CHAPTER X

Drifting-Sand Rapid Filters

A type of rapid filter called "drifting-sand" was put into use at Merthyr Tydfil, Wales, in 1913, and soon afterwards in a half dozen cities of the Western Hemisphere, notably at Toronto and at Recife, State of Pernambuco, Brazil. It was exploited as novel but its basic principle—ejecting filter sand from bottom to top of a filter—had been applied by Hyatt in the United States 30 years earlier and by Bollmann, on the continent of Europe, ten years earlier. The same general principle was adopted by a filter manufacturer at Belfast, Northern Ireland, about 1925, and by a French concern at Paris in the early 1930's. Outlines of these five systems of washing rapid filters, used before or after reverse-flow wash, are here brought together for the first time.

Hyatt Sand-Transfer Wash

In the second stage of the development of the American mechanical filter by John W. Hyatt, the revolving-jet and reverse-flow wash gave place to the sand-transfer system. In this the entire body of sand was transferred by reverse flow through vertical pipes extending from the bottom of the filter unit to the top of an upper compartment and dropped there. Attrition of the sand grains against each other during the transfer dislodged the dirt which was discharged with the wash water from the top of the compartment. On completion of the washing, the cleaned sand was dropped through valves back into the filter compartment. This washing system was first used for a municipal supply in 1885 in the second installation of Hyatt filters for the Somerville and Raritan Water Co., in New Jersey. Subsequently it was used in the much larger Hyatt plant for Atlanta, Ga., and apparently in some other municipal installations.

Hyatt took out two United States patents on sand-transfer wash apparatus, covering many variations. The first of these was dated March 6, 1883 (application filed September 15, 1882). The bulk of the specifications was devoted to describing a quadrangular group of filters interconnected to operate in series, with one empty to receive sand being washed in transfer from one being cleaned. The sand-

transfer pipe rose at an angle of 45 degrees from the bottom of the side of one filter to the top of the next. Provision was made for introducing a jet of water in the inclined riser pipe to accelerate the movement of the sand.

The second patent (February 19, 1884; application August 11, 1883) was on a washing process and apparatus by means of which the filter was continuously washed without interfering with filtration. This was effected by "moving a current of the filtering substance, together with a stream of water, from the lower to the upper part of the bed without checking the flow of liquid to be purified, whereby the particles are separated and washed in transit and the impurities are carried off by the escaping water without interfering with the filtering process." This patent covered (a) reverse-flow wash through the underdrainage system, and (b) a "jet pipe placed directly below" the lower end of a central sand-transfer pipe (an ejector). The cleaned sand brought up through the central transfer pipe forms a mound on the top of the bed.

Bollmann Sand-Transfer Wash

A sand-ejector washing system used after the common reverse-flow wash is the leading feature of a rapid sand or mechanical filter made by the Bollmann Filter-Gesellschaft of Hamburg, Germany. The manufacture of this type of filter was begun in 1903. In the early 1930's a more elaborate form was put into use. The first form is called *"einem Lenkkörpern"* and the second *"mehreren Lenkkörpern,"* or "one guide" and "many guides" to direct the sand to the ejector by a "spray wash."

In both forms the upper part of the filter tank is cylindrical, the lower part is shaped like an inverted truncated cone, and the ejector is placed at the base. The ejector discharges into a chamber formed by two cones, the lower cone being inverted. The lower or inverted cone is concentric with the inverted conical bottom of the tank, with a narrow space between the two, down which the sand flows to the ejector when it is in action. Between the upper cone and the conical bottom of the filter tank is a V-shaped space, filled with sand. A "rinse wash," supplied by a separate pipe, aids the flow of the sand down the upper cone of the ejector chamber. This sand joins with that flowing down the inside of the conical bottom of the filter tank to the ejector.

In the simpler type of filter, the combined underdrain and reverse-flow wash apparatus is located just above the bottom of the cylindrical portion of the filter unit and also just above the top of the upper cone of the ejector chamber. This apparatus, as shown in the trade catalog, consists of closely spaced perforated pipe extending in both directions from a central pipe or manifold.

