SCIENTIFIC—SANITARY ENGINEERING.

Lectures by Professor H. T. Bovey, of McGill College.

ANSWERS TO QUESTIONS IN LECTURE No. V.

1. State your opinion as to the admission of "road detritus" into sewers, and its influence upon the disposal of sewage.

Ans. The proper channel for the conveying away of all waste matters from the streets is afforded by the main sewers of a town, lying directly beneath and in a line with the streets. Where the sewage is to be utilized as manure, or chemically treated, the difficulty of dealing with it increases in proportion to the amount of road detritus mixed with it, and its value as a fertilizer is lessened. Experience, however, shows that the proportion which the road detritus bears to the total sewage of a town is so small as hardly to be worthy of being taken into account. For example, in Manchester, the population of which, in 1841, was 164,000, the proportion which the total street sweepings for the year bore to the total sewage was 7%. Wherever any difficulty arises regarding this question, catchpits may be provided to intercept the road and street detritus. Road detritus, freed from decomposing matter and from the salts of sewage, may be sold as material for mortar, or for ballast, or for foundry purposes. Mortar is said, however, to be injuriously affected by salts left from the sewage.

H. S. ARCHBALD (2nd year).

2. Compare the respective qualities of "Back Drainage" and "Drainage to the Street."

Ans. Each of the two systems of "Back Drainage" and "Drainage to the Street" has its peculiar advantages and disadvantages, demanding the careful consideration of the sanitary engineer.

The chief features of the "Back Drainage" system are as follows: From the main or street sewer a smaller sewer runs up into the courts separating the different blocks till it reaches the rear of the houses facing on the street; it then branches in both directions, and is carried behind them, and also behind the houses facing on the court, should there be any. Into these branch sewers is discharged the sewage of a certain number of the houses on the court as well as those fronting on the street, the number depending on the interval between the courts and on the elevations or depressions of the ground in the locality.

As each house drains to the rear under this system, it possesses the advantage of not having any pipes passing beneath the houses, and though this is nearly all that can be said in its favour, still it is of considerable importance. Theoretically, the conveyance of sewage under dwellings by means of a *perfectly constructed system of pipes and pipe connections* appears quite free from objections, for if these conditions be fulfilled there can be no escape of gas or sewage from the pipes. But the degree of perfection in construction requisite to ensure these results is hardly attainable in practice; it requires a too minute exactness in those details that are apt to be overlooked or neglected by the average workman, who cannot, or does not, realise the necessity for such precautions. For instance, if one of the pipes does not rest equally on the earth throughout its length, but is sustained here and there at intervening points, it will in all probability tend to sink (especially if the ground be naturally moist), and by so doing strain the joints and in time start a leak, through which the sewage will pass out to pollute the surrounding soil and engender foul odours, and the sewer gas escape to pass up through the earth into the house and bring disease and death on its inmates.

Among the most important objections to this system of back draining is that the branch sewers must pass through private property, and in consequence cannot be provided with man-holes at those points where they are needed to place the sewerage under control without entailing a heavy expense on the authorities, as the right of easement will have to be purchased in most cases; at the same time these man-holes will cause serious inconvenience and encroachment on the rights and privileges of private citizens. Another objection is that the sewage from the house will have to pass round three, and in some cases four right-angles, before being discharged into the street sewer,—a most important consideration, as deposits would frequently accumulate at the points of curvature and be difficult to remove unless a man-hole were provided at each of these points, which would not be at all practicable.

Under the system of "Drainage to the Street," the sewage of each house is led by independent pipes directly into the sewer, if it fronts on the street, or into a branch sewer that runs up into the court if it fronts on the court.

The advantages of this system are:—(1) It is more economical to local authorities than the other system, for the drains passing directly under the houses do not require any man-holes on private property, and therefore no right of easement has to be purchased; (2) The pipes are less liable to become clogged by deposits, there being generally but one curve in them before reaching the main sewer; and (3) The sewage is placed under an almost complete control, owing to the easy access afforded to each independent set of pipes.

The main objection to this system is that of allowing the drains to pass under the houses.

JOHN S. O'DWYER (3rd year).

3. What is meant by the hydraulic mean depth of a sewer? Find the hydraulic mean depth of the sewer introduced by "Hawksley."

Ans. The hydraulic mean depth is the sectional area divided by the wetted perimeter.

The area C D H B F $= 2 \times$ area C O G F + area F G H $= 2 \times$ (area C D F − area D O G) + area F G H $= 2 \times \left(\frac{\pi R^2}{2} - \frac{R^2}{2}\right) + \frac{R^2\left(2-(2)^{1/2}\right)^2}{2}\frac{\pi}{2}$

$$= \left\{\frac{5\pi}{2} - \pi(2)^{1/2} - 1\right\}$$

The wetted perimeter $=$ C F B H D $= 2$ C F + F H

$$= \pi R + \left\{2 - (2)^{1/2}\right\} R\frac{\pi}{2} = \left(2\pi - \frac{(2)^{1/2}}{2}\pi\right) R.$$

$$\therefore \text{Mean hydraulic depth} = \frac{R^2\left(\frac{5\pi}{2} - \pi(2)^{1/2} - 1\right)}{R\left(2\pi - \frac{(2)^{1/2}}{2}\pi\right)} = R\frac{4.826}{8.127} = \frac{3}{5}R$$

nearly.

