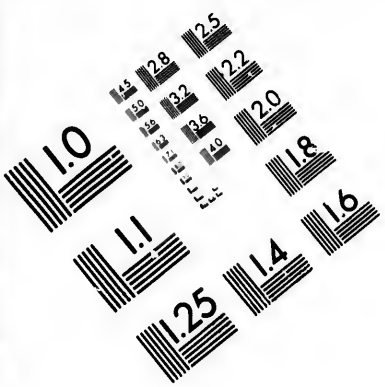

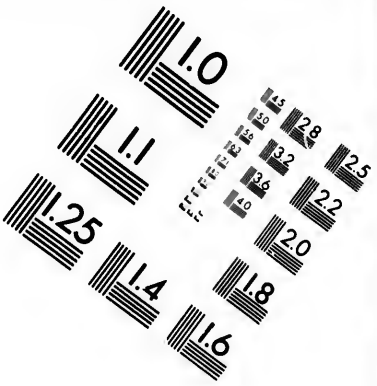

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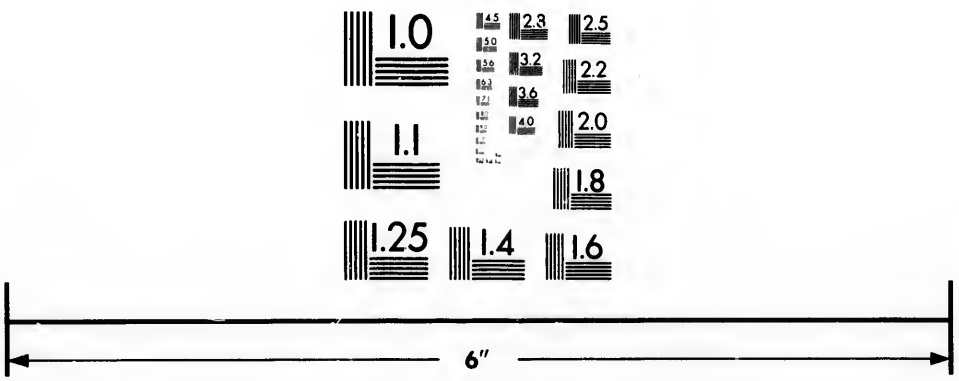

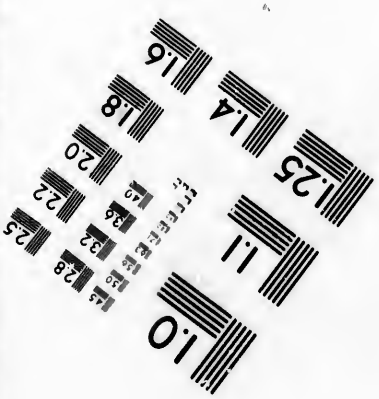

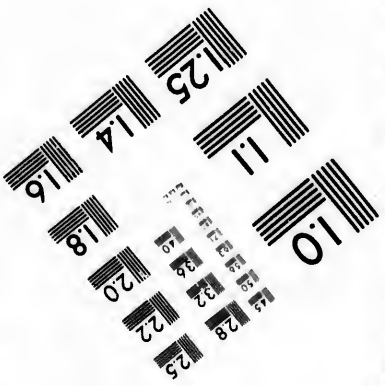

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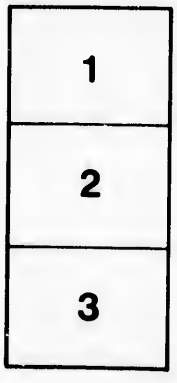
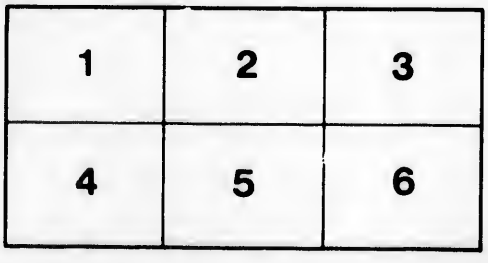




Mr. T. C. KEEFER, C.M.G.

ON

THE VANCOUVER SEWERAGE SYSTEM

"In reply to an enquiry as to whether during his stay in the city, he had examined the sewerage system which is now being built, Mr. Keefer said he had. Mr. Mohun, who has designed the system, and superintended the work of construction, laid the plans before him. Mr. Keefer said he had no doubt but that the separate system which was the one Mr. Mohun had adopted, was the proper one for this country. Where, as in some of the eastern cities, immense bodies of water resulting from the melting snow, had to be quickly discharged from the surface of the streets, there might be some reason for adhering to the old plan of large brick sewers capable of carrying off the surface water as well as the sewerage. But in such a climate as we have here, he considered Mr. Mohun had acted judiciously in adopting the separate system. As regards the material used for the sewers and the form in which they were made, Mr. Keefer was inclined to think that the Council considering the limited means at their disposal for this purpose, had been well advised by Mr. Mohun. The timber drains would, if well laid, last at least five years, and, in all probability, much longer. With a good supply of water for flushing purposes, he thought the sewerage system now being constructed would be satisfactory. 'With such a system of water works as you will have,' said Mr Keefer, 'with a very comprehensive sewerage system, with your excellent roadways, worthy of any old and wealthy city, and which are so different from those found in other cities of the size of this place, I think Vancouver shows enterprise which, even in this age of progress, is remarkable.'"

—*Daily News-Advertiser, Vancouver, October 30th, 1887*

Canadian Society of Civil Engineers.

SESSION 1888.

TRANSACTIONS.

Thursday, 11th October.

SAMUEL KEEFER, President, in the Chair.

Paper No. 20.

THE SEWERAGE SYSTEM OF VANCOUVER, B. C.

BY E. MOHUN, M.CAN.SOC.C.E.

Vancouver, the Western Terminus of the Canadian Pacific Railway, is situated upon a peninsula, along the northern shore of which extends the magnificent harbour of Burrard Inlet, while its southern beach is washed by the shallow waters of False Creek.

The population at the present date, February, 1888, is about 6,000, and is rapidly increasing, every incoming train and steamer bringing some addition to the number of its residents.

On the 13th June, 1886, occurred the disastrous fire, which destroyed the whole city with the exception of two houses; yet, six months afterwards, such was the indomitable pluck of the inhabitants, not only was the city rebuilt, but companies were formed for the introduction of the electric light, gas, water, and street tramways; and the question of sewerage was being discussed.

In addressing an assemblage of engineers, it is needless, at the present day, to insist upon the necessity of efficient sewerage, and upon the criminal negligence of civic authorities who neglect the means which science places at their disposal for preserving the health of, and decreasing the mortality among their fellow citizens. The only points as to which there can be a diversity of opinion are, the system to be adopted and the details of construction.