In the latter type of filter, the combined underdrain and reverse-flow wash system is located at a lower level than in the earlier type,

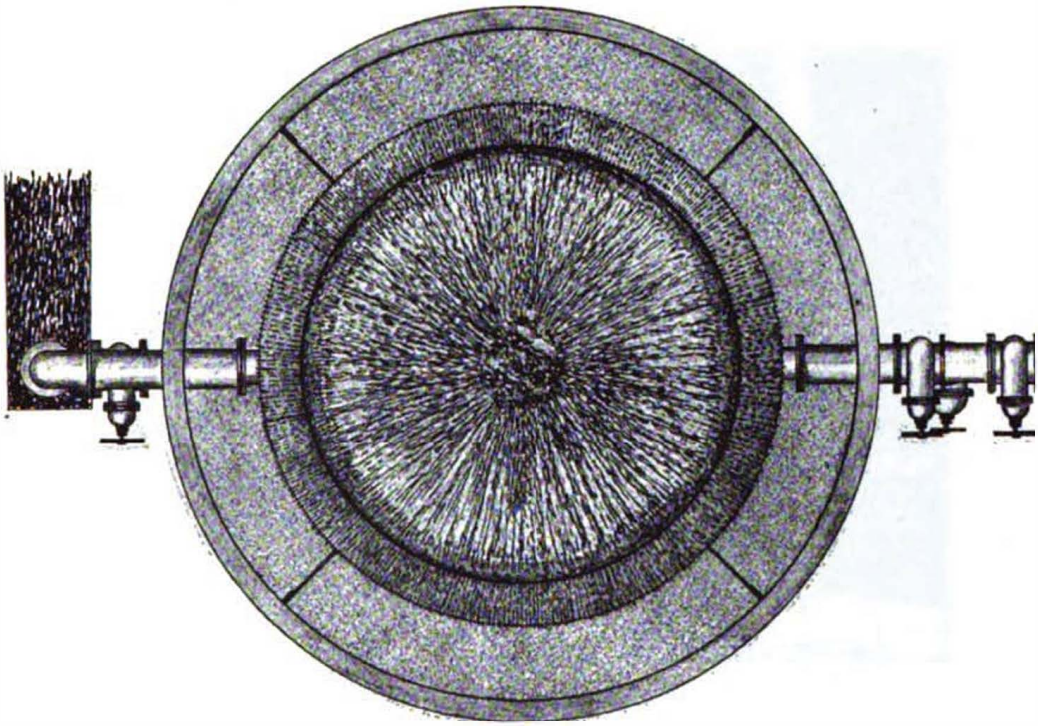

FIG. 53. BOLLMANN COMBINED REVERSE-FLOW AND SAND-EJECTOR-WASH FILTER
View from top of "flat dome-shaped roof or spreader"
(From Bollmann Trade Catalog, Hamburg, Germany, received 1934)

well down in the space between the upper cone of the ejector chamber and the conical bottom of the filter tank. There are two concentric troughs, with perforated bottoms. The filtrate passes up through perforations into the troughs and out through a filtered-water pipe. These troughs are covered by steeply pitched roofs. The roofs are the *"mehreren Lenkkörpern"* or "many guides" which direct the sand each way when being sucked down to the ejector, that is, toward the sloping side of the bottom and upper cone of the ejector chamber.

When water is turned into the ejector of either type of filter, it passes up, laden with dirty sand, through the ejector chamber and then up through a central pipe to the top of the filter. There it overflows upon a flat dome-shaped roof or spreader, then runs down the gentle slope into a circular gutter, from which the dirty water is wasted. The washed sand is discharged from the dome-shaped roof upon the top of the filter unit, forming two concentric craters. When the ejector or secondary wash is completed and the supply valve closed, the reverse-flow wash is turned on and restores the level of the top sand.

