The filter sand has to be selected with great care and its effective size and uniformity co-efficient kept within certain well-defined limits. Recent improvements in the art of sand washing have greatly reduced the cost of securing a suitable sand for this purpose.

Sand Filters.

The raw water stands several feet over the sand and passes downward through it at a vertical rate of ten to twenty feet a day, collects in a system of underdrains laid in the gravel drainage, and is conveyed by a central outlet pipe to a pure water reservoir, also covered. In passing through the sand there is a certain amount of friction, increasing as the bed becomes clogged, which has to be overcome by the pressure of the water. Consequently, the level of the water at the outlet is lower than that of the water on the filter, and this difference of level is termed the "loss of head." Filters are provided with devices for measuring the loss of head and the rate of filtration, which are the guides that the attendant follows in determining when a filter bed needs to be cleaned.

The rate of filtration varies according to the character of the raw water. Comparatively clear waters can be filtered at a higher rate than muddy waters. In Europe the rates are seldom much above two or two and a half million gallons per acre daily, but in this country especially of late, there has been a tendency to use higher rates of filtration, and with clear water rates as high as six million gallons per acre daily have been established, as, for example, in the case of Toronto, where the water supply is taken from Lake Ontario. In other places rates of ten million gallons per acre daily have been recommended. Even in the case of muddy waters there is a tendency to use high rates of filtration, and to more thoroughly prepare a water for these high rates by some appropriate preliminary process, such as the use of scrubbers or chemical coagulants.

After a filter has been in use for some time its surface becomes clogged and the sand has to be removed and washed. The filter may be thus pared down several times, but finally it is necessary to restore the washed sand. Filters are usually scraped by hand, using shovels, the men wearing wood sandals in order to prevent the sand from becoming compacted under the feet. The dirty sand is thrown into a portable ejector, from whence it is carried by water through a line of hose to a sand-washer placed outside the filter. There it is agitated and washed with water, the dirt flowing away with the water and the sand being carried through a hose to storage bins, where it is kept until needed for use.

The chief purpose of sand filtration is to clarify the water, remove the bacteria, and the success of the process is attested by long years of experience in many cities. Ordinarily, the efficiency of a sand filter is upwards of 99 per cent.; that is, the filtered water contains less than 1 per cent. of the number of bacteria in the raw water. Thus, in Washington the average number of bacteria in the Potomac River for the year ending June 30th, 1908, was 6,299, while the average number of bacteria in the filtered water was 55 per c.c.

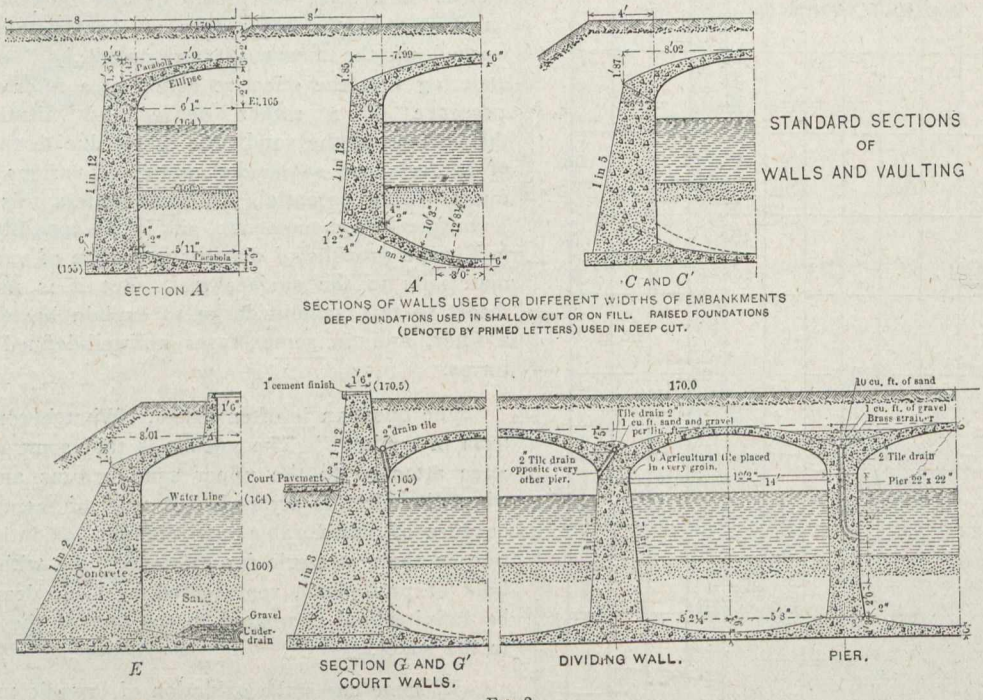

FIG. 2.

Tests for the colon bacillus showed that this intestinal germ was reduced to about the same extent, and inference, any typhoid fever or other disease germs in the water were likewise reduced in number. The real efficiency of a sand filter is usually higher than is represented by the calculated bacterial removal, for not all the bacteria found in the filtered water pass through the filter. Some of them represent growths in the drainage system below the sand bed.

A sand filter not only makes a water clearer and safer, it removes a part of the color and organic matter. There are many cases, however, where a sand filter cannot be economically used and some where it may utterly fail. For example, no sand filter by itself could be made to economically purify the muddy waters of the Middle West or the deeply stained waters coming from swamps. In these cases where one is dealing with large amounts of matter in colloidal suspension and organic matter in chemical solution, it is necessary to resort to chemical treatment. This brings us to the next division of our subject, i.e., coagulation.

Coagulation.

By the coagulation of water is meant the use of chemicals to produce an artificial flocculation of the colloidal matter and fine particles in suspension so as to neutralize