

A MODERN FILTRATION PLANT.

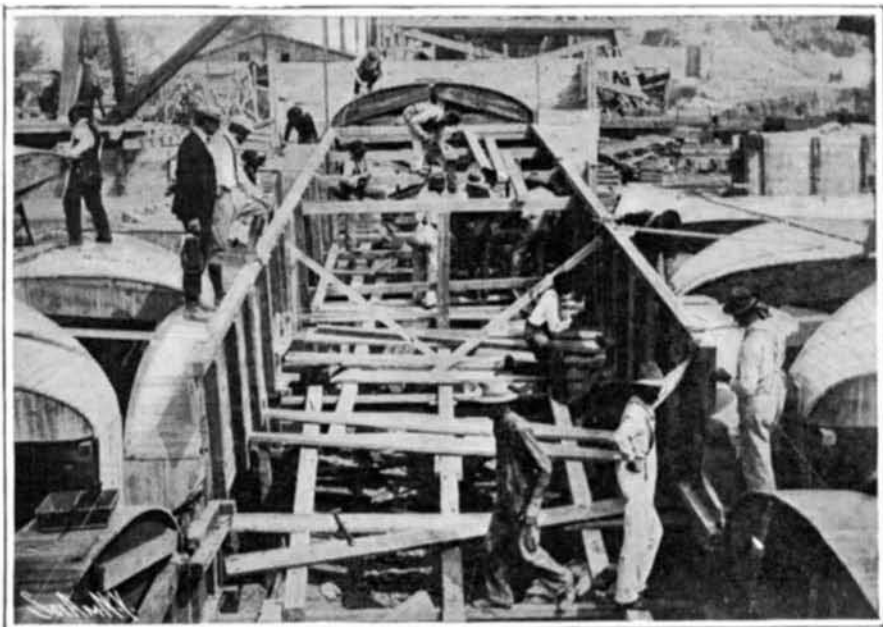
BY JAMES G. FERNALD, L.H.D.

Modern methods of filtration, like all that is best in scientific attainment, reach their result by closely copying nature. They build on a vast scale subterranean sand-beds, where the gathered water percolates through into the city mains, as it does by natural process into the deep well or the mountain spring.

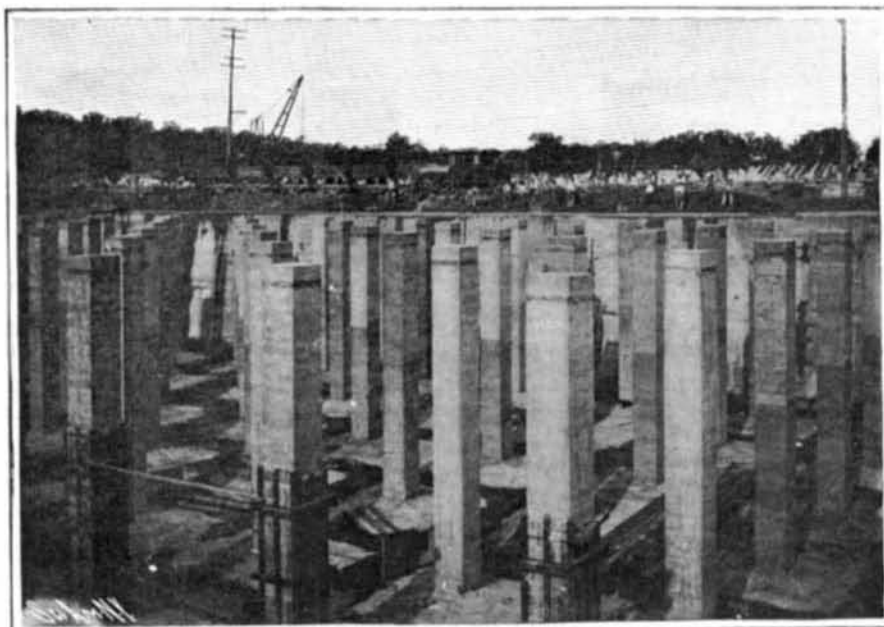
Of the way in which this is done, the filtration plant now in course of construction at Washington, D. C., the second largest in the world, is a good illustration.