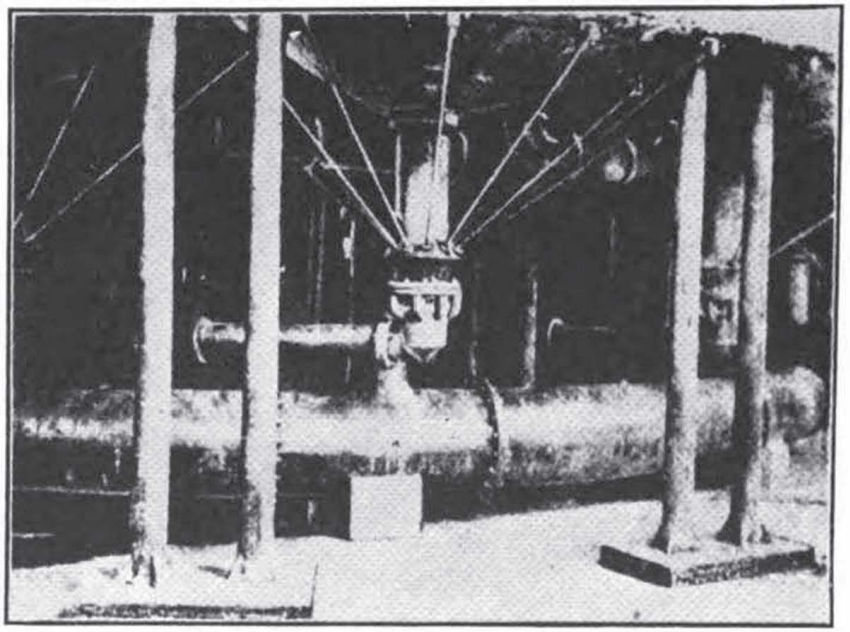

FIG. 54. SAND TRAPS, EXTRACTOR PIPES AND WASHERS IN TORONTO DRIFTING-SAND FILTERS

Small inclined pipes lead from sand traps to washer, which extends up through bottom of tank; there are 264 traps and sand pipes and 30 washers to each of the ten filters

(From *Eng. News*, September 21, 1916)

The sand is 1 to 2 m. (39 to 78 in.) deep, varying with the character of the raw water and desired quality of the effluent. The sand is of uniform size. Water is applied to the top of the unit. Filtered water from the bottom of the unit passes up through the bottom of the collecting channels. These, as already stated, also serve to distribute the water for reverse-flow wash.

The maker of the Bollmann filter claims that the whole of the unusually deep unit is effective; "that catalytic and biochemical processes

are not confined to the surface layers; that catalysis, dialysis, absorption and agglutination also take place in the lower layers during filtration." The company also claims that reverse-flow wash, even when reinforced by compressed air, does not thoroughly clean the filter, but the cleaning process is completed by the attrition of the sand grains on each other as they are ejected. Mud balls, the maker states, cannot form in the filter.

The largest plant listed in their catalog of 1930 was installed in 1914 and extended in 1925 at one of the stations of the water works of Berlin. Its enlarged capacity was 70,000 cu.m. or 18.5 mgd. (U.S.) (1).

Ransome or Gore-Ransome Drifting-Sand Filter

A decade after the Bollmann sand-transfer wash filter first came into use, the "drifting-sand filter," also employing an ejector washing system, made its appearance in Great Britain, was patented there and was introduced at a few places in Canada and elsewhere. So far as can be learned, the first drifting-sand filter plant ever built, and the only one in Great Britain, was the small one put into use for Merthyr Tydfil, Wales, in 1913. On December 4, 1913, a British patent on the filter was granted to William Gore and Martin Deacon, engineers of Westminster, England. Gore, it is said, was the inventor. The Ransome ver Mehr Co., maker of the Ransome concrete mixer, took over the manufacture of the filter. After the operation of a demonstration plant at Toronto, the city contracted with the John ver Mehr Engineering Co. of Canada for drifting-sand filters with a total capacity of 72 mgd. (U.S.). The plant was put into use in 1918.