In May, 1887, the author received instructions to prepare plans and specifications for sewering the most densely populated district.

In deciding upon a system of sewerage, it was considered advisable that such a plan should be adopted as would be capable of extension

with the growth of the city, so that the work first performed, would, in the end, become a portion of an efficient and economical system for the whole city.

It will be readily believed, that after the disaster before referred to, the City Council was in no position to expend money in costly or experimental works; and, to use the homely phrase, we had to cut our coat according to our cloth. The construction of an economical system was greatly furthered by the peculiar circumstances of the case; the city was favourably situated for sewering, and there were no vested interests to be consulted.

Since the utilization of the sewage could not be undertaken, its deposit in the sea was the only available mode of disposal.

In weighing the comparative merits of the "combined" and "separate" systems, it was considered, that under the conditions which obtain in Vancouver, the latter should be adopted for many reasons.

From October to March the mean monthly rainfall, as observed in the neighbouring city of New Westminster, is 7.27 inches, and from April to September, 2.48 inches.

The climate is mild; the frost rarely penetrates the ground more than a few inches in depth; the snow-fall is light, and the snow seldom lies for more than a day or two.

The city is built on two small eminences, rising gently on all sides from the salt water, to a height of about 150 feet, and its site offers every facility for the rapid and economical removal of surface water.

Further—the cost of the "separate" system was within the means of the Corporation, while had local conditions rendered the adoption of the "combined" system advisable, the available funds would have been inadequate for the purpose.

The city was subdivided into the Eastern, the North Central, the South Central, and the Western Sewerage Districts.

The Western District, having collected the sewage in intercepting sewers, will have its outlet in English Bay. A few blocks in this District have been sewered, and these, for present convenience, are temporarily connected with the North Central District sewers.

The North Central District, in which, up to the present, most of the work has been done, discharges into Burrard Inlet.

With reference to the South Central District, as it would be unadvisable to discharge sewage into the shallow land-locked waters of False Creek, it is proposed that an intercepting sewer should be constructed along Prior street, and thence along the shore to Dupont street, where the sewage would be discharged into a reservoir, from

which it would be raised, by a hydraulic engine, supplied from the water main, into the Columbia Avenue main sewer, and conveyed thence into the Harbour. The pumping might be done at night, when there would be but a small demand upon the capacity of either the water mains or the sewers.

The Eastern District would discharge directly into the Harbour.

The following recommendations were approved by the City Council :—

1st. That the sewers should be constructed for the conveyance of sewage alone, the surface waters being carried to their natural outlets over the surface.

2nd. That the city should not undertake the sewerage of basements ; thus practically putting a stop to the unsanitary custom of placing water closets and kitchens beneath the surface of the ground, while permitting the minimum depth of excavation to be placed at 5 feet instead of 11 or 12. ft.

3rd. That the outlet works and manholes should be of a permanent character ; while the sewers should be constructed of timber, to be replaced in the future, when desirable, with vitrified pipe.

It may be remarked here that vitrified pipe is not manufactured in British Columbia ; on English, Scotch, and Californian pipe there is a duty of 35 per cent., while the freight on pipe from Eastern Canada is not less than $20 a ton.

Twenty-five thousand dollars were voted by the people in order to commence the work. Tenders were called for in June, and the contract was let in July, 1887.

The dimensions of the sewers, and their falls, were determined from the following data :—

1st. That the sewer, running half full, should have a capacity of five gallons an hour for each inhabitant of the area sewered.

2nd. That the estimated population should be based upon the assumption, that every twenty-five feet frontage of the area sewered, was occupied by a house with five inhabitants.

Wherever practicable, the sewers have been laid in the alleys, in the rear of the buildings, and, in consequence, the danger, arising from carrying sewers beneath dwellings, is generally averted, while the cost to the individual householder is materially decreased. Further, better grades for private sewers are obtained, while the expense and inconvenience resulting from tearing up and remaking the streets, either for original construction, repairs, or connections, are reduced to a minimum.

Such are the general principles upon which the Sewerage System of Vancouver is based.

The author will now endeavour to describe, in as few words as possible, some of the details of construction.

OUTLET WORKS.

The Outlet Works for the North Central District, consist of a concrete chamber, the bottom being faced with hammer-dressed granite, into which three mains independently discharge at points near, but above high water mark; from the bottom of the chamber, the sewage is carried in a 12-inch cast iron pipe $\frac{5}{8}$-in. thick, 369 feet long, to a point in the Harbour 50 feet beyond extreme low water mark, where it is discharged beneath the surface. The chamber is also furnished with a 12-inch cast iron overflow pipe, 100 feet long, and both pipes are encased in concrete for a distance of 100 feet from the chamber; beyond that point the pipe is covered with rock. These pipes have a fall of 1 in 40.

MANHOLES.

Manholes are built of 5 to 1 concrete with timber covers, and are placed at all junctions, and at all changes of direction, horizontal or vertical. The curves in the manholes at junctions have not a less radius than 5 times the diameter of the sewer, and have increased falls to compensate for the loss of velocity due to the increased friction. Inverts exposed to heavy and rapid flows are lined with hammer-dressed granite. On steep gradients, ramp breaks are provided.

Each manhole is furnished with a flushing groove, and can be used for a flushing chamber, provision being made for a connection with the water main.

Gratings, flap doors, and ladders are provided for the purposes of ventilation and inspection.

Galvanized iron dirt-trays are placed beneath the gratings.

The inlet ends of sewers are provided with vulcanite flap valves.

VENTILATION.

In addition to the means of ventilation afforded by the manholes and private sewers, ventilators, which also act as lamp holes, have been placed at average distances of from 225 to 250 feet.

SEWERS.

The sewers are built of picked planed timber, three inches thick for 12 and 9-inch sewers, and two inches thick for 6-inch sewers; the

pipes are from twenty to twenty-five feet in length. The sewers are rectangular and are laid with one diagonal vertical. The planks are spiked together with 6 and 5-inch cut steel spikes, a strip of tarred felt being placed in each joint.

The pipes are butt jointed, each joint being covered with a timber sleeve, lined with tarred felt, securely spiked to the pipes.

The junctions of ventilating shafts with the sewers are encased in blocks of 6 to 1 concrete.

In made or unsound ground 2-in. by 12-in. planks are first driven down, until a solid foundation is obtained; they are then centred and levelled, and notches sawn in them to fit the pipe.

The following sewers have been laid under the first Contract:—

1,800 lineal feet 12 " square, equivalent to 14 " circular
6,000 " " 9 " " " " 10 " "
8,400 " " 6 " " " " 7 " "

The sewers are laid in absolutely straight lines, vertical and horizontal, from manhole to manhole.