flows 9½ miles to the Dalecarlia reservoir, which has a capacity of 150 million gallons, and was originally constructed by the damming up of the Little Falls branch of the Potomac, and which is entirely without lining of stone of any sort. Thence the water passes through a similar conduit for a distance of 1.1 miles into the old distributing reservoir, which has a total capacity of about 151 million gallons, and has paved slopes—it also being divided into two basins containing 98 million gallons and 53 million gallons respectively. Thence the water passes into the Washington

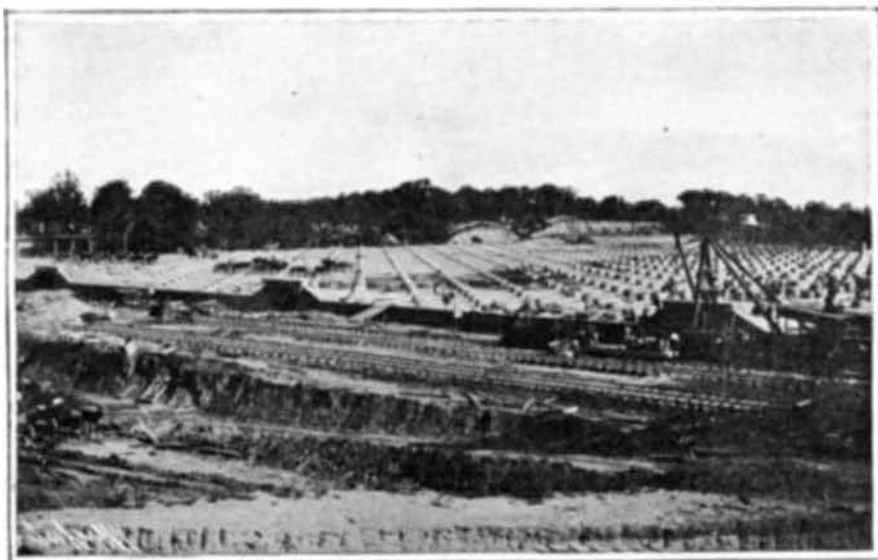
these cannot be used for cooking on any great scale. So the people are fain to use the muddy hydrant water and hope for the best. Worse than the mud, however, are the unseen germs which the scientist's microscope discovers. In fact, the muddy water is the purest. It is after rains or freshets, when a flood of fresh water has been poured into the river, that it comes down charged with earthy matter and looks so forbidding. But in quiet times, when animal and vegetable matter decays on the banks and is washed into the stream by occasional showers, or blown upon its sur-



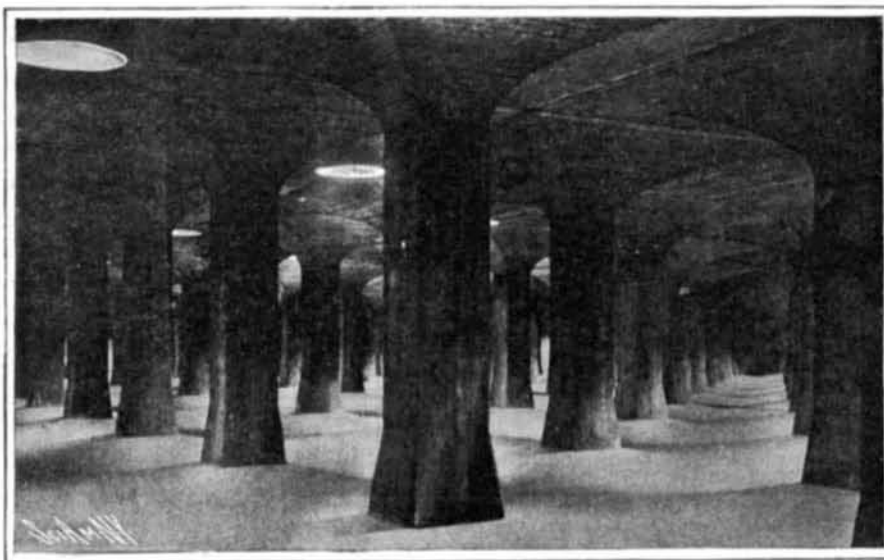
Fitting the Wooden Frames for Concrete Roof of Filters.



