CHAPTER VIII

Upward Filtration in Europe and America

Utilization of the force of gravity to throw down suspended matter was the primary motive of most of the many designers of upward-flow filters from the seventeenth to the twentieth century. "Upside-down" would be an apt term to apply to the upward-flow filter, for as a rule the media were in layers graded, from bottom to top, from coarse to fine. It was assumed that gravity, acting on the suspended solids in the ascending water, would draw them to the bottom of the raw-water chamber beneath the filter, not only from the water in the chamber but also from the interstices in the filtering media, particularly from the coarse layers of the filter. Likewise, in washing, the larger interstices at the bottom of the filter were supposed to facilitate carrying the dirt below. It was not even suspected that the major force in filtration was adhesion to the media rather than straining. This is made clear by repeated assertions that filters were merely strainers, the small interstices barring the passage of the suspended particles of larger size. This theory was pressed home with supposedly telling force when removal of disease germs, as well as mud, was claimed for filtration.

Such claims, however, did not arise until long after Porzio described multiple filtration by successive pairs of upward-downward filters in 1685 (see Chaps. II and IX). Amy, aware or not of Porzio's plan, brought forward the same general scheme in the 1750's (see Chap. IV). To meet an urgent need during the Siege of Belgrade in 1790, Mederer von Wuthwehr, Surgeon General of the Austrian Army, improvised upward filters in the holds of old transport ships lying in the river.

British and American Patents

The very next year, James Peacock, in the first British patent on filters, claimed as a new and useful departure from current practice, filtration by ascension and cleaning by reverse flow. Whether his patent was ever put into effect, except for a trial about 1800 on three ships of the British Navy, is unknown (see Chap. V). In 1798, Joseph Collier went Peacock one better by patenting a combination of upward sedimentation and double filtration (see Chap. IX). During

the next century scores of British and a few American patents on upward filters were taken out. Most of them came to nothing.

Of the few American patents on upward-flow filters, the most notable were four granted in the last half of the century. Henry Flad, an eminent engineer of St. Louis, Mo., was granted a patent March 5, 1867, on a filter much like the one patented by Peacock in 1791 but with better provision for regulating its operation. A few were installed in local buildings. J. D. Cook, of Toledo, Ohio, water works engineer of note in his day, obtained a patent November 6, 1877, on a series of pairs of filters, which alternated upward and downward flow (see Chap. IX). John W. Hyatt, prolific patentee of filters, was granted a patent December 10, 1889, on "Apparatus for Upward Filtration." Raw water was admitted to a filter in a closed tank through strainers at the bottom of the unit. The filtrate was drawn from strainers below the filter surface. No installations have been found recorded. George H. Sellers, a Philadelphia engineer, included upward filters in three American and a British patent taken out in 1896.

Nineteenth and Twentieth Century Installations

At Greenock, Scotland, filter beds designed to work by either upward or downward flow, with reverse-flow wash, were completed in 1827. They were designed by Robert Thom, who built similar filters at Paisley and Ayr, Scotland, about ten years later. At Glasgow, in or about 1830, the Cranston Hill Water Co. built an upward-flow filter (see Chap. V).

Albert Stein, a German-American engineer, completed upward-flow filters at Richmond, Va., in 1832. They failed immediately. This was the first American attempt to filter a municipal water supply (see Chap. VI).

At Leghorn, Italy, three pairs of upward-or-downward-flow filters were installed about the middle of the nineteenth century.

First of the American upward-flow filters after the ill-fated ones at Richmond, Va., was a small one built in 1874 at New Milford, Conn., after designs by B. H. Hull, of Bridgeport. Gravel, sand and charcoal were placed in a brick chamber in an impounding reservoir. Apparently its use was soon discontinued. Croes, in his paper of 1883 on early American attempts at filtration (1), describes briefly, besides the Richmond and New Milford filters, five other upward-flow installa-

tions. The locations of these, in chronological order * were: St. Johnsbury, Vt., 1876 or 1877; Burlington and Keokuk, Iowa, 1878; Lewiston, Me., and Stillwater, Minn., 1880; and Golden, Colo., 1882. Filtering media were: charcoal, sand and gravel at Keokuk; gravel and charcoal at Stillwater; sand or gravel at the other places. False bottoms, so far as can be learned, were generally planks or boards on edge, set ¼ to ½ in. apart. The Stillwater filter was 50 × 100 ft. in plan. Next in size was the Burlington filter, 120 × 20 ft. It was built by the Citizens