They are invariably carried beyond the last house to be drained, and are provided at their heads with a ventilating shaft and automatic flushing tank. Doulton's patent syphons are used.

GRADES.

The grades are generally good, and in only one instance has a main a less fall than 1 in 400. In the branches the grades are rarely less than 1 in 150.

HOUSE JUNCTIONS.

The City provides cast-iron junctions for connecting private with public sewers.

These are cast in one piece, and consist of a plate, through which a curved socket pipe passes, screwed on to the upper plank of timber sewer.

By the adoption of this plan, there is a great gain in economy, since the cast-iron junction can be fitted at any time and point, without injury to the sewer: whereas, in laying vitrified pipe, junctions must be provided as the work proceeds, not only at the points at which they are immediately required, but also at those at which connections may possibly be needed in the future.

COST.

The cost of labour in Vancouver, compared with Eastern rates, is high; thus, foremen get from $75.00 to $100.00 a month. Masons

get from $4.00 to $5.00; carpenters $3.00 to $4.00; and labourers $2.00 a day.

The work has been done at the following rates, principally by Contract:—

Excavation per cubic yard	$0.60
Trenching and refilling average depth 7 feet (with a considerable amount of rock), per lineal foot	0.35 55
Earth filling per cubic yard	0.40
Rock " " " "	1.50
Granite for facing inverts per superficial foot	0.50
Concrete (3 to 1) per cubic yard	15.00
" (5 to 1) " " "	11.65
" (6 to 1) " " "	10.00
Sewers in place 12 inch square, per lineal foot	0.38
" " 9 " " " " " "	0.31
" " 6 " " " " " "	0.17
Cast-iron outlet pipes in place; per ton	55.34
Galvanized iron dirt trays, each	1.50
Ventilators in place, average cost each	24.75
Flushing tank, approximate cost each	85.00
Cast-iron junctions for house sewers, 4 inch diam, each	1.75
" " " " " " 6 " " "	2.20

The following observed results of the flow in the timber sewers may be of interest. A sewer, 9 inches square, with a fall of 1 in 400, was almost choked with earth washed into it from a cave in an uncompleted manhole. Wishing to flush the sewer, the surface water was admitted to the pipes and manholes to the extent of 9,000 gallons; on removing the flush gate, the whole quantity was discharged in 13 minutes, carrying with it from 15 to 20 cubic feet of earth.

The mean velocity was 5.4 feet a second.

The length of pipe was nearly half a mile, with three changes of direction.

The amount of solid matter was in excess of the proportionate amount of solid sewage.

Other experiments have been made at various times, which more or less bear out the general results of the above.

HOUSE SEWERAGE.

While the Council has recognized the construction of public sewers, as coming more especially within its province, it has also been fully aware that defective House Sewerage would render the best designed and constructed public system of no avail, and by an amendment of

the Health By-Law, it retains the control of all the sanitary appliances used by private individuals in connection with the public sewers, within the city limits.

The author had advocated the entire suppression of all privy vaults and cesspools, and the substitution therefore, at the discretion of the owners, of earth or water closets.

The Council, however, did not see its way at the time to so radical a sanitary reform, and sought to reduce the evil to a minimum by the following regulations:—

1st. Every privy, vault, or cesspool, if connected with a public sewer, shall be connected by a 4-inch vitrified or cast iron pipe, such pipe to leave the privy vault or cesspool at a height of not less than two feet above its floor, the upper end of such pipe to be provided with a grating of ¼-inch iron, with openings of not more than one inch in width securely fastened into the wall; each seat to be provided with a pan and drop pipe, reaching three inches lower than the level of the outlet-pipe and a ventilator reaching above the roof. All privy vaults shall be of brick, set in cement, or other impermeable material, and the floor thereof shall not be placed more than four feet below the surface of the ground.

2nd. Any person desirous of connecting a water-closet with the public sewer, shall give 48 hours' notice in writing to the Inspector, who shall examine the premises, and on finding the water-closet, soil-pipe, ventilators, and traps efficient, and provision made for an ample and automatic supply of water, shall authorize such connection to be made by a licensed pipe layer, under the supervision of the Inspector.

3rd Every water-closet shall be provided with a waste preventor cistern, a ventilating and a soil pipe, the pipes to be 4 inches in diameter, open on top, and carried up above the roof; the foot of the soil pipe to be provided with a fresh air inlet, and the pan with a trap and ventilating pipe.

4th. Every person desirous of connecting sinks, baths, lavatories, wash-houses, etc., with a public sewer, shall give 48 hours' notice, in writing, to the Inspector, who shall examine the premises, and finding all discharge pipes properly trapped and connected with a grease trap, shall authorize such connection to be made by a licensed pipe layer, under the supervision of the Inspector.

5th. No person other than a licensed pipe layer, acting under the supervision of the Inspector, shall be permitted to make any connection with a public sewer.

6th. No extension of any work previously accepted, or alterations to or new connections with, such work shall be made, except under the authority and supervision of the Inspector.

7th. The work of laying private sewer pipes shall not be commenced or continued, unless the permit is on the ground in the hands of the pipe layer.

8th. All openings for private sewers must be so made as to cause as little inconvenience as possible to the public; on completion, the surface must be left in as good order as it was before the opening was made, and all materials, loose earth, and rubbish must be removed within 24 hours; all such openings are to be fenced by day and lighted at night in such a manner as may be approved of by the Inspector.

9th. No house sewer shall have a less fall than 1 in 40, unless special permission is granted by the Inspector.

10th. The ends of all pipes, not to be immediately connected with the house service, are to be securely closed against the intrusion of earth, rubbish, etc.

11th. The interior of every sewer pipe to be left perfectly clean and smooth after it is laid, and all iron pipes to be coated inside and out with black varnish.

12th. No sewer in actual use shall be disturbed, except under the special direction of the Inspector.

13th. All water and gas pipes shall be protected from injury or settling to the satisfaction of the Inspector.

14th. No exhaust from steam engines, or blow off from steam boilers, shall be connected with either private or public sewers, without special permission from the Inspector.

15th. On all changes of direction, horizontal or vertical, curves of a radius not less than five times the diameter of the pipe shall be used.

16th. All house sewers shall be 4 inches, and all waste pipes 2 inches in diameter, except when otherwise authorized by the Inspector.

17th. All private sewers or soil pipes shall be of cast-iron or vitrified pipe, with lead joints for the former and cement joints for the latter.

To recapitulate: the two objects aimed at have been: 1st, Efficiency, and 2nd, Economy.

With a view to their attainment, the endeavour has been made to secure absolutely tight, straight, and truly graded sewers, and also to keep sewage in unceasing motion in all parts of the sewers. It is stated that fresh sewage affords food for fish, while after the process of decomposition has set in, it becomes poisonous; it is therefore sought to discharge it into the harbour before decomposition takes place, and before any dangerous gases are generated.

