tabulation gave "bad" or "very bad" results. Red lead when used was employed only in the first coat, yet the results were characterized as "good" or "very good." It is not impossible, therefore, says Mr. Sherman, that two or three coats of red lead would have shown better protection than any of the other paints.

Practical Results Confirm Experiment

Mr. Kneen says: "Under the writer's supervision, we have had the inside of fifteen standpipes painted and repainted in the past seven years, the combined area of which is over 112,000 sq. ft., and the results obtained are similar to those obtained in the experimental tanks. Our conclusion to date is that paints having pitch or asphalt for a base, applied in this manner, are not suitable for iron in contact with water, but that two-coat work with a good quality of iron oxide or a paint with a good red lead base for the first coat, and an iron oxide paint for the second coat, if the iron is properly cleaned and the paint is properly applied, will protect the iron in contact with water for at least four years, unless the water is of unusual quality or the conditions are different than usually met with in water works practice."

The engineers of the Metropolitan Water Works (Boston) have adopted the policy of cleaning the steel by sand blast, and applying three coats of red lead to the interior surface of their steel standpipes. The following quotation from the fifteenth annual report of the Metropolitan Water and Sewerage Board describes the cleaning and painting of the Bellevue Hill standpipe:—

"On March 25th, the tank was taken out of service and drained, and the work of sand blasting and painting the steel was begun March 30th, by the W. L. Waples Co., of Boston, subconstractor for this work. The plant used consisted at first of a twenty horsepower gasoline-engine-driven air compressor, a compressed air reservoir, two lines of air hose and two nozzles. Sand blasting was stopped in the latter part of the afternoon of each day, and the cleaned surfaces were painted before rusting commenced. The force employed included one foreman, two painters, who also did sand blasting, and one helper. This force could sand blast and paint an area of about 330 sq. ft. per day. Later, in order to increase the rate of progress, a second compressor, operated by an automobile engine, was installed on April 19th. The entire inside and outside surface of the tank, having an area of 35,650 sq. ft., was sand blasted and painted. Work was completed June 14th, with the exception of the third coat on the outside, which has been deferred until after the masonry tower which encloses the tank in completed. All painting materials were furnished by the department, but were mixed by the contractor under the direction of the engineer. For the inside of the tank, National Lead Company's red lead in oil paste, litharge, and Spencer-Kellogg & Son's boiled linseed oil, were used; the first coat natural color, the second and third coats tinted with lampblack in oil. For the outside of the tank, red lead paste, raw linseed oil, and drier were used for the first coat, and for the second coat white lead, raw linseed oil, turpentine, and drier tinted with lampblack were used. One gallon of red lead paint was sufficient to cover 700 sq. ft. of surface with one coat. The subcontractor's price for sand blasting and painting the tank was $1,600. . . ."

Paint Immediately After Sand-Blasting

Mr. Sherman inclines to the opinion that the method just quoted represents the best practice of the present time. He would put especial emphasis on the thorough cleaning of the metal, and the *immediate* application of the paint to the cleaned metal before the latter has cooled and moisture has condensed upon it. The following quotation is pertinent in this connection:—

"Every specification for painting bristles with clauses prescribing what shall or shall not be done, and still the fact remains that there are more failures than even indifferent