Part of Filtered Water Reservoir, Showing Pillars Twenty-Seven Feet High.



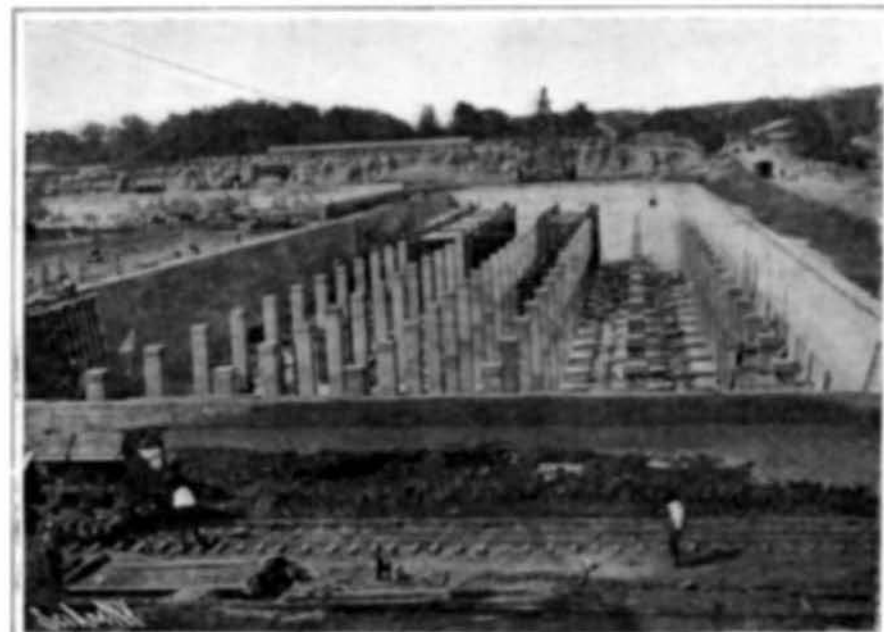
General View of Filtration Plant.



Interior of Filter.



Construction Work of Filtration Plant.



Partly Completed Filter.

A MODERN FILTRATION PLANT.

The water is drawn from the Potomac River above Great Falls, at a point 14 miles from Washington, whence it is brought to the city through a circular conduit of brick, which is 9 feet in diameter, and has a fall of 9½ inches to the mile. President Washington estimated that the city which he planned would require 8 million gallons of water daily. The present aqueduct has a daily capacity of 75 million gallons, and engineers are urging the immediate increase of this supply by paralleling the existing conduit with another of the same dimensions.

After entering the conduit at Great Falls, the water

city tunnel, commonly known as the Lydecker tunnel, which is 3-9 miles in length, to the Washington city reservoir, which has a total capacity of 300 million gallons. This, in addition to the Reno reservoir, and the Brightwood reservoir, gives a total storage of 635 million gallons, or about 9 days' supply, assuming 75 million gallons daily consumption.

The water as it now comes from this reservoir into the homes of Washington is often so muddy that one hesitates even to wash in it. Yet this is the water that Washington is compelled to drink. Many persons of course buy spring or other bottled waters. But

face by the wind, the clear water may be and often is much more fully charged with dangerous microscopic life.

The filtration plant that Washington is building to meet the city's need covers 29 acres, each acre a separate unit or section of the system.

As you stand at the southern gate of the Soldiers' Home and look southward toward the city, you see great fields covered with rows of small circular ridges looking like corn fields, with the hills rather large and rather far apart, and without the growing corn. Those circular ridges are the rims of the manholes that let

light and air as needed into the filter below. These manholes are 3 feet in diameter and 28 feet apart, and are guarded with double covers, so that they may be opened or closed as occasion demands. The filters are built in double lines, intersected by depressed roads, on which great double gates open, through which the filter may be entered for cleansing purposes at suitable times. Long aisles stretch away between rows of pillars.