By the system of automatic flushing, we hope to keep the sewers free from deposit, while the frequent and sudden rushes of water will, it is anticipated, dispel any gas which may be generated, through the numerous outlets provided for it.

By the arrangement shewn on the plan "Typical House Sewerage," it is believed that the traps can neither be forced nor syphoned. With reference to the "interceptor," it should be understood, that no particular form of trap is intended to be represented, but merely the illustration of a principle, by which an exit is provided for the gas generated in the sewer, and a fresh air inlet for the ventilation of the soil pipe.

From some little experience of the timber in British Columbia, the author is inclined to believe that these sewers will probably last for ten years, perhaps much more; once laid they are always wet,—a condition unfavourable to rapid decay.

CONCRETE.

Owing mainly to a pressure of business, accurate measurements, unnecessary for the purposes of the contract, of the raw material requisite for a definite quantity of concrete in place, have not been made; but it is believed that the undermentioned results are not far from correct.

As, owing to local conditions, broken stone could not be procured, unless specially broken for the purpose, a process too costly to be incurred, it was resolved to use shingle; this, with clean, sharp sand, was procured at and brought in scows from a point about eight miles outside of Burrard Inlet, both being, naturally, perfectly free from loam and other impurities.

By weight, the shingle showed voids of about 33 per cent., and on this basis the Contractor was informed as to the approximate amounts required for the different portions of the work. The results agreed fairly well with the estimated quantities.

In all cases the concrete was spread in thin layers, and thoroughly well punned.

Taking the aggregate of the materials in the 5 to 1 concrete,—the proportion principally used,—it was found that to make one cubic yard of concrete, approximately the following quantities were required, viz.,

Cement	6.48	cubic feet.
Sand	16.20	"
Shingle	16.20	"
	38.88	

but while there is every reason to believe that these figures are closely approximate, they cannot be guaranteed from actual measurement.

It should be added that the whole of the cement used was the best English Portland, White's or Beavan's.

As far as principles are concerned, there is very little new in the Vancouver System; the only novelties in it are:—

1st. The substitution of concrete for brickwork—and it may be submitted for the consideration of Engineers, whether concrete might not be more frequently and advantageously employed in construction than it now is.

2nd. The mode in which the pipes have been constructed and laid—and the author would call attention to a natural, though at first sight a curious, result, namely, that with equal falls, the sewage, which will half fill a pipe, will have the same velocity in any other larger pipe, irrespective of its size.

3rd. The substitution of vulcanite for the (costly in this Province) usual cast-iron flaps with hinges, double or single.

Since the original article was written, house connections have been made, and up to the beginning of September the sewers had been working satisfactorily for several months. No stoppages have occurred in the sewers, and only one complaint has been made as to an offensive smell from one of the ventilators. This is believed to be due to insufficient flushing, and will probably be cured when, the water being brought in and connected with the flushing tanks, a daily flush is provided. Until then, the tanks are supplied by water cart, two or three times a week.

DISCUSSION.

Mr. P. W. St. George remarked that the author in his paper called attention to the fact, that there was little that was new in the construction of the sewerage system, except the use of vulcanite instead of iron for valves. As to the system of wooden boxes, the use of which at the present day has become nearly obsolete, he imagined that they were only employed by the author on account of his inability to get either a brick sewer or a tile pipe. The most expensive part of the work, however, viz., the excavation, had been carried out, and the difference in the cost of a wooden box and a tile pipe would have been but a small proportion of the total outlay. The substitution of a tile or a brick pipe for the wooden box will now necessitate a re-excavation, entailing as great an outlay as at the first. Wood should not be regarded by young engineers as a desirable material for sewers. Square sewers, especially in separate systems, require a large quantity of water for flushing purposes, involving a constant supervision of the flushing tanks. The cost of maintaining these flushing tanks, and the necessity for the appointment of superintendents to see that the flushing is properly carried out, would be a serious disadvantage in any system of sewerage. In adopting a system, the form of sewer, requiring a minimum amount of water to keep it clear, should be adopted. This object cannot be attained with a square section. To facilitate flushing and to diminish the amount of water required, the sewer should be made of as small a radius as possible. In the combined system it is usual to depend upon rain-water for flushing. In placing sewers, calculations as to the amount of water available for flushing should not be based upon the amount used by the inhabitants, but upon the amount of rainfall in a given area. Mr. Mohun had adopted the form of sewer which required the largest quantity of water for flushing, and had not availed himself of the natural rainfall. His system was therefore entirely dependent upon artificial tanks, which had to be continually replenished. It had not been long enough in operation to judge fairly of the result; and with a 12-in. box, and in a much more densely populated place than Vancouver, it would be three or four years before any serious obstruction would be observed. There was practically nothing to choke the sewers except the human excreta. He considered the square section faulty, and he would warn young engineers against its adoption. It should, however, be borne in mind that the system adopted was a cheap and temporary method of giving drainage to a city which cannot at present afford a better. Mr. St. George.

Prof. Bovey.

Mr. Mohun has distinctly given us to understand that the construction of timber sewers was only undertaken as an expedient, because of the lack of funds, and that they would be replaced as soon as possible by vitrified pipe. He has also explicitly stated the pressing reasons which led to a choice of the separate system. Respecting other features of the system, the speaker is of the opinion that except when the sewers are running full, they would not be completely saturated, and there would be a tendency to decay, notwithstanding the moisture retained by the surrounding earth. No provision seems to have been made for the removal of subsoil water, a precaution of the greatest moment, and one which is absolutely necessary for the well-being of the people.

Mr. Mohun is certainly in error in saying that when the sewer is running half full, the velocity of flow, for equal falls, is the same for sewers of different sizes. This can only be true when the mean hydraulic depth, $\left(=\frac{\text{area of water-way}}{\text{wetted perimeter}}\right)$ is constant. In the present case the mean hydraulic depth, for a depth of water h, (less than half the depth of the sewer), is $\sqrt{\frac{h \sin a}{2}}$, $2a$ being the lowest angle. In other words, so long as the sewer is not running more than half full, the velocity of flow will vary as the square root of the depth of the fluid, a being constant. When the sewer is more than half full, the expression for the mean hydraulic depth is a little more complicated.

Mr. Peterson.