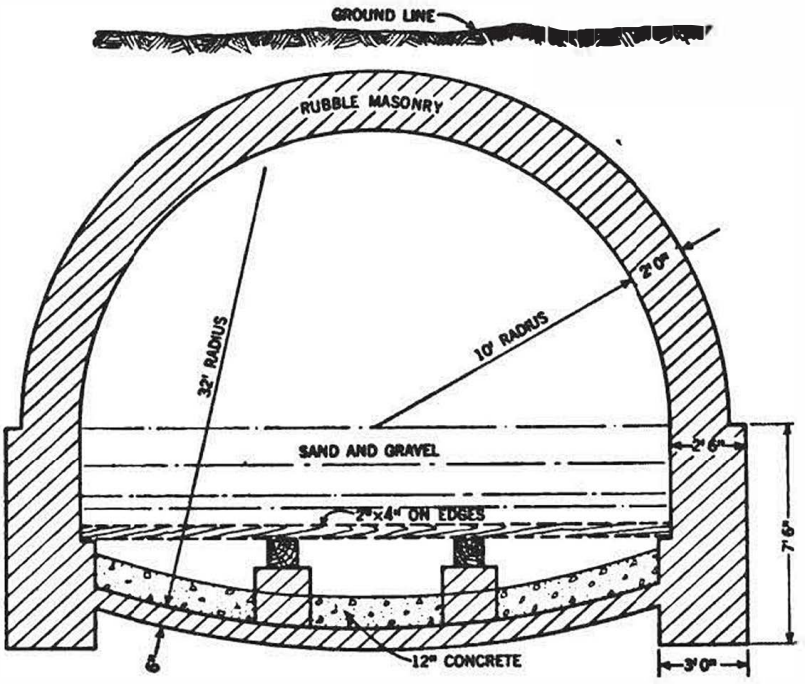

FIG. 49. UPWARD-FLOW FILTER AT BURLINGTON, IOWA, 1878
Designed and built by T. N. Boutelle, Engineer; 20 × 130 ft. in plan
(From blueprint supplied by Frank Lawlor, Supt., Burlington Water Works)

Water Co., of which T. N. Boutelle was Chief Engineer. The Lewiston filter had an area of 400 sq.ft. and was designed by M. M. Tidd, a well-known Boston engineer.

At Pawtucket, R.I., a small upward-flow filter was built in 1883 and superseded in 1888 by a larger one at a new pumping station. Both were designed by Edwin Darling, Superintendent of Water Works, who got the idea for the first installation from the filter at Lewiston. The false bottom of the earlier filter was boards set on edge; of the later

*Some of the dates given by Croes have been slightly changed to agree with later information.

one, an iron grating. The earlier filter consisted of 24 in. of stone, egg sized at the bottom, decreasing to the size of peas at the top. The second filter, from the bottom up, was: stone, 2 in. and smaller in size; 1 ft. of birch and maple charcoal; and 18 in. of stone, graded to the size of pea gravel at the top. When the writer visited the new filter in 1889, soon after its completion, Darling stated that the object of the earlier filter was to remove fish, spawn and inorganic matter of comparatively large size. The new filter, he said, removed nearly all suspended matter and, "it is claimed," also "a large percentage of microorganisms" (2). It should be remembered that even the filter of 1888 was designed when there were only three typical slow sand filters in the United States. The water consumption at Pawtucket in the first full year after the completion of each was 2.3 mgd. and 3.35 mgd. This would give working rates of 200 mgd. an acre for the first and 75 mgd. for the second filter. To clean the larger filter, stated Darling in 1889, the supply was shut off, the filter drained, and water under 40 psi. pressure applied to its top through hose attached at point after point in a pipe running the length of the filter. The larger filter was used for 42 years, or until 1930, when it was given up to make room for a 54-in. supply main. Fine-screening and chlorination were then adopted (3).

Storm Lake, Iowa, put an upward-flow filter in use in 1891 (4), as did Bartlesville, Okla., in 1894 (5). At Bartlesville highly turbid creek water was coagulated and settled before filtration. Superintendent C. E. Perkins stated in 1933 that the scanty information available indicated that the filter was soon abandoned because it could not be cleaned successfully (6).

Coagulation with comminuted metallic iron, produced at the plant, followed by aeration and upward filtration was put in use at Tacoma, Wash., in 1892 and at Wilmington, Del., in 1894. The Tacoma plant was hastily improvised by A. McL. Hawks, under the general direction of George H. Sellers, who had in mind utilization of the so-called Anderson process of coagulation, aeration and filtration—but not by upward flow. Sellers elaborated the Tacoma plant in one built for Wilmington. Susequently he patented his combination. The Wilmington plant worked at a high rate, probably with little benefit either from coagulation or aeration. It was abandoned in 1903 when Theodore Liesen became chief engineer (see Chap. XIII).

Revival of Upward Filtration in England

In the 1920's an upward-flow filter, similar in general principle to Peacock's patent of 1791 and Thom's filters of 1827 and later at Greenock and elsewhere in Scotland, was patented in England by Pennell. It has since been utilized at two municipal water works in England and at many industrial plants in that and other countries. It is a rapid filter, washed by reverse flow. Either open or closed tanks may be used, but the filtering head is low and the washing head only a few feet greater. The municipal filters are small. One at Blackburn was put into use in 1925. At Grange-Over-Sands a filter was completed in 1927 and duplicated in 1930. All these are in open-topped rectangular masonry tanks. The Grange-Over-Sands filters, writes Thomas Huddleston, engineer of the district (7), "are based on the Pennell-Wylie patent," controlled by F. W. Brackett & Co. The makers (8) state that the chief function of the carefully graded sand and gravel used as media is to remove peaty matter from moorland water.

