New Jersey – Birthplace of the Filter

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***Contents in Brief** — Present-day practice in mechanical water filtration and coagulation had its beginnings in New Jersey sixty years ago. M. N. Baker, dean of American writers on water supply, sketches the history of this significant development in water purification.*

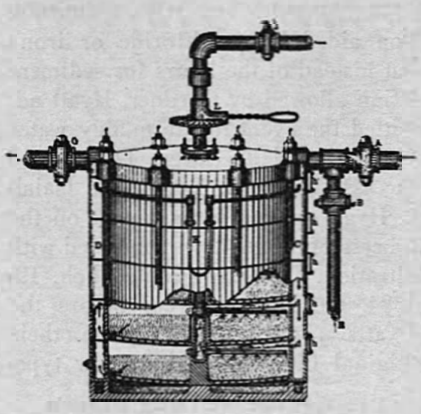
NEW JERSEY was the birthplace and fostered the development of the American mechanical water filter. In a crude way the water filter took form at Rahway under the hand of Patrick Clark. Adapted and improved by John Wesley Hyatt it assumed a new mechanical form at Somerville and later was combined with the coagulation process of Isaiah Smith Hyatt. Then with further mechanical changes by J. W. Hyatt it was installed at Long Branch. All this occurred in the decade ending with 1888. Fourteen years later, a radically different mechanical or rapid filtration plant designed by George W. Fuller was put in operation at Little Falls.

Although the essential feature that gave mechanical filtration its name had been anticipated and to a limited extent utilized long before the days of Clark and the Hyatts, they were probably blissfully unaware of it. None of these anticipations included coagulation, which was to make mechanical filtration a success and warrant the name rapid in contrast to slow sand filtration.

Clark's jet wash

Called on in March, 1876, to find a remedy for the "almost constant turbid condition" of the water supply of Rahway, Patrick Clark, the city engineer, reported that instead of furnishing "spring water" from an infiltration basin built in 1871, a large part of the supply was drawn from the North Branch of the Rahway River, made turbid by every rain. He advised the construction of "a large settling reservoir and filtering apparatus." The board engaged for this purpose George H. Bailey, who designed filter basins for Newark and Rahway. Almost immediately, the water board abandoned the project.

Clark became chief engineer of the Rahway Water Board on May 8, 1878. On October 21, 1880, he resigned his position and the board voted "that the filter constructed by P. Clark at the works be allowed to remain there." When and under what conditions it was put in, its nature and how long it remained in service is unknown. In a special report of the Tenth Census of the United States, transmitted to the director on June 1, 1882, these words appear in a description of the Rahway waterworks: "Filtering Apparatus: Clark filter, 16 ft. sq.; sand, 6 in. deep on fine wire cloth; cleaned once in 24 hours. Consumption, 0.5 mgd." This indicates a filtration rate of 85 mgd per acre.



The Hyatt filter illustrated in *Engineering News* of January, 1882.

Evolution of Hyatt's filter

Four days before his resignation, Clark applied for a patent on his filter. On Feb. 11 following, John Wesley Hyatt applied for a patent, virtually embodying Clark's design. Both applications, assigned to the Newark Filtering Co., were granted June 21, 1881.

Rahway was only a few miles from Newark, where John Hyatt and his brother Isaiah had a flourishing business as manufacturers of celluloid. It may be assumed that Hyatt saw Clark's filter at Rahway and set his inventive mind on its exploitation. His patent of June 21 was the first of 65 filter patents taken out by him in the period 1881–89.

Clark's patent claims were confined to cleansing filter surfaces by jets of water discharged from the underside of perforated revolving pipe, with outer ends closed. His filter bed was a layer of sand only 3 to 6 in. thick supported on wire cloth. Hyatt converted Clark's filter from an open gravity to a closed pressure apparatus and superimposed any desired number of filters within a single tank. Each filter was independent of the other in action. As described and illustrated in *Engineering News*, Jan. 7, 1882. p. 3, the Hyatt filter had these advantages: economy of space; sand washed in place; any filter could be washed while the others were in use.

Alert for a customer, Hyatt noted that the Somerville Water Co. was building works to supply Somerville and Raritan, a few miles from Newark, and that the supply was to be taken from the Raritan River, made turbid and colored by its red shale gathering area. The minutes of the water company for Aug. 25, 1881, state that Messrs. Hyatt & Co. (Newark Filtering Co.) proposed to furnish four filters, height 8 ft., diameter 50 in.; to stand a pressure of 300 lb. per square inch, for $2 500. The offer was accepted, but subject to a guarantee of satisfactory operation for one year. Subsequent agreements reduced the guarantee period first to six months, then to three months, and stipulated that each of the four main tanks should contain 20 in. depth of sand and the whole plant should have a capacity of 350 gal. a minute (0.5 mgd). On Oct. 20, 1882, the directors voted to pay $1,000 on account of the purchase price of the filters, with the proviso that "if

upon further trial (since they have just been perfected), it is found that they do not work to the satisfaction of the board, the $1,000 is to be returned and the filters taken out." The "further trial" must have been satisfactory for on Dec. 11, 1882, final payment was authorized.