Mr. Peterson remarked that Mr. St. George, in speaking against the square section, seemed to have overlooked the fact that Mr. Mohun had laid the sewers with the diagonals vertical, so that a very small amount of water will suffice to flush them. The objectionable point in connection with the present flushing arrangement is, that the water is to be supplied to the flush tanks by means of carts. Such a method may very probably result in some of the tanks being missed or in the work being entirely neglected, in which case the sewers will become foul. This difficulty will be overcome when the city obtains a regular supply of water, by gravitation, which, the speaker is informed, will be effected in the course of a few months. The water can then be so connected with the tanks that flushing can take place as often as may be required. A small amount of water suddenly thrown in a mass from a flush tank will suffice to keep the wooden pipes clean and absolutely free from sediment. With the combined system, very little flushing would be done by the rainfall during the season when it is most required, as the summer in Vancouver is very dry. In his opinion, the system adopted will prove satisfactory, and while there was not much

that was novel in it, he thought that Mr. Mohun had taken the best course considering the limited means at his disposal.

Mr. St. George. Mr. St. George stated that in his opinion the humidity of the earth would keep the sewers damp. Means should certainly have been provided for drainage of cellars, and he also thought that the boxes would have been much stronger if placed with vertical sides. As to the difference between the combined and separate systems, the latter system was advocated 12 or 15 years ago by Mr. Shedd of Providence. That city was sewered almost entirely with tile pipes on the separate system. To-day nearly all these pipes have been taken up, and the combined system substituted. With a large population there was not sufficient water, unless the rainfall was also utilized, to flush any system of sewers except by the adoption of very costly methods. This has been the experience at Providence, which is now considered one of the best sewered cities in America.

Mr. Peterson. Mr. Peterson said, that in Providence, where they had spent millions upon the water works, they were obliged to pump the water, whereas in Vancouver they would soon obtain a large supply for flushing purposes, by gravitation, and, therefore, at little or no expense. Providence is a manufacturing city with a very dense population, and in his opinion should be provided with the combined rather than the separate system of sewers. He was far from advocating the separate system for every place.

No one can say that any system is best for all situations. That system should be adopted which is best suited to the local conditions and requirements of the place to be drained.

There are many towns and small cities in this country that, owing to the expense of a proper combined system, have existed for a long time without any system of drainage at all. If, however, the separate system, with its small expense, had been adopted, the drainage would have been efficient and the death rate very much lower. There can be no doubt that every city should be thoroughly drained so as to take away the surface water, and to drain below the foundations of all the cellars. When this is not done by natural means, it should certainly be done by artificial, and it then becomes a question whether or not there should be two systems, one for house drainage, and another for surface and for subsoil water; but as he had already remarked, the system to be adopted could only be determined after a careful study of the question in all its bearings.

In the case of Vancouver, it is certainly better to have a separate system for house drainage, leaving the surface and subsoil water to take

care of itself, than to have no system at all, thus allowing the house drainage to run into pestiferous cess-pools to poison the air in the surrounding dwellings, as is still done in many parts of Montreal.

Mr. St. George. Mr. St. George thought that if Mr. Mohun had given some data as to the area of land to be drained, and the amount of rainfall, they would be better able to judge whether he had adopted the best system. The rainfall without the area was not of much value.

Mr. Metcalfe. Mr. Metcalfe, said it seemed to him, that in order to consider the question properly, some information as to the water supply should have been afforded, and some idea of the hydraulic power available for pumping should have been given.

It is generally necessary at some point to pump the sewage, and it often becomes the most important feature in the scheme. Taking into consideration the different facts, as stated by the author, he thought that Mr. Mohun had adopted the best and cheapest method, especially as there would be a good head for pumping.

Mr. St. George. Mr. St. George further desired to say that if the area Mr. Mohun had to drain were known, it would be possible to judge whether the box he had built would be able to drain the rainfall also. A 14-ins. box would drain a large area of land with a heavy rain-fall. In this connection he thought that if Mr. Mohun had combined the two, he would have had ample means for a thorough cleansing during the rainy season.

Mr. Metcalfe. It seems that Mr. St. George does not think that the surface drainage has been properly dealt with. The speaker, however, considers that with the falls given and the apparently small area of Vancouver, there was hardly any question of disposal. The city of Melbourne, with a population nearly twice as large as Montreal had, up to 1884, all its rainfall removed by surface drainage.

Mr. Gower. Mr. Gower thought that under the circumstances, Mr. Mohun had no alternative but to use wooden pipes. It would have taken months to get tile pipes to Vancouver by sea. If he remembered rightly, the Water-Works in Victoria had, through an accident at sea, to wait 12 months after the contract had been given, before their pipes arrived. Besides, in a railway journey of over 3,000 miles, the chances are that there would be a breakage of tile pipes to the extent of perhaps 50 or 75 per cent., while the rate of freight would be about 85 shillings or $25 per ton. He thought a mistake had been made in not adopting the combined system, as the expense would not have been much more. With regard to the 14-in. pipe, hydraulic tables shewed that a 12-ins. circular pipe would carry off the sewage of a town of 50,000 inhabitants, as well as a rainfall of 25 miles of streets.

Mr. G. E. Waring had been very much interested by Mr. Mohun's description of the sewerage of Vancouver. Mr. Mohun certainly has the true engineering instinct for the application of means to ends; or, rather, for finding a way to reach his end when ordinary means are not available. Mr. Waring.

So far as he knew Mr. Mohun's use of rectangular wooden sewers set with one diagonal vertical is entirely original, and he has no doubt that it will prove successful in accomplishing the end now in view—, *i.e.*, the satisfactory sewerage of the town during its earlier stages, when the usual material is not available because of its cost. Indeed, it is not improbable that these wooden conduits may last so well in view of their almost complete saturation, as to make it seem advisable, when they finally do fail, to replace them with the same material.

The speaker would not hesitate, if the occasion should arise in his own practice, to follow Mr. Mohun's lead in this matter.

Not knowing the local conditions, it is very difficult to say much about the value of Mr. Mohun's recommendations in general or detail. Still, some ideas may be safely expressed. Mr. R. Hering

The fundamental recommendations approved by the City Council seem to be wise.

The topography, the rainfall conditions, and the item of cost for so small a community as 6,000 inhabitants, strongly point to the superiority of the separate system of sewerage, and to the wisdom of not having water-closets and kitchens in cellars or basements, and thereby securing shallow sewers over the whole city.

The laying of sewers in the back alleys instead of in the streets is likewise a very good custom, for the reasons given by the author of the paper discussed.

As to the wisdom of using wood, with the expectation of replacing the sewers later with vitrified pipe, the speaker can express no opinion. Here, in the East, this would not be done, even if it were necessary to pay double the price for the pipe, as the excavation and laying are the largest items in the expense.

Mr. Mohun's provision to place manholes at all changes of direction, horizontal and vertical, and their details, are, we here consider, the best plans and methods.

If wooden sewers are the best, then the rectangular section with one diagonal vertical is the proper way to lay them. The cast iron junctions, for the house sewers, are a very good contrivance.