As you look down at the floor of the partly completed work, you see that the groined arches overhead are repeated there inverted.

At the apex of many of these inverted arches may be seen openings leading downward, which are to carry the collected water after passing the filter into 2-foot mains that run under the floor. Lines of split tile with uncemented joints are laid with the convex side upward across the unpierced arches to reach these openings, along which the water will find its way as it does through a tile underdrain in a wet meadow.

Over the floor thus prepared is spread one foot of fine washed broken stone, and above this fine, clean sand is laid 4 feet deep. When this has become thoroughly settled, water will be let in from the pumping house with even flow till it reaches the depth of 4 feet above the sand, at which depth it will be maintained with unvarying accuracy by an automatic apparatus in the pumping house.

The filling of the filter is a very nice undertaking. It must be filled backward. When the broken stone and sand are well packed, water is let in through the mains underneath, and allowed to soak up gradually through the mass till the whole is thoroughly wet. By this slow absorption the sand is evenly moistened and firmly packed together.

Then the water may be let in over the top. But even then it is not allowed to flow directly upon the sand lest it disturb the surface and start a washout, which the water will wear more and more, going down

deep, stopping just 4 inches short of the upper rim of the manholes, so that no surface water can enter by way of the manholes. But how is the surface water falling in every rain to be kept from converting this earth covering into a swamp, and gradually working rifts, as water will, through the masonry of the roof? This is prevented by an ingeniously simple device. In the center of each pillar is set a 2-inch terra-cotta pipe, bent with an elbow so as to come to the surface of the north face of the pillar one foot above the level of the sand in the filter. Over the top of the pier, where the radiating arches spring, there is naturally a sump or depression. The terra-cotta pipe set in the stone of the pier opens upward in the center of this depression. Over the top of each of these pipes is placed a brass-wire screen, and over this 1 cubic foot of fine gravel and 11 cubic feet of sand. Thus water can never gather in pools upon the roof and become stagnant, but must work its way down through these prepared channels, and in going down must pass through sand and gravel, by which any impurities it may have gathered, as of decaying vegetation, will be mostly removed before it joins the mass of water in the filter below, again to pass through 5 feet of sand and gravel before reaching the underlying mains.

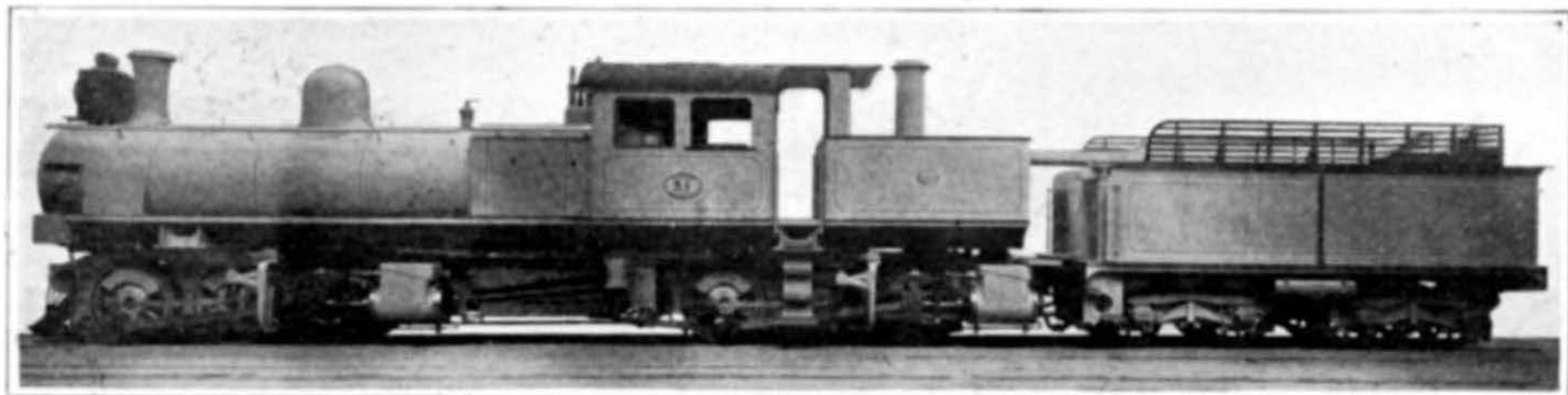
The filters are to be cleaned once a month, one filter a day, so that it will take practically a month to clean the whole plant. In cleaning, about one inch of the top surface of the sand will be carefully scraped away and removed. So carefully must this be done, that the workmen who do it will be required to wear flat-soled wooden sandals about 18 inches long by 6 inches wide, on which they go skating or sliding over the surface, where any dent of a boot heel might start a washout, through which the water would ultimately rush unfiltered. The water pressure will be very great, because each filter will contain water covering a surface of approximately 45,000 square feet and 4 feet in depth, giving 180,000 cubic feet of water, which