The Toronto plant consists of ten main cylindrical filters, each divided into 30 units having a hopper bottom. At the bottom of each hopper there is a sand ejector into which the water to be filtered is discharged and passes upward through a central pipe which serves the double purpose of inlet for a part of the raw-water supply to the filter and sand-transfer pipe. Sand to be cleaned is brought to each ejector by many small tubes, called sand extractors, leading from points on the outer edge of the unit near its bottom. Washing is effected in the ejector, from the top of which dirty water is drawn to waste. The cleaned sand passes up through the sand-transfer pipe and drifts out in every direction, forming a mound shaped like a volcanic crater in each segmented unit of the filter. Sand is constantly drawn from the

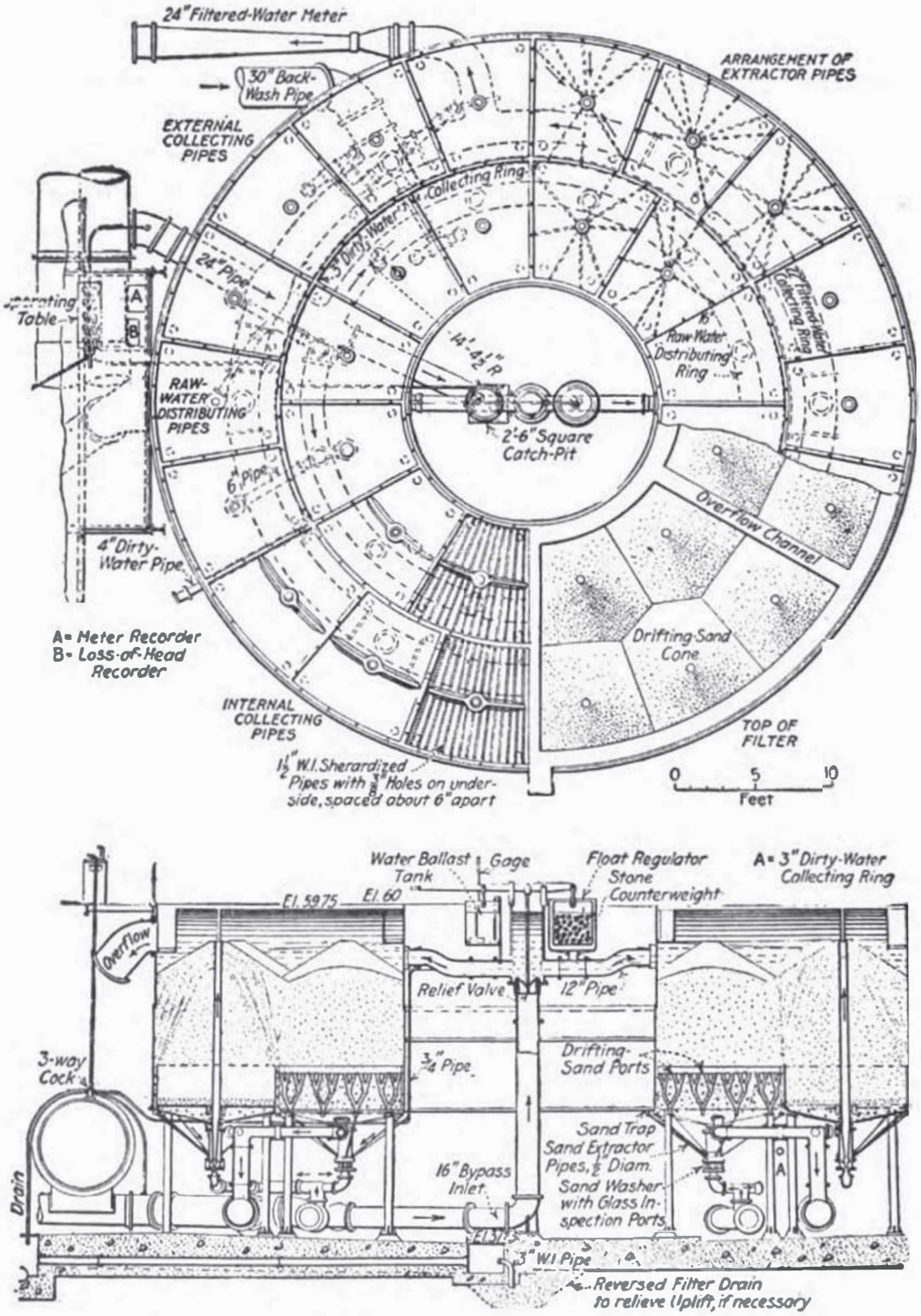

FIG. 55. GORE-RANSOME DRIFTING-SAND FILTER AT TORONTO

Horizontal and vertical sections; continuous washing effected by multiple ejectors which carry dirty sand to top of filter from which it drifts down to a flat conical surface; each filter made of many units, each with one ejector supplied by many extractor pipes

(From *Eng. News*, September 21, 1916)

bottom of the bed, washed and deposited at the top without interfering with filtration. When needed, reverse-flow wash is used (2, 3).