That the Council has recognized the propriety of controlling also the house sewerage is a very fortunate circumstance, and one which is often difficult to secure in the older cities.

Without knowing the local circumstances, it is impossible to say much about the details of plumbing. It is difficult to understand why, when a sewer is built to the house, a privy vault, placed not more than four (4) feet below the ground, should, in any case, be preferred, as specified in the 1st section, unless it exists already, and is kept simply for economical reasons. To build a new one, as described, water-tight, would cost more than a plain hopper closet The method of ventilation and flushing is good, as are, also, the details mentioned in sections 2 to 17. The latter section provides that private sewers shall be of cast iron *or* vitrified pipe. It is not safe to have vitrified pipes inside the buildings, because the cement joints are not always air-tight, and it seems that a further provision should cover this point.

In the arrangement shown on the plan of typical house sewerage, it appears that the alley sewer is ventilated through an opening in the yard, in the same box with the fresh air inlet in the house drain. If this is so, it would appear that the escaping sewer air might be objectionable at such a point. It would be preferable that the sewer air should escape into the alley, and it is not a matter of importance to secure any ventilation for the short branch pipe, because if there should be an undue pressure of air at any time, which rarely occurs, it would escape through the trap and fresh air inlet.

The speaker fully agrees with Mr. Mohun that concrete sewers, of Portland cement, have great advantages; not the least of which is the smooth and even surface which can be given them.

It is difficult to understand the conclusion reached, that, with equal falls, the sewage, which will half fill a pipe, will have the same velocity in any other larger pipe, irrespective of its size. In the flow formula, $v = c\sqrt{RS}$. If v. c. and S are constant, R must also be constant; therefore the same velocity will occur, only as long as R., *i.e.*, the mean radius, remains the same.

The *shape* of the sectional area, however, can vary; R being constant, the same velocity will be obtained in every case. If this is the intended meaning. Mr. Mohun's conclusion is correct.

Mr. Fleming.

Mr. R. P. Fleming said he had considered the paper carefully, and thought that the system of ventilation and flushing of the sewers was very satisfactory. It would, perhaps, have been better to have spent a little more money, and made a combined system of sewerage, as the lack of any surface water drainage was an objectionable point. There are always some level lying streets, where rubbish will collect and decay in stagnant pools of water, and this is a condition dangerous to the public health. With regard to the wooden pipes, he thought there was always a tendency to retain a temporary system after it had become

inefficient. The top of the wooden boxes would probably decay rapidly, as they would not often be flushed. The trapping of the house branches he approved of, but disapproved of the ventilation of the sewer into the courts close beside the drain trap, as the escaping sewer air from its proximity to the fresh air inlet would certainly be drawn into the latter and the purpose of the trap frustrated. The ventilation of the sewers was so thorough that any additional ventilation was unnecessary, and the additional ventilation proposed was dangerous. This he considered one of the most important points of the system.

The section of the sewers he said, was the best possible with wooden sewers, and he approved of the manholes and flap valves, the latter improving the efficiency of the ventilation by making each section of sewer between manholes ventilate independently. On steep grade sewers, there is a tendency for the sewer air to rush to the highest point and escape there, passing by intermediate ventilating manholes.

The construction of the sewers in the back lanes he thought was a good plan, having many advantages pointed out by the author. The gradients fixed for house drains he also approved of, and the system of house drainage and plumber work generally. He, however, disapproved of coating the cast-iron soil pipes with black varnish, as it hid defects in the piping. The best solution for this purpose is that patented by the late Dr. Angus Smith, which is transparent and unaeted upon by sewage. He believed it was the only satisfactory solution yet in the market. He referred also to the author's remark on the flow of sewage through a pipe which it half filled, wherein he said the writer was evidently in error.

Mr. Hopkins. In this system perhaps the greatest defect is that it does not provide for the drainage of basements. In many places a cellar, undrained, stores up the surrounding surface water, and there is no reason why this should not be the case in Vancouver, particularly as there is no systematic surface drainage, while there will in all probability be many basements. Most of the sewers, however, will be self-cleansing on account of their good gradient.

Mr. St. George. Mr. St. George said the discussion being for the benefit of the members, especially the young members, if Mr. Mohun had given some idea of the area he had to drain, they could have judged better whether he had used the right system or not. Some of those who had taken part in the discussion seemed to have jumped to the conclusion that Mr. Mohun was perfectly right in adopting the separate system, without any basis upon which to form their opinions as to the best system of drainage.

They should be careful not to form any opinion until they had some information as to depth of rainfall and drainage area.

Mr. Hopkins. Mr. Hopkins said that possibly a drain laid carefully under a house did not do any harm, especially if the house were occupied by the owner, and were properly looked after; but while engaged in examining houses with the smoke-testing machine, he had observed the course of the smoke showing the track of the drain-pipe under the house most distinctly, and sewage gas would come up in the same manner. This would happen in many of the poorer parts of the city, and he therefore thought that the locating of sewers at the back of the houses made it very much safer for the majority of the people. With reference to the trap, the author had said he simply wished to represent a trap, not any particular kind, and, therefore, he did not think Mr. Mohun intended to have the one ventilated into the other, as would seem probable from the sketch. He thought a mistake had been made in allowing cess-pools to be built; they were not only expensive but dangerous. With the wooden pipes, of course, there was more friction, but the fall was very great, and it was therefore unnecessary to have a very finely shaped sewer.

Prof. McLeod. Professor McLeod said he had with him the average rainfall covering a period of 15 years for New Westminster. He failed to find any great period of drought as had been mentioned by some. The figures were as follows:—

Jan. 7·57 in., Feb. 6·88 in., March 6·68 in., April 3·18 in., May 2·41 in., June 2·42 in., July 1·67 in., Aug. 2·03 in., Sept. 3·20 in., Oct. 5·61 in., Nov. 7·90 in., Dec. 8·98 in.

The rainfall, even in the dry period, cannot be considered as exceedingly small, and in the autumn, winter and spring it is extremely great. He quoted the figures merely as a commentary upon the remark that there were extended periods of drought.

Mr. Peterson The rainfall record, as quoted, was a *mean* for a period of 15 years, but there might still have been droughts during that time, lasting a month or even more.

Mr. W. Whited. Mr. Whited asked if it would not be an improvement to insert a fillet of wood so as to make the bottom of sewer flat for one or two inches in width. It would afford less chance, he thought, for solids to lodge in the sewer, and the expense would be very small. It would also diminish the coefficient of friction.

Prof. McLeod. Professor McLeod said that it occasionally happened that for a month in that district there was little or no rainfall, but there was no such thing as a "succession" of months with no rainfall.