The Brackett Upward-Flow Filter, as the manufacturers have named the Pennell or Pennell-Wylie apparatus,* has a hopper-bottomed settling chamber below the perforated false bottom of the filter. In the open-topped filter, raw water enters the top of a large central vertical tube, passes down into the settling chamber, rises through the false bottom and the sand. The filtrate is drawn off from just above the filter tank. To wash the filter a lever above the filter tank is pushed to one side. This lifts a wash-out valve in the bottom of the hopper. The downward rush of water from above the sand automatically closes the raw-water inlet and carries down suspended matter from the filtering unit and sediment from the hopper. On closing the wash-out valve, the raw-water inflow is resumed automatically. In pressure filters, the raw water is admitted directly into the hopper, just below the perforated false bottom. The filtrate is collected in two concentric pipe rings, just above the unit; one at the circumference, the other a third of the way across. The air between the water surface above the sand and the tank dome is said to be compressed and to reinforce the down-draft of water when the wash-out valve in the hopper is opened. A coagulant is admitted directly to the incoming raw water if needed to help remove either color or suspended matter.

* A British patent was granted to Reginald Humphrey Lee Pennell September 11, 1922, for improvements in the filtration of turbid water or liquid. This patent seems to be the basis of the Brackett filter.

73. FULLER, GEORGE WARREN. Personal Letter. New York (March 12, 1934).

74. BENZENBERG, GEORGE H. *Report to the Board of Trustees. A Brief History of the Old Water Works, 1897–1909.* Ebbert & Richardson Co., Cincinnati (1909). [D]

75. FULLER, GEORGE WARREN. *Report on the Investigations Into the Purification of the Ohio River Water for the Improved Water Supply of the City of Cincinnati, Ohio.* Commercial Gazette Job Print, Cincinnati (1899). [B]

76. BAHLMAN, CLARENCE. Personal Letters. Cincinnati, Ohio (1934–42).

77. JOHNSON, GEORGE A. The Typhoid Toll. *Jour. A.W.W.A.,* 3:249–326 (1916).

78. ST. LOUIS BOARD OF WATER COMMISSIONERS. *Annual Reports.* St. Louis (1865–). [D]

79. KIRKWOOD, JAMES P. *Report on the Filtration of River Water, for the Supply of Cities, as Practiced in Europe.* D. Van Nostrand, New York (1869). [B]

80. SEDDONS, JAMES A. Clearing Water by Settlement. *Eng. News,* 22:607–609 (1889). [E]

81. GRAF, AUGUST V. Notes sent to the author through the courtesy of Edward E. Wall, Director of Utilities. St. Louis, Mo. (n.d.). [X]

CHAPTER VIII

Upward Filtration in Europe and America

1. CROES, JOHN JAMES ROBERTSON. Methods of Filtration of Water in Use in the United States and Europe, With Details of Construction, Cost and Efficiency. *Proc. A.W.W.A.,* pp. 65–72 (1883).

2. ANON. The Pawtucket (R.I.) Water Works: General Description. *Eng. News,* 21:493–504 (1889). [E]

3. HARDING, THOMAS E. Personal Letter. Pawtucket, R.I. (March 11, 1938).

4. ANON. Filter Bed at Storm Lake (Iowa). *Eng. News,* 2:519 (1891).

5. ANON. Coagulation, Sedimentation and Upward Filtration at Bartlesville, Okla. *Eng. News,* 9:212 (1894). [X]

6. PERKINS, C. E. Personal Letter. Bartlesville, Okla. (1933).

7. HUDDLESTON, THOMAS. Personal Letter. Grange-over-Sands, England (September 20, 1939).

8. BRACKETT, F. W. & CO. The Brackett Upward-Flow Filter. Colchester, England (Latest date of testimonials 1935). [X]

CHAPTER IX

Multiple Filtration: Seventeenth to Twentieth Centuries

1. BACON, FRANCIS. *Sylva Sylvarum, or a Natural History in Ten Centuries.* W. Lee, London (1670). [D]

2. ROCHON, M. Memoir on the Purification of Sea-Water, and on Rendering It Drinkable Without Any Empyreumatic Taste by Distilling It in Vacuo. (From the *Jour. de Physique.*) *Repertory of Arts, Manufactures and Agriculture,* Second Series (J. J. Wyatt, London), 24:297–302 (1814). [D]

3. PORTIUS, LUCAS ANTONIUS. *The Soldier's Vade Mecum; or the Method*