eral construction of the bed allows a complete aeration, whereas with soil the atmosphere has great difficulty in penetrating to depths of over 2 feet.

During the period of aeration, when nitrification is taking place, the contact bed is practically a breathing thing, taking in oxygen and expiring carbon dioxide. That this action is biological, there is practically no doubt. If a well matured bed be treated with chloroform or mercuric chloride, nitrification at once ceases, although for a time the film will continue to absorb oxygen and produce carbon dioxide, proving that this action is due to chemical causes and not to micro-organisms, or possible to a decomposition brought about by enzymes, as in the case of a septic tank.

Loss of capacity and clogging are the great drawbacks to contact beds. The Royal Commission (Fifth Report) give the following factors as chiefly responsible for failure:

(1) Disintegration of the filtering material.
(2) Consolidation of the filtering material.
(3) Deposition of colloidal matter.
(4) Growth of organisms.
(5) The volume of liquid passed on to the bed.
(6) Insufficient rest.
(7) Inefficient drainage.
(8) The amount of suspended matter passed on to the bed.

A very brief consideration of the above factors will convince anyone that they can all be guarded against by proper construction and careful working.

Nos. 1 and 2 may be taken together and they point to the necessity of choosing a filtering material which will not disintegrate either by contact with the liquid or by frost. The material must, primarily, be hard and insoluble, and of such a character and size that it will build itself up in the bed without crushing or settlement. Soft sandstones producing grit silt are useless, and the same may be said of certain soft and unwashed furnace clinkers, although well burnt hard furnace makes an ideal filtering material. Nos. 3 and 4 can be reduced by flushing and rest. Nos. 5, 6, 7 and 8 are all matters which should be primarily attended to in construction and design of the work.

With reference to the size of material, from ⅜th to ⅝th inch diameter is suitable for sewages from which about 60 per cent. of the original solids in suspension have been removed

THE DURHAM MAIN SEWERAGE WORKS.*

By H. W. Taylor, A.M.Inst.C.E.

As is well known, the city of Durham is a very old town, and dates for many centuries back, and consequently the drainage and sewerage arrangements, such as they were, date from these times. The houses and streets were no doubt originally drained by old stone culverts and drains (many of which are in evidence to-day), discharging into the river.

The first attempt at systematically sewering the town was about the year 1853, when Mr. Hawkesley, of London, designed and carried out a system of what he termed "pot-pipe sewers," picking up the drains of the houses and discharging the sewage into the river at about 33 points.

The city of Durham is situated on both banks of the river Wear, this river having a very tortuous course through the city and dividing the town roughly into three parts—namely, the North-road and Western Hill districts in the west, the Cathedral, Claypath and Gilesgate district in the centre and north-east, and the Elvet district in the south-east

Generally speaking, the town slopes steeply to the river which is the natural outlet for the sewage. There are two dams across the river in its course through the city—namely, near Framwellgate Bridge and near Prebends Bridge. These dams impound the water, and consequently sewage matter remains in them for long times at a stretch, the only flushing possible being by means of floods. The fall in the river is not very great, and consequently the difficulty of drainage is thus increased when one bears in mind the very roundabout and tortuous course of the river.

Original Scheme.—The original scheme adopted by the Council about 1898 was to lay gravitating sewers following the course of the river on both sides to a point opposite Sands House, where the sewage was to be raised by large gas engines and centrifugal pumps from a pump well into chemical precipitation tanks. Thence the sewage was to pass through filters and ultimately over about 8 acres of land.

Intercepting Sewers.—It will be readily seen that with this system the gradients of the sewers were necessarily extremely flat, the flattest one having an inclination of about 1 in 872, while others were of 1 in 670 and 633. This was an important point in the drainage system, as these gradients necessarily were not self-cleansing and the Council feared deposit taking place in the pipes, which fear the author shared. The alternative of this was to bring the sewage from the Elvet district by means of a tunnel under Claypath to the Sands. Great difficulties and dangers were prophesied, and it was stated that if an attempt were made to drive this tunnel terribly bad ground would be encountered and the cost would be enormous. The Council, however, acting upon the advice of the engineer, had a series of bore-holes sunk along the line of the intended tunnel which showed the ground to be very much better than the prophets foretold, with the result that the tunnel was successfully driven without incurring any exceptional trouble or expense.

The result of this tunnel is that the gradients of the sewers have been greatly improved, the flattest one being 1 in 300, as compared with 1 in 872, for the circuitous route following the river banks. It is also interesting to note that by this means one river crossing was avoided.

Some of the intercepting sewers had to be constructed upon piles in the river, and this was carried out in the following manner. Rolled steel joists were driven to a solid foundation, the soil was excavated to well below water level, the joist was then encased in a sanitary pipe filled with cement concrete. The result of this is that the work has been very satisfactorily done at a very reasonable cost. Flushing chambers are provided where necessary at the heads of the sewers, and a system of ventilation chiefly by shafts near the houses and ventilating manhole covers in the fields will be shortly installed.

Scheme Finally Adopted.—The disposal works finally adopted by the Council are as follows: The sewage upon arriving at the pump well will be raised by (a) small gas engines and centrifugal pumps dealing with the dry-weather flow, or (b) large gas engines and pumps dealing with the greatly increased flow in times of heavy rains into (c) detritus tanks, then passing through (d) storm overflows into (e) hydrolytic tank, thence through (f) rectangular percolating filters, the effluent from which will, by a series of carriers, gravitate over (g) about 12 acres of land, and, passing into the underdrains, will ultimately reach the river in a thoroughly purified state. The excess flows from the storm overflows will discharge respectively into the river and on to storm-water percolating filter-beds, so that the system of purification will be very thorough.

Sewage Flow.—The population of Durham has slowly increased during the past twenty or thirty years, but the chief increase took place at Western Hill. Up to 1906 this district was outside the boundaries of the borough, but since then the boundaries have been extended, and the population increased accordingly from about 14,000 up to 18,000. The system of sewers will easily convey the sewage from at least 30,000 population, while the sewage disposal wroks are designed for 18,000 population, but it should be noted that the system adopted is essentially elastic.

Pumping Machinery.—The pumping arrangements consist of two distinct sets of engines and pumps for dealing

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