Mr. Dodwell. Mr. Dodwell said it was rather late to add anything to the very full discussion, which he thought, however, had been rather on the severe side. The means at the disposal of the people of Vancouver for sewage

works were very small, and he thought Mr. Mohun had made about as good use of them as was possible. The system was not of a permanent character.

Mr. Fleming remarked, with regard to the triangular wood proposed to be placed in the bottom of the sewer, that it might be an improvement as it would reduce the chance of obstruction in the sewer, especially if the wood had a very smooth surface. Mr. Fleming

Mr. Gower said that the fillet idea did not seem to him a very good one, because unless it was glued to the bottom, the nails and cross joints would catch lint and solids, and would cause much more obstruction than is experienced with the present form of construction. Mr. Gower.

Mr. Rust thought that the experience gained in the case of the sewers of Toronto would indicate that a mistake had been made in not constructing the sewers of sufficient depth to drain the basements. Doubtless, the growth of Vancouver within the next few years will be large, and it will increase in proportion, necessitating the construction of a number of wholesale and manufacturing establishments, and the inability to drain the lower floors of such buildings will give rise to serious complications, as generally, boilers, furnaces, washrooms, sinks, etc., are necessarily confined to the basements. Mr. Rust.

In Toronto, unless sewers are built at a sufficient depth to drain the basements, it frequently happens that an application to the Court results in the property owners being exempted from paying any portion of the cost of the work.

In his opinion, a mistake was also made in not taking the sewers to a sufficient depth, to lower the subsoil water below the buildings, which is considered a most important desideratum by sanitary engineers. The extra cost would probably not exceed 30 cents per lineal foot of sewer.

The question of carrying sewers in the alleys in rear of the building, is one that demands a careful consideration, and opens up to a certain extent the question of combined or separate sewers. Looking at the growth of Vancouver, Mr. Rust would imagine that some means will be required to provide, by means of street gullies, for the removal of surface water, especially from the principal streets. The question of carrying sewers beneath buildings is merely one of sentiment. With perfectly constructed house drains the danger is only imaginary, and when the alley-ways are private property, the question becomes still more complicated. It also gives the property owners every facility and encouragement for draining that abomination of abominations, the filthy privy pit, which further deposits a large quantity of solid excreta in

the sewer without the compensating power of water, which is obtained when properly constructed closets are built in the house. The question of better grades has to be considered only when the buildings are constructed on shallow lots.

There is some doubt as to the durability of plank. The upper portion being, comparatively speaking, dry, will no doubt decay quicker than the lower which is covered with water at all times. The expense of a sewerage system is not confined to the first cost; there is an annual one for repairs which in sewers constructed of plank rapidly increases.

It is therefore a question whether the Council has not made a mistake in not asking the people for, say, $5,000.00 more, and substituting pipe in place of plank.

In reference to the substitution of concrete, he entirely agrees with the writer that the substitution of concrete for brickwork can in a large number of cases be made with advantage.

Mr. Ruttan. Mr. Ruttan desired to refer briefly to two points in Mr. Mohun's description of the Vancouver sewers:—

1st. The use of wood instead of vitrified pipe; and

2nd. The construction of the sewers at a minimum depth of five feet.

It is generally understood that, when a temporary purpose is to be served, or when it is a question between the adoption of inexpensive work or none, as in the case of wooden pavements and bridges, engineers are justified in recommending such temporary works. In the case of sewers, however, the difference in cost between permanent and perishable material, should be very great to justify the adoption of the latter, particularly in a growing city like Vancouver, the streets of which will, no doubt, soon be paved.

He thinks that the author has under-estimated the expense and annoyance which will be occasioned by renewing the sewers with more permanent material in the near future.

The cost of vitrified pipe, less freight, would have been something ess than the cost of the wooden sewers.

The freight, in the quantities of pipe used, would, at $20 per ton, have been $4,500, a small amount to have influenced the decision in favor of a temporary system of sewers.

In regard to statement, that the Council has not undertaken the sewerage of basements, and that the minimum depth of sewers has been fixed at five feet, instead of the 11 or 12 ft., Mr. Ruttan is not aware of any other place where people would either do without basements and cellars, or undertake their own drainage, independently of a system of public sewers for which they were taxed.

One of the greatest sanitary advantages to be derived from the system of sewers is the removal of subsoil water, sewers only five ft. in depth, can perform this necessarily only to a limited extent.

For the reasons stated, he does not think that any adequate advantage has been obtained from the saving in cost effected by using perishable material, and placing the sewers at such a short distance below the surface of the ground.

Mr. Mohun.

Mr. Mohun begs to express his sincere appreciation of the honor done him, and is much gratified with the interest which has been evinced on a subject ~~which he deems~~ of such vital importance to the inhabitants of any city.

The principal objections which have been made are as to the wisdom of adopting the separate system, and the choice of the material of which the sewers have been built.

The separate system was adopted for the reasons given in the paper, not entirely as has been suggested on the ground of economy, though that consideration had much weight.

There is not in Vancouver any necessity for carrying surface water in the sewers; there is probably no part of the city more than half a mile from, and with easy grades to, the salt water. A system of surface drainage independent of the sewers is now being carried out and will cost but little. The rainfall is never of a tropical character, necessitating underground drainage to prevent the inundation of streets and basements.

The city of Providence has been referred to as an instance of the failure of the separate system; but a system should not be condemned on that account, rather the causes of failure should be sought, and it might perhaps be found that local conditions from the first pointed to the combined system as the better. The first city, it is believed, sewered on the separate system was Alnwick, Eng., population 7,000, in 1879, and this system still gives satisfaction. In our President's address last January, the separate system in Vancouver was referred to as one "for which all the conditions are favorable." There are merits in both systems, and only a consideration of the local conditions can justify a decision on the point. Reasons, which seem to many adequate, have been given for the adoption of the separate system in Vancouver, nor does the writer think that its opponents have advanced arguments to prove their fallacy.

With regard to material, the extra cost of vitrified pipe has been under-estimated by both Messrs. Rust and Ruttan.

Quotations were obtained for English, Scotch, Canadian and American pipe, and timber was found to be so much cheaper, that its adoption

was unanimously voted by the Council, doubtless the fact that such a course would cause the expenditure of a considerable sum among our own people had some influence on the City Fathers.

Mr. Mohun fears he is regarded by some as an advocate for timber in preference to vitrified pipe; this is not the case, as the following extract from his report to the City Council will show:—

"The choice of material appears to be limited to vitrified pipe and timber. The former, though more expensive, is in every way far preferable to the latter. The only advantages timber possesses over the former, arise from its comparative cheapness, and the greater ease with which it can be laid in a straight line to a true gradient."