J. T. MORKHILL and R. WADDELL (2nd year).

LECTURE VI.

VARIATION IN THE DISCHARGE OF SEWERS.

The outflow of the sewage from the houses of a town will vary at different times of the day, for it is governed by the habits, domestic arrangements and trades of the inhabitants, which in different towns will differ very greatly. For example, in mining towns the people are actively engaged during the night, and thus the outflow of sewage will be copious and foul, while in ordinary towns the outflow will be reduced to a "minimum" at night, and will be very small in amount if the sewers are watertight.

A common rule is to assume that ½ of the total quantity of sewage is discharged in 6 or 8 hours, and the remainder in 18 or 16 hours.

Thus, in designing a sewer, the engineer must consider:—(1) The maximum outflow; (2) The quantity of subsoil water admitted, by design or accident, *(and which will be an almost "constant" quantity)*; (3) The maximum quantity of surface waters to be admitted in time of rainfall.

N.B.—The engineer must deal with all materials, solid or liquid, which have once entered the sewer.

DISCHARGE OF SEWERS.

Various formulæ have been employed for the purpose of calculating the "velocities" of discharge, but the two most commonly used are:—

I.—$V = 55\,(2\,D\,F)^{1/2}$ where
- V is the velocity in feet per *minute*.
- F is the fall in feet per mile.
- D is the hydraulic mean depth in feet.

II.—$v^2 = \dfrac{2\,g\,h}{1 + e + c\frac{l}{d}}$ where
- v is the velocity in feet per *second*.
- h is the head of water in feet.
- l is the length of the pipe in feet.
- d is the diameter of the pipe in feet.
- c is the co-efficient for friction in the pipe.
- e is the co-efficient of resistance for entrance of water into pipe.
- g is 32.2.

c is given by the formula $c = .02439 + \dfrac{.016921}{(v)^{1/2}}$

The average value of e is .505, but by rounding the inlet this may be reduced to .08.

Formula II. is due to Weisbach, and is employed in the calculations in the Tables of discharge to be found in Latham's Sanitary Engineering.

Gravity is the sole cause of motion.

Water flowing along a sewer is retarded by the resistance offered by the sides and bed of the channel.

Opinions differ as to the resistance offered by different materials, but for all practical purposes the nature of the materials need not be considered. Experiment has shown, indeed, that the quantities given in the Tables of Discharge are absolutely equal to the observed quantities flowing through ordinarily constructed sewers.

GAUGING.

The volume of water flowing through a sewer may be determined by different methods—

1. Ascertain the mean velocity of flow and multiply it by the sectional area of the water-way and the product will be the volume required.
2. If the size and inclination of the sewer be given, it will be only necessary to know the depth of water flowing through it at any time in order to calculate the quantity discharged *(for $V=55$ 2 F. D.)*
3. By Overfalls. A weir is placed in the sewer, and the depth of the liquid falling over is observed, from which may be determined the quantity discharged.

If H be the total depth in *feet* falling over the sewer. V the velocity of water approaching the sill in *feet* per *second*, and Q the number of cubic feet discharged over each foot-width of the sill,—

Then $Q = 214\,(H^3)^{1/2}$, of the stream above the sill is at rest;

or $Q = 214\,(H^3 + .035\,V^2 H^2)^{1/2}$, of the stream above the sill is in motion.

In gauging, the weir should be placed vertically. The sill should be horizontal, have a very narrow edge, and be sufficiently removed from the bottom and sides as not to be influenced thereby. The corners of the sill and sides should be full and sharp. No rounded or bevelled edges should be allowed on the up-stream side of the weir. The depth of the weir should, if possible, be about one-third of the width; but these dimensions are not absolute. Another formula sometimes used is:

$$Q = \tfrac{2}{3}\,m\,l\left\{H\,(2\,g\,H)^{1/2} - h\,(2\,g\,h)^{1/2}\right\}$$

where
- Q is the quantity in cubic feet discharged per second.
- m is a co-efficient.
- l is the width of the notch or overflow in feet.
- H is the height in feet of still water above the edge of the notch or board.
- h is the height in feet of still water above the level of the water as it flows over the board.

4. By Drowned Weirs. A weir is said to be drowned when the water on the lower side has risen above the level of the sill.

The quantity flowing over will be divided into two portions, the one flowing freely over and determined by the formula $Q = 214\,(H^3)^{1/2}$, and the other flowing over against a head of water, and determined by the formula

$v = 46.5\,(2\,g\,h)^{1/2}$, where
- v is velocity in feet per minute,
- g is 32.2, and
- h is the head of water in feet.

The depth of water falling over a weir may be registered direct on to a diagram by a *Recording Gauge*.

(The Re ording Gauge consists of a mechanical arrangement communicating a given rate of speed to a cylinder, to which is fixed a piece of paper. A float with gearing records the height of the water, at any moment, on the paper.)

Questions.

1. What is the best method of sewage removal for rural districts? Give reasons for your preference.