The Toronto drifting-sand filters were built to supplement slow sand filters whose capacity was outgrown. In 1941, a large installation of the latest type of rapid filters was put into use, giving the city three filter plants. Trouble with clogging at the Toronto drifting-sand filters was stopped by probing, and wear on pipes was reduced by replacing ⅜-in. with ½-in. pipes.

Drifting-sand filters were installed before 1920 at Brampton, Oshawa and Rockland, Ont. (2, 3); at Kingston, Jamaica, B. W. I., in 1915 (4); and at Pernambuco (Recife), Brazil, in 1918—added to in 1921 and in or about 1930 (5). Except at Pernambuco, all these plants have given way to the more common type of rapid filter, either by conversion or new installation. At Pernambuco, a battery of Bollmann filters was added in 1938. Such evidence as can be obtained indicates that the sand ejector pipes gave trouble by clogging.

The drifting-sand filters at Pernambuco were a part of an extensive addition to the water works designed by the late distinguished Brazilian sanitary engineer, Saturnino de Brito. They treated impounded water. Later in 1943, H. C. Baity (6), after interviewing the younger Brito, wrote from Rio de Janeiro as follows:

> Sr. Brito tells me that all of the drifting-sand filters which were installed at Recife, including the eight units of Ransome filters constructed in 1918 and the eight units of Bollmann filters added in 1937 or 1938, are in continuous and satisfactory operation. Coagulation and sedimentation facilities were added to the Ransome units after their original installation. During times of heavy raw water turbidity, I am informed by Sr. Brito, the filters often have to be washed as much as three times a day. Whether this can be called satisfactory operation depends upon the standard of comparison.

The drifting-sand filters installed for Merthyr Tydfil were still in use in 1942, being operated by the Taf Fechan Water Supply Board which was also supplying water passed through regular British makes of rapid filters (7).

Turn-Over Filter Company, Belfast

The Turn-Over Filter Co., Belfast, Northern Ireland, in 1925 added to the product from which it had taken its name filters of the sand-transfer-wash type. Up to January 13, 1925, wrote Charles B. Bramwell, director of the company, a number of its "Uneek" filters had been

installed on municipal and other water supplies (8). In 1940 the filter was still being advertised. The filter medium is a single-sized fine sand, confined in cylindrical closed tanks, placed vertically or horizontally. An ejector is used to move the sand through a pipe leading up outside the filter and to discharge it onto the top of the same or an adjacent filter—substantially as in the Hyatt patents of 40 years earlier. Reverse-flow wash is also used.

Trailigaz Filters in France

Seventeen water works in France installed rapid sand filters washed by sand transfer and reverse flow during the five years before the outbreak of war in 1939. These filters had the trade name "Trailigaz." They were provided by Societé Traitement des Liquides et des Gaz, Paris.* An installation seen at Rennes, France, in 1938, had a daily capacity of 10,000 cu.m. (2.64 mgd.). It treated highly colored water, containing clay, organic matter and iron salts. Before filtration the water received sulfate of alumina and was settled. After filtration it was chlorinated. The filter layer consisted of 5.75 ft. of sand, placed in a reinforced-concrete tank nearly 10 ft. high, having a hopper bottom. The underdrains had very fine slits. Besides being cleaned by reverse-flow wash, the filter sand was also cleaned by forcing it to the top of the bed by an ejector, placed in the bottom of the hopper. From the top of the discharge tube the washed sand fell back in *gerbes* (showers, as in pyrotechnics) (9).