ment as well as a source of incalculable benefit to the beautiful and rapidly-growing capital city.

A UNIQUE LOCOMOTIVE FOR SOUTH AFRICA.

BY F. C. COLEMAN.

For working heavy freight trains over the severe grades and sharp curves encountered on the Rhodesia railway, which has now been recently extended to Kalamo, 90 miles to the north of the Victoria Falls, and which is destined to form a very important link in the projected Cape to Cairo railway, a unique type of locomotive, illustrated herewith, has been introduced into service. This engine is divided into three main portions—the superstructure and two steam-driven trucks. The superstructure consists of boiler, coal bunker, water tanks, and cab, which rest on two long girders, that are themselves carried at two pivot points on the six-coupled trucks. By this means the whole weight of the engine is upon the coupled wheels, and is, on that account, available for adhesion. It can be accurately adjusted by means of a special spring connection, introduced at a selected position away from the center of the bogie; and as the wheel-base of each engine is not more than 8 feet 6 inches, the engine here illustrated, which weighs 81 American tons, can pass round curves of three chains radius without causing the slightest injury to the road-bed. In addition to the advantage of traversing these severe curves, the line of pull from the engine itself is kept in a position which reduces the side resistance at the pulling end. Each bogie is in itself an engine, with a pair of cylinders, valve motion, brake gear, and sanding gear complete, and bears the weight of half of the superstructure on a recessed steel casting. There are bolts passing through slot holes in these castings, which form a connection between the bogie and the superstructure, and a further security against an excess of movement is provided by the addition of check chains. The mechanical details by which the power



Each Truck is Driven by Its Own Complete Engine. The Smokestack at Back of Cab is for the Exhaust of Rear Engines. Weight of Engine is 81 Tons.

ARTICULATED LOCOMOTIVE FOR THE RHODESIAN RAILWAY.

through it in a stream unfiltered, instead of working its way through drop by drop. So the new water is let in behind a detaining wall, the top of which rises just 3 inches above the surface of the sand, so that the incoming water flows slowly and evenly over upon the sand.

Here then we have the subterranean waters in cool dark chambers under the earth, slowly trickling down through fine, clean sand, the nearest artificial reproduction yet attained of nature's great filter that supplies the wells and springs.

The whole vast structure is built of concrete, which is really artificial stone, prepared by mixing 1 barrel of cement with 11 cubic feet of sand and 19 cubic feet of broken stone or gravel. It has been found that an arch of concrete so prepared will bear practically any weight that can be piled vertically above it. These arches are of 14-foot span, the concrete being 6 inches thick at the crown of the arch.

