

derrick or other device, and the scraper lowered into position in the upper box.

In a section about to be scraped, the main valves should be opened wide to avoid hindrance to the scraper. In order to prevent filling of service pipes with debris from the scraper's activity, they are to be shut off. As the air valves must be left open, they should be cleaned out after the work is over.

There will be a heavy discharge of water through the open hatch box at the far end of the section. A plug is put in place at one end where the hatch box opens into the part of the main next to be cleaned. Thus is prevented the washing of debris into that section. In the American system, a pipe is put in place at the far end of a section. This is inclined to the vertical and serves to throw the water out upon the general surface.

The scraper used on the 16-inch main weighed about 335 pounds. Going through the main it had an average speed of perhaps 2 miles an hour with a 15-foot hydraulic head back of it. It will be seen from this that the actual normal cleaning operation is by no means protracted. There were no very steep climbs taken by the scraper. There was one incline of 1 in  $9\frac{1}{2}$ , 980 feet long, and no difficulty whatever was experienced in negotiating it.

The lower hatch box and its excavation must be pumped out after the work is over.

After the scraper arrives at the hatch box, which is its destination, the water is shut off. It is judged important to do this quite promptly, if the drainage from this point is not good. As the scraper passes the successive scour valves they are shut off. When the scraper has finished the section, these valves are opened up again. In order to get word back to the point of water control at the head of the section when the scraper finishes, a field telephone may be employed. Or, as in the present case, a system of signalling may be used.

**Locating the Scraper.**—When the scraper finished its first trip through a section, it was hauled back for a second. In this way, each section was given two cleanings without any delay between.

When the scraper is working its way between termini, it is very important to have some adequate means of locating it. It may, in fact, encounter an obstruction which it is incapable of passing or carrying along. There are ways of stirring it into activity, but these sometimes fail, when the only alternative left is to excavate down to the main and cut out a short length where the scraper is or else quite close to it. There are two principal methods of keeping track of the apparatus. One, employed in the United States, and perhaps elsewhere, is to attach a line to the rear end. The length of line at any moment will indicate the advance of the machine. Another method is to follow the ongoing apparatus by sound. Sometimes the noise is able to penetrate to the surface and reach the ear of an attendant workman without the aid of a special apparatus. At other times, a kind of stethoscope is employed. In this case, a number of men will set up the stethoscope at short intervals. When the slowly moving scraper passes the rear man he goes forward and sets up his instrument at the head of the line, and so on.

If the machine stops, it may at times be persuaded to resume by means of an induced water hammer. Presumably this is effected by a quick shutting off of the water and a quick subsequent release. Sometimes a mere jarring of the main will be sufficient; at others, a wisp of hay floated down to the rear end of the scraper may be successful in getting it going again.

**Result of Cleaning.**—The two portions of the cast-iron main were cleaned one year apart. The 16-inch main was originally laid in order to get a flow over high ground that was located in the first 8 miles. When the 14-inch main was scraped and its capacity restored, the pressure line at the junction fell to such an extent that at one point it was no higher than the pipe itself. The result was that the remainder of the line became nothing more than a series of inverted siphons and certain consumers were cut off from their supply. This condition required the closing down of some of the valves and a consequent throwing of the pressure back on the main behind. In consequence, the natural advantages of the cleaning operations upon this 14-inch section were not secured until the 16-inch section above was cleaned one year later.

The capacity was then almost fully restored to its original theoretical amount.

After a period of two years subsequent to the completion of the scraping, a capacity test was tried with the result that 40.5 per cent. of the gain was found to have been lost. In other words, in two years—or possibly we should call the interval something over two years because of the early cleaning of the 14-inch main—the interior condition was two-fifths as bad as before scraping.

It would seem that the necessity of a yearly cleaning, or even a more frequent one is indicated. The actual cost of cleaning is not great, once the hatch boxes have been built into the line and walled-in excavations provided. In the present instance, the scrapers themselves were purchased, one for each size of main. New leads and leathers are necessary for each cleaning operation. The incrustations in the pipe line were due to an oxidation of the iron, presumably at points left exposed by some imperfection in the coating process. Apparently, a nodule grows upward and radially from this centre, while a corrosive activity goes on downward into the metal and over the surface beneath the growing nodule. Layer grows upon layer, causing the nodule to project more and more. The spread of the corrosion on the metallic surface undermines the coating. A nodule cited by Mr. Macfazelean had a diameter of  $1\frac{1}{2}$  inches. The central decomposition of the iron was  $\frac{3}{16}$ -inch deep and the general decomposition  $\frac{1}{16}$ -inch. The coating and the iron were sound beyond the area covered by the nodule. Apparently, there is a somewhat regular increase of the corrosive effects while individual nodules continue distinct. Upon their coalescence, however, and the formation of a continuous layer of incrustation, corrosion slows up. There is reason to think that it will cease altogether when the coating of incrustation has reached a definite thickness, presumably different for differences in conditions as respects the chemical constitution of the iron and the water.

It will be of interest to add here that one main at least is known in which cleaning is done regularly year by year, where the loss of capacity and restoration are also regular and equal in amount. That is to say, during the year the capacity falls off, but is fully restored by the cleaning operation. This would not appear to bear out the idea that the pipe requires more frequent cleaning because of the cleaning itself.

It seems that some trouble has been experienced with having the plug at the lower hatch box driven up into the main ahead. A method of avoiding this difficulty has been to use a scoop in the pipe over the plug. It seems that a "fish cutter" has proved serviceable in preventing the scraper from sticking in the main.