From some experience of timber in British Columbia it is not anticipated that the pipes will soon decay. Nine years ago the writer constructed a somewhat similar ~~chain~~ drain of the same material at his house in the country, which is still quite sound; and he was informed that some wooden pipes taken up in Victoria, after being in the ground over twenty years, showed no signs of decay; this, however, he cannot vouch for from personal observation.

The writer thinks with Mr. St. George that Prof. Bovey is mistaken in assuming that the crown of the pipes will not be perpetually wet, believing that the water in the made earth over them will keep them saturated.

Mr. St. George has misunderstood, as pointed out by Mr. Peterson, the mode in which the pipes are laid, which is in accord with the principle of the egg-shaped sewer. As regards strength, they are in any position stronger than the vitrified pipe.

It may not be out of place to describe the precautions which were taken to insure good workmanship in the pipes. Each plank was examined to see that it was perfectly straight, smoothly planed, of true dimensions, and free from soft knots, shakes, or other imperfections, and any which did not come up to this standard were rejected. The pipe was then made and tested to see that it was truly rectangular; that the ends which had been cut in a mitre box were square; and that no spikes or splinters projected into the pipe; a failure in the first or last of these qualifications involved the rejection of the pipe; if the ends were not square they had to be sawn again until cut truly.

In laying, the upper half of the sleeve was not put on until a close butt joint had been made, and if the two ends did not fit closely, one was raised and recut, after which the sleeve was completed and the joint accepted.

The small quantity of water required for flushing the pipes of the separate system, the use of the automatic tanks which require no super-

vision beyond that of an occasional visit, and the abundant supply of water, combined to render this method of cleaning preferable to that which is dependent on rainfall at irregular intervals, which generally also involves a considerable extra expenditure in the dry season.

It is proposed to try the effect of a daily flush at first, and, if necessary, shorten the interval as may be required. The present supply by cart is a temporary expedient in order to obtain the use of the sewers at once. By arrangement with the Water Works Co. the twelve flush tanks now built will each be supplied once daily for $292 per annum, and as often as may be necessary at the same rate.

The water pipes are being laid in the town, and in a few weeks Vancouver will have one of the best water supplies on the continent. This is, however, a subject which it is to be hoped will be dealt with by another member of the Society.

The question of basement sewerage was one that received very careful consideration, and it was decided that the special conditions of the case would not warrant the additional expenditure. There are not probably more than twenty basements in the city of, to-day, 9,000 inhabitants, each of these basements can be and it is believed has been drained by its owner with from 60 to 150 feet of pipe, and it is not reasonable that the whole of the rate-payers should have their sewer rates doubled for the benefit of the few. Indeed it would have been cheaper for the Council to have paid for the extra pipe required. Again, some members of the Council felt strongly that there was a risk of the foreshore being contaminated through the discharge of the sewage into the harbour; though not sharing this feeling, the author suggested that it would be easy to raise the sewage in such a case into the proposed intercepting sewer discharging into English Bay; in this event it would be very undesirable to increase the amount to be raised by pumping. Again, the practice of placing w. c.'s and sinks in basements is most unwholesome, and should be discouraged in any city by the authorities. The additional cost was, however, the chief objection; and while the author is completely in accord with those who recognize the importance of thorough drainage, he still thinks the decision arrived at was wise, more especially when it is understood that to have so lowered the sewers would have brought their outlets below H. W. M., and, without pumping, the discharge would have been stopped for some hours each day. He regrets that by his failure to correct a figure in the proof he may have misled Mr. Rust as to the cost of trenching and refilling; the contract schedule price was 55 not 35 cents a lineal foot for a depth of 7 feet, for 12 feet deep $1.00, and for 14 feet deep $1.20. Hence while with a minimum depth of 5 feet we had an average depth of 7 costing $8,900.00;

a minimum depth of 12 feet with an average of 14 would have cost $19,740.00 and this for trenching and refilling alone, without taking into consideration the extra cost on manholes and flushing tanks.

While acquiescing with Mr. Rust, that "with perfectly constructed house drains the danger is merely imaginary," the author believes that the danger is in practice very real, since in spite of all care absolute perfection is rarely attained, and prevention, being better than cure, would place the sewers where the risk was least.

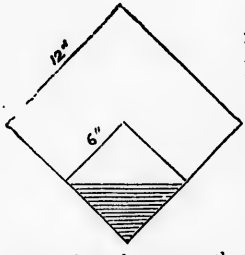
The exact area sewered cannot now be given by the author, as he has no map with him. It is, however, about 100 acres, and it must not be forgotten that the system has been designed so as to permit of extension, when expedient, over a much larger area without alteration in the work already completed.

With reference to the iron pipes for house drainage, the writer quite agrees with Mr. Fleming as to the desirability of testing before use. Under the By-Law, the Inspector has large power, and need only accept such materials and workmanship as are satisfactory. The coating of American black varnish appeared to answer well with some of the cast iron outlet pipes which were exposed to the weather from October to March.

Some engineers think an interceptor between the house and the sewer unnecessary, while others recommend it. In the case in question it is intended as an additional safeguard (should the ventilation of the sewer prove defective), by which an exit is provided for any gas which may find its way into the house drain; it also provides a fresh air inlet for the soil pipe. If too close to the house the foul air outlet might be connected with a ventilating pipe.

The author does not understand Mr. Fleming's remark, if correctly reported "that the two pipes were exactly together. They came up into one chamber, the grating under the house certainly had a draft, and the air escaped exactly at that point." If the two pipes referred to are the soil and ventilating pipes, they are supposed to be each provided with their own fresh air inlets and foul air outlets. The ventilating pipe is not connected with the soil pipe at the foot of the furnace.

Since the Council declined to sanction the entire suppression of privy vaults, the regulation referred to by Mr. Hering was adopted to meet cases in which cesspools had been or were about to be constructed in accordance with the By-Law. A reference to the paper will show that Mr. Rust is incorrect in assuming that any solid matter can be introduced into the sewer from these vaults.



In the case of the velocity, Mr. Mohun regrets that he failed to make his meaning plain, but must still maintain that his statement, as referring to the sewers under consideration, is correct, and capable of proof as follows: $v = c\sqrt{s.R}$. If c, s, and R are constant, then v is constant. The value of c depends on the values of n, s, and R. Take the case of a 6″ pipe running half or less than half full, and assume that its contents are transferred to a 12″ pipe (both pipes having the same fall), then the material and the fall of both pipes being the same in each case, n and s are constant, and as not only a, but p, is constant (owing to the angles of the inverts being the same) $\frac{a}{p}$ R, also a constant; hence c, s and R being constants, v is the same in the large pipe as in the small one. It is of course obvious that no such result follows with circular pipes.

From the Drawings accompanying this Paper, Plate X has been prepared.