ence to bell and spigot pipe; with other patterns this condition does not exist.

In directing the teamsters on which side of the street to deliver the pipe, consider on which side of the trench the bulk of the dirt is to be thrown, and have the pipe dropped on the side opposite to that, and thus avoid having to lift the pipe over an embankment of loose earth.

CHAPTER II.

FIELD WORK.

Engineering or None—Pipe Plans—Special Pipe—Laying Out a Line—Width and Depth of Trench—Time-Keeping Book—Disposition of Dirt—Tunneling—Street-Piling.

IT is well understood by the readers of THE ENGINEERING AND BUILDING RECORD that the best preparation for any considerable amount of main-pipe laying is found in a careful survey of the proposed line, which shall take note of every feature which is likely to affect the work. Cross streets or roads, existing or proposed, brooks, bridges, drains, culverts, sewers, gas-pipes, and old water-mains, if there be any, should be indicated on plan and profile, and forethought given to schemes for avoiding and overcoming evident obstacles.

Let me warn the novice that, in spite of his most earnest forethought, obstacles that could hardly be foreseen even by one of experience will almost certainly arise, and he can at best only strive to reduce the number of the unexpected difficulties.

The need for laying pipes to line and grade is an imperative one on the main line from a reservoir in a gravity system; is almost as necessary with any main larger than ten or twelve

inches, though perhaps less important in the smaller pipes through the streets of a town.

A town may build a respectable system of water-works with a wonderfully small amount of engineering, but money saved at the outset in this way is generally expended at a later date in correcting blunders and repairing defective work. The writer calls to mind at this moment an instance in which a defective length of pipe which was made a part of a submerged river-crossing has since caused an expenditure of not less than $2,000 at different times for repairs; enough to have paid for a reasonable amount of engineering and thorough inspection.

Let us suppose that full surveys and drawings have been made; in what form, then, shall they be put, so as to be intelligible to the foreman in charge of the gang? If an assistant engineer is constantly on the trench, he may not need a full drawing; his own notes made at the office may be sufficient, but this arrangement is not always practicable. We give herewith Figure 10, a sketch copied from blue prints used by Mr. R. C. P. Coggeshall in his work at New Bedford, Mass. These sheets are not large, 10x15 inches or less, and are given to the foreman a few days before the beginning of the work, so that he may get the gates, hydrants, and specials on the ground in advance of the digging. The writer has followed essentially the same plan, but in his drawings no attempt is made to show the form of the special castings. Single or double lines, with the names of the castings and size of gates, the whole drawn to scale of forty feet to one inch, are used as shown in Figure 11, page 29.

If a draughtsman is available the first method is certainly to be preferred, but if one must be his own engineer, super-

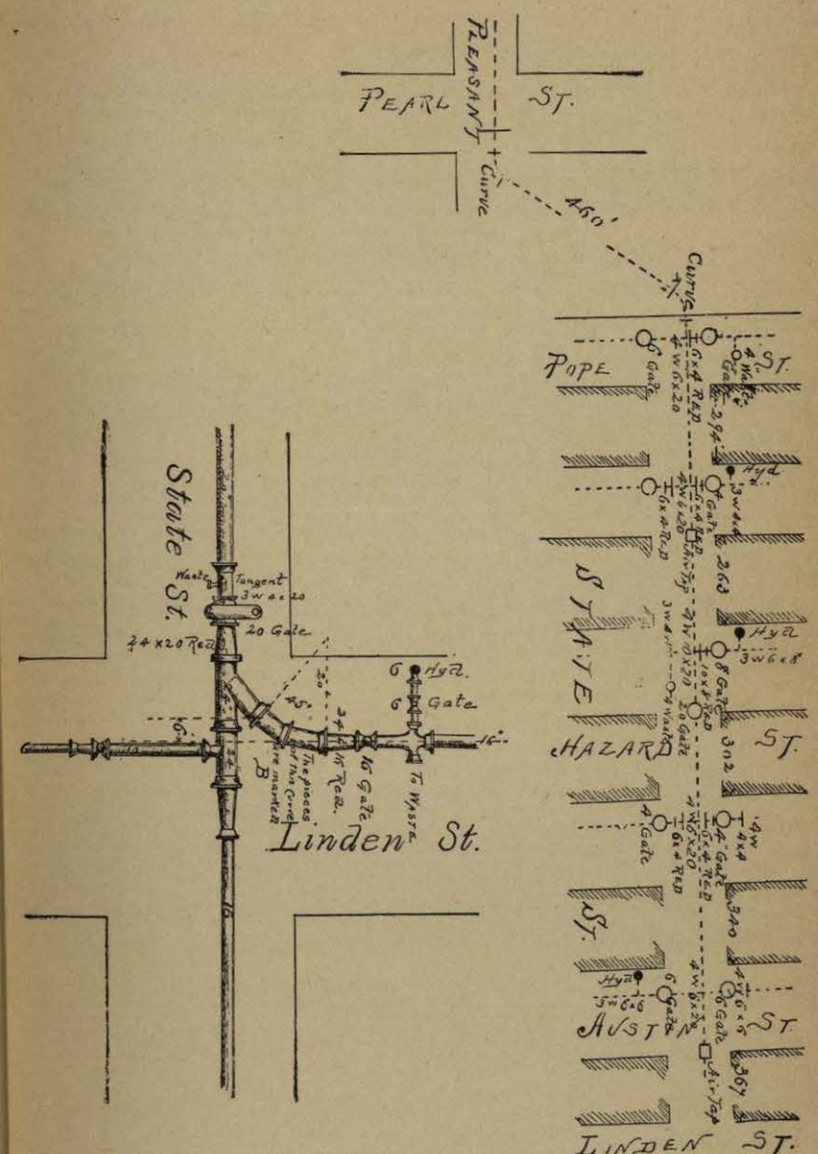

FIGURE 10.

intendent, and draughtsman, as is often the case in small towns, the second method has its advantages.

These pipe plans represent the best practice, but if the earth could be thrown off some main-pipe systems, as the valet of Frederick the Great used to throw the bed-clothes off his master in the morning, the easy curves and special angles which the foregoing plans provide would not be found.

I once heard a man of wide experience in handling pipe say that he could lay cast-iron pipe in the crookedest town that was ever laid out on the cow-paths, if he had single branches and plenty of pipe. Such work is not to be commended, but it has been, and probably will be, done.

It would be outside the scope of these papers to describe methods which may be employed in locating a pipe-line and staking out the curves and angles according to railroad practice, but some beginner may be glad to receive suggestions as to simple working methods. When he is given a gang of men, a quantity of straight pipe, and told to lay a main on B Street from a given point to a branch on S Avenue, his instructions will probably include the location of the branch with more or less accuracy, but on reaching the scene of operations he may find that this branch points all askew for B Street, and the street itself straggles along to a junction with the avenue in a tangential, uncertain sort of way that is more picturesque than satisfactory.

The first comforting fact is that we *can* swing around the sharpest curve which is likely to present itself by cutting the pipe into short pieces and making the joints as one-sided as we dare.

