barrows. This arrangement is shown in Figs. 4 and 5. All sand was put through a half-inch mesh screen.

After the cement-gun got under way progress was made at the rate of three to four thousand square feet of lining per day.

During the past irrigating season, water has been in the canal constantly. The saving of water is strikingly

Fig. 5.—Loading Wheelbarrow from Hoppers

evidenced by the withering of all the weed and willow growth which had previously been quite dense on the hillside below the flume.

Despite the fact that the gunite was placed without expansion joints there are no apparent leaks or cracks in the lining.

The cement-gun used was the standard N-Z size made by the Cement-Gun Co. and the compressor was a port-

Fig. 6.—Showing Finished Canal Ready for Filling

able 8¾-in. x 12-in. direct connected fuel-oil-driven machine.

The work was done by the Nevada Gunite Manufacturing and Construction Co.

Of the two large drydocks to be built at either end of the Panama Canal, the one at Balboa is to be the largest. This dock will be 1,000 ft. long, the entrance width will be 110 ft., and at mean low water the depth over the keel blocks will be 29.3 ft. The structure will be of concrete, and the entrance will be closed by mitre gates. Here it will be possible to repair the largest vessels afloat, as the main repair shops in the canal are also situated at Balboa. This dock is to be completed late in 1917. The dock that will be built at Cristobal, on the Atlantic side of the canal, is to be started very shortly, and will be 300 ft. long.

A SANITARY INTERPRETATION OF WATER ANALYSIS*

By E. C. Richardson

A SANITARY analysis of a water is made along two distinct lines, bacteriological and chemical. The former attempts to show the presence or absence of sewage contamination through the finding of living bacteria that are characteristic of sewage. A sanitary chemical analysis, on the other hand, does not consider living bacteria, but attempts to show by the presence or proportion of certain chemical substances that sewage has found entrance into a water supply.

The usual kind of germs found in water are non-pathogenic—those which will not produce disease. The constituents of sewage-contaminated water that are directly detrimental to human safety are the pathogenic microbes of some infectious disease. The detection of such microbes in a water supply is the most direct evidence of the unfitness of such water for human consumption.

All sewage and sewage-contaminated water, however, contains the wastes from human bodies, and such wastes are almost sure, sooner or later, to contain the bacteria of infectious disease. For this reason most of the bacteriological examination is directed toward detecting microbes that normally inhabit the intestine instead of detecting those of specific disease. This is a safe procedure, since water-borne diseases, such as typhoid, dysentery and cholera, have their seat of activity in the intestines.

Organisms of these diseases come from persons specifically affected, hence there is more or less uncertainty attending the search for such bacteria, unless there is an epidemic. Normal intestinal bacteria serving as a basis for the detection of sewage contamination are those belonging to the Bacillus Coli group. Its presence in water is indicative of pollution, but to be sure of pollution by sewage its abundance rather than its mere presence must be considered as the criterion. The test for Bacillus Coli, in order to be of definite value, therefore, must be not only qualitative but quantitative.

Single isolated determinations of the number of bacteria in surface water are of little value, unless accompanied by a full knowledge of the conditions under which the sample was collected, since rainfall, streamflow, wind and many other factors materially influence the number of organisms present. A single examination may, therefore, lead to erroneous interpretations. Sometimes, however, it may afford some evidence as to the sanitary character of the water; and scattered determinations are often useful in showing the relative character at different times, of water obtained from any particular source. Quantitative bacterial determinations are of special value as affording the best index of the efficiency of filtration. Here each separate test is of some importance.

In the collection of samples of water to be analyzed great care should be exercised in securing a characteristic sample, since it is only by the utmost care in all steps leading to a final interpretation that error can be reduced to a minimum. The sample bottles should be sterilized and care should be exercised to avoid bringing the hand or other objects against the parts of the bottles which come into contact with the water. Hold the stopper by the handle when collecting a sample. Do not lay it down.

---

*Journal of the Cleveland Engineering Society.