Ejector wash and coagulation

The next stages in the evolution of the Hyatt filter were the substitution of upward-lateral for downward filtration and upward-ejector for downward-jet surface wash, combined with coagulation. After this combination became an assured success the Hyatts sought to introduce it at Somerville. On March 23, 1885, they proposed to furnish the water company with four new filters for $7,000. The company invited proposals from other filter manufacturers. Only one was received. The Crocker Filtering Co. offered to put in two of its "largest filtering machines" for $5,000. What their nature was, is not known.

Next, the Newark Filtering Co. was asked its terms for four of its "improved filters." These proved to be $6,500, less $2,500 for the existing filters. On May 23, the water company ordered "four Hyatt filters, 6½ ft. in diameter by 13 ft. high, capable of standing an internal pressure of 150 lb. per sq. in.; and *accompanied by a suitable coagulating apparatus.* [Italics mine.] They must be guaranteed to deliver 0.5 mgd of "bright, clear and wholesome water for 24 hours if washed once each day." They were to be subject to a service test "after the river water had been muddy for ten days."

On Aug. 17, 1885, the water company authorized a part payment of $2,000 on "the new filters just put in," to be a loan in case the filters, "after use," did not "come up to the terms of the contract." On Sept. 7, the water company accepted an offer to allow the old filters to remain in place provided the filter company was paid the second $2,000 that would be due when the plant was accepted.

The second filters had little in common with the first except that both worked under direct pumping. In the new filters each of the tall tanks was in two compartments, the lower containing the filtering material. Raw water was admitted at the bottom, rose, and, curving outward, passed through an inner perforated cylinder to a concentric clear-water chamber. In washing, the sand was ejected by a reverse flow of water into the upper compartment from which the dirty water overflowed into a waste trough. Finally, the sand was let fall down into the filter compartment. In general principle, this washing system was similar to that of the drifting sand filters built thirty years later at Toronto, Ont.

Genesis of coagulation

After J. W. Hyatt patented his new mechanical apparatus in 1883 his older brother, Isaiah Smith Hyatt, went to New Orleans as sales agent. Unable to cope with the muddy Mississippi River water for the supply of an industrial plant, he adopted a suggestion made by Col. L. H. Gardner, superintendent of the New Orleans Water Works Co., who had been experimenting with sedimentation aided by perchloride or iron; but instead of the hours for sedimentation allowed by Gardner, Hyatt admitted the agent to the muddy water as it entered his filter. This was a success. On Sept. 20, 1883, Isaiah S. Hyatt applied for a patent on the process of coagulation combined with filtration. This was granted Feb. 19, 1884, more than a year before the Hyatts proposed to replace their original filters with their new type.

Pre-aeration at Long Branch

In New Jersey, the Hyatts' next innovations were pre-aeration, a change in filter media and sand agitators. These were introduced at Long Branch in 1888. Waterworks for that famous summer resort had been built by a private company in 1877. The supply was from "springs and a small creek . . . somewhat discolored, especially in the season of greatest demand." (*Engineering News*, Oct. 13, 1888, p. 280). This water, gathered in a small pond, was aerated by discharging it down a 16-in. pipe sunk 100 ft. in the ground. A vertical partition divided the pipe from top to bottom. Raw water fell down one compartment to the bottom, sucking in air, rose up the other side and went to the pump well. Alum was applied to the water on its way to the filters. The filtering media was "prepared coke" and sand, in the ratio of 3 to 1. Sand agitators on a revolving vertical shaft were used.

Aeration by other means than a pipe sunk in the earth became a feature of iron-removal plants. First of these in America was the one completed at Atlantic Highlands, N. J., in October, 1893. It was followed in 1895 by plants at Asbury Park and Keyport. Today New Jersey has twenty-five iron-removal plants on municipal water supplies, most of which include some type of filter.

Although mechanical filters multiplied rapidly after 1887, most of them were on small supplies until many years had passed. Conflicting claims of rival manufacturers, questions of bacterial efficiency and the best methods of design and operation led to experimental tests on various makes of filters, sometimes parallel with tests of slow sand filters. Early and most notable of these were the experiments on mechanical filters at Louisville, accompanied by studies of coagulation and sedimentation, made by George W. Fuller.

Fuller's classic report on the Louisville experiments was published in 1898 but it was not until 1902 that its lessons were embodied in a permanent plant—located in New Jersey instead of Kentucky. It was designed by Fuller and built by the East Jersey Water Co. at Little Falls on the Passaic River above Paterson. Its primary object was the removal of bacteria. In place of cylindrical tanks of wood or steel, rectangular tanks of concrete were employed. Most revolutionary of all its features was pre-coagulation instead of instantaneous coagulation. This was not to avoid the Hyatt patent which had expired in 1901, but because the Louisville experiments showed the importance of giving coagulants adequate time to act before the water entered the filters. The Hyatt patent had been upheld in a long court battle during which bitter competition had crippled more than one company, including the original holders of the Hyatt patent.

The Louisville experiments and the application of their results at Little Falls established rapid filtration on an engineering basis. With the advent of chlorination, first applied in 1908 to a municipal supply, mechanical filtration forged ahead. Subsequently it led and finally almost displaced slow sand filtration in America. Such was the outcome of its modest beginnings sixty years ago in New Jersey.