commonly used for jointing pipes is clay, which is one of the worst materials that could be found for the purpose." There is no reason for any change in this opinion expressed so long ago. It was also reported to the investigators that joints on the house connections had been made with mud. This on inspection proved to be a very weak mortar made with a dirty sand of poor quality. Instead of the clean sharp sand called for in the town ordinance, a dirty loamy sand had been used. Instead of a mortar, consisting of one part cement and two parts sand, the mixture was about one part cement to six parts sand. It was found that in some cases in removing the caps from the Y-branches that the latter had been broken and then had been patched in very crude ways, so that large quantities of ground water were admitted to the sewers. In one town the wet-weather flow from leaky house connections was considerably reduced by requiring that in wet trenches the connections should be made with cast iron pipe with lead joints. It may be thought that a few leaky joints or a broken pipe on a house connection is not a serious matter, until a person realizes that the total length of the house connections is generally equal in length to the main sewer system, and in some cases even double the length of the main sewer. For example, if a main sewer has a connection every 25 feet, and each of these connections is 25 feet long from the main to the house, the total length of house connections is equal to the length of the sewer. Consequently, a few leaky joints on each sewer connection are in wet soils often capable of overloading the main sewer.

Some people believe that the admission of ground water into a sewer system is desirable. This belief is based upon the assumption that it is necessary to wash out the sewers, and provide a flow of water adequate to float the solid material. The benefits of this practice, however, are greatly overestimated, as a properly constructed sewer on a proper grade will cleanse itself, and if it is necessary to flush sewers laid on a low grade, it is better to rely on some means of flushing that can be readily controlled, such as the periodic flushing of the sewer with a fire hose, hand-operated flushing manholes, or automatic flush tanks.

Apparently the advisable methods of preventing the infiltration of ground water into the sewer system by way of the house connections is to improve upon the methods of making the joints, and also to improve upon the methods of placing the caps in the Y-branches. For the latter purpose disks of galvanized iron have been used, but would appear to be of little value, due to the rusting out of this type of cap in unused branches. The ordinary terra cotta caps may be held in place with a gasket of oakum, or jute, completely filling the space between the sides of the cap, and the bell of the Y, and a thin rim of cement placed over the oakum to hold the cap in place.

As to the methods of laying the pipe, some of the patented jointing compounds would be of great advantage when used with care, and by using pipe 3 feet in length only two-thirds as many joints would have to be made. The objections to some of the present methods of making house connections have been pointed out above, and the financial aspects of the situation have been briefly outlined, hoping that this subject will be discussed, and that rational methods for the prevention of this costly infiltration may be advanced.

In closing, it is desirable to indicate that there are certain sewer systems where the admission of certain portions of the ground water is permissible, but this privilege should only adhere to the combined system of sewerage, and even in this case the privilege should not be abused.

HIGHWAYS.

By W. Muir Edwards,
Professor of Civil and Municipal Engineering, University of Alberta.

IN the first article of this series the general principles governing the construction and maintenance of public roads was discussed, and a classification into Country Roads, Branch and Main Highways was suggested. The second article dealt with the first of these, and it is proposed in this article to consider Highways.

It is to be understood that the distinction made is between roads constructed of material in place and those whose roadbed, or at least the centre portion of it, is built up of material brought and placed therein. This improved centre portion varies in width from 10 to 24 feet, a width of from 12 to 16 feet being all that is required in most instances. The object of bringing in material and placing it on the natural soil is to make a hard, smooth surface upon which the rolling resistance will be small, due to its not yielding under the wheel loads. To accomplish this it is necessary that the natural soil, which must ultimately carry the load, be not exposed to too great an intensity of pressure. The filling material is compacted together and has more or less rigidity. The wheel loads cause a certain pressure over the surface of the road in contact with the rim, and this pressure is distributed by the filler to a much larger area of the soil supporting the roadbed. The principle is the same as that used in house foundation, bridge piers, etc.

The filling material is placed on the natural soil, which has been previously thoroughly compacted by rolling. This subgrade, as it is termed, may be either flat, requiring a greater depth of filling material at the centre to form the crown, or may conform to the shape of the finished surface, giving a uniform depth to the filling material throughout. The amount of material required depends upon the heaviness of the traffic and on the method of maintenance. There is a constant wearing away of even this hard roadbed, and this may be replaced either periodically or by continuous upkeep. In the former case the initial depth must be such that the improved surface will not wear too thin. This minimum allowable thickness depends on the traffic and the nature of the subgrade. The greater the depth, the larger is the area of subgrade over which any wheel load is distributed.

The filling material must be sufficiently hard to resist the crushing action of the loads and sufficiently tough to prevent its breaking under the continual blows to which it is subjected by the traffic. There should also be a binding together of the surface coat and of the body of the roadbed in order that water falling on the road shall not find its way down to soften the subgrade. The materials generally used are gravel and broken stone, but if neither of these is available any material which would satisfy the requirements might be used as a substitute. One of the functions of the alert highway engineer is to utilize local material, such as well-burned clinker, hard brick spalls, slag or other by-products, which may be economically used in the body of the roadbed, and thus save the expensive imported material for the wearing surface.

Pit-run gravel should not contain too great a proportion of sand or of clay if satisfactory results are to be obtained. About ten per cent. of clay or loam is