The basic principles of all the sand-transfer methods of washing filter sand here described are identical: Eject dirty sand, with water, from the bottom to the top of the filter, thus detaching and eliminating material retained by filtration. In effect this is what is done by ordinary reverse-flow wash, which, it should be noted, is used in conjunction with sand-transfer wash. Although John W. Hyatt seems to have put into use only his simpler form of sand-transfer, his patent specifications described apparatus like those of the later inventors: notably, washing of sand continuously and drifting of sand down on top of the filter. As a final tribute to this versatile inventor, it may be noted that his patents anticipated various other devices, including a porous false filter bottom for reverse-flow wash.

* In an advertisement appearing in *L'Eau*, of Paris, it was stated that, after a competition, Paris had decided to put in a Trailigaz plant of large capacity.

of Curing the Diseases and Preserving the Health of Soldiers. R. Dodsly, London (1747). [B]

4. ANON. Gerson's System of Filtration. *Eng.*, 44:534 (1887). [E]
5. DELBRÜCK. Die Filtrazion des Wassers in Grossen. *Allgemeine Bauzeitung*, 18:103–129 (1853). [2 plates Nos. 556 & 557 in separate atlas.] [D]
6. WILLIAMS, JOHN. *An Historical Account of Sub-ways in the British Metropolis for the Flow of Pure Water and Gas, Including the Projects in 1824 and 1825.* London (1828). [D]
7. KIRKWOOD, JAMES P. *Report on the Filtration of River Waters, for the Supply of Cities, as Practiced in Europe.* D. Van Nostrand, New York (1869). [B]
8. BOOTH, T. Discussion of "Antwerp Water Works," by WILLIAM ANDERSON. *Proc. Inst. C.E.*, Part II, 72:78 (1882–83). [E]
9. GOETZ, EUGEN. Filtration for Public Water Supplies With Especial Reference to the Double Filtration Plant at Bremen, Germany. *Trans. A.S.C.E.*, 53:210–217 (1904). [E]
10. CARRIERE, J. E. De Voorbehandeling Bij Langzame Zandfiltratie van Rivierwater. Korthuis, 's-Gravenhage, Netherlands (n.d.). [B]
11. LÜSCHER, O. Personal Letters. Zurich, Switzerland (November 1939 & March 1940).
12. DAVIDSON, J. R. Personal Letters. London (1935–39).
13. BARNES, A. A. Personal Letter. Birmingham, England (May 18, 1942).
14. BIRMINGHAM (England) WATER DEPARTMENT. *Description of Water Supply From Wales.* Birmingham (1908). [X]
15. VANLOAN, SETH M. Personal Letters. Philadelphia, Pa. (1937, 1939, 1940).
16. CLARK, HARRY W. Double Sand Filtration of Water at South Norwalk, Conn.—Removal of Organisms, Tastes and Odors. *Jour. N.E. W.W.A.*, 30:86–100 (1916).
17. BRACKEN, ELMER F. Personal Letter. Norwalk, Conn. (1940).
18. FIELD, FREDERIC E. Personal Letter. Montreal, Que. (1933 & 1939).

CHAPTER X

Drifting-Sand Rapid Filters

1. BOLLMANN FILTER GESELLSCHAFT. Personal Letters. (January 24 & March 9, 1934).
2. ANON. A Large Drifting Sand Water Filtration Plant for Toronto, Ont. *Eng. News*, 71:1446–1448 (1914). [E]
3. ANON. Drifting Sand Water Filters for Toronto, Ont. *Eng. News*, 76: 556–570 (1916). [E]
4. KIRKPATRICK, W. Personal Letter. Kingston, Jamaica, B.W.I. (October 20, 1939).
5. HANSON, TERENCE C. Personal Letter. Pernambuco, Brazil (February 28, 1940).
6. BAITY, H. C. Personal Letter. Rio de Janeiro, Brazil (1943).
7. MILLER, LEONARD. Personal Letter. London (January 20, 1942).
8. BRAMWELL, CHARLES B. Personal Letter. Belfast, Ireland (January 13, 1925).
9. ANON. Les Distributions d'Eau en France. L'Usine de Mézières-sur-Couesnon. (Alimentation en Eau de la Ville de Rennes.) *L'Eau* (Paris), pp. 31–34 (March 1939). [E]