A visitor to the filtration plant sees vast piles of wooden forms of various shapes lying ready to be carried where they may be put in place to have the concrete masonry formed upon them. The work is necessarily slow, because the concrete is so thinly spread over so vast an area. The forms must be carried by hand from point to point, a dozen or fourteen men carrying one form, and carrying it no faster, of course, than a man can walk, to the place where it is to be set up. After the concrete has hardened, the forms must be removed and carried to a new place by the same slow process. So the inverted arches are formed for the foundation. Then the pillars or piers, monoliths of concrete 10 feet high and 22 inches square, are built where they are to stand. Looking across the partly-completed filters, one sees long rows of these roofless columns like the ruins of some newly-excavated Pompeii. When these are ready, the arched wooden forms are placed upon them, and the concrete spread above, which is to set into solid stone for the arches of the wide roof.

Over the roof is laid a level covering of earth 2 feet

at an estimate of 63 pounds per cubic foot, would weigh 11,340,000 pounds.

When the water has passed down through the sand and broken stone into the underlying mains, it flows through these to the "regulator houses," of which there are six, neat brick buildings, each controlling five filters. The water from the five filters is conducted into a central chamber in the "regulator house," and from this through 48-inch mains to the "filtered water reservoir."

This is a vast underground structure, 612 feet long by 162 feet wide, the roof of which is formed of arches 18 feet in span resting upon columns of monolithic concrete masonry, 2½ feet square and each 27 feet high. As one walks through the empty structure now the likeness to a vast cathedral is still more impressive than under the arches of the filters. This reservoir will hold one-third of a day's supply for the city (25 million gallons). This supply must of course be drawn off three times every day, which is to be done by five great engines in the Trumbull Street pumping station, to which the water is conveyed by four 48-inch mains from the filtered water reservoir.

The filters have been described as subterranean. They are, indeed, largely built upon excavated ground, but even so they are higher than the water in the Washington city reservoir, from which their supply is drawn. This makes necessary a special pumping station in connection with the filter plant, having for its sole work to raise the water from the reservoir and distribute it to the filters. The completion of the work is promised by September, 1905. The total cost is estimated at \$3,000,000.

The earth covering the roofs of the filters will be sown to grass, and the intersecting streets paved and parked, so that, with the vast lake of the Washington city reservoir on the west, the wide lands of the Soldiers' Home stretching far to the north, and the Capitol, the city, and the Washington Monument full in view as one looks southward from this elevated ground, the Washington filtration plant will be an added orna-

is supplied and controlled for each of the bogies have been carefully designed. The steam is carried from the front end of the boiler by means of ball-and-socket joints to each pair of cylinders. The exhaust of the front bogie is carried through the smokebox, and is sufficient to keep up a draft through the firebox, and so maintain steam. The exhaust steam of the hind bogie is passed into the atmosphere, but could be utilized either for the purpose of increasing the draft or for an exhaust steam injector, if required. The driver supplies steam to both sets of cylinders by one movement of the regulator handle, and in the same manner he is enabled to reverse both engines, put the brake on, and actuate the sanding gear by one movement of each of the handles concerned. There is no difference in the method of lookout, or of handling the engine, from the practice of ordinary locomotives. The boiler is of the "Belpaire" type, so commonly used on British railroads, and provides a specially large steam capacity and the usual facilities for washing out, etc. The locomotive was built by Messrs. Kitson & Co., of Leeds, England, and as illustrative of its great hauling capacity, it may be stated that the engine illustrated herewith is now regularly drawing twice the train loads formerly hauled by the most powerful locomotives on the Rhodesia railroad.

Each bogie has six wheels coupled, each of 4 feet diameter, and two outside cylinders of 16 inches diameter by 24 inches stroke. Other dimensions are: Heating surface, firebox, 136 square feet; tubes, 1,590 square feet; total heating surface, 1,726 square feet. Grate area, 34 square feet. Internal diameter of boiler, 5 feet. Length of boiler, 13 feet 4 inches. Thickness of boiler, 9-16 inch. Boiler pressure, 180 pounds per square inch. Length of firebox, 8 feet 3 inches. Height from rail level to top of funnel, 12 feet 10 inches. Height from rail level to center of boiler, 7 feet 2 inches. Rigid wheel-base, 8 feet 6 inches. Total wheel-base, 34 feet. The engine tank has a fuel capacity of 3 tons of coal. The tender has a capacity of 7 tons of coal and 2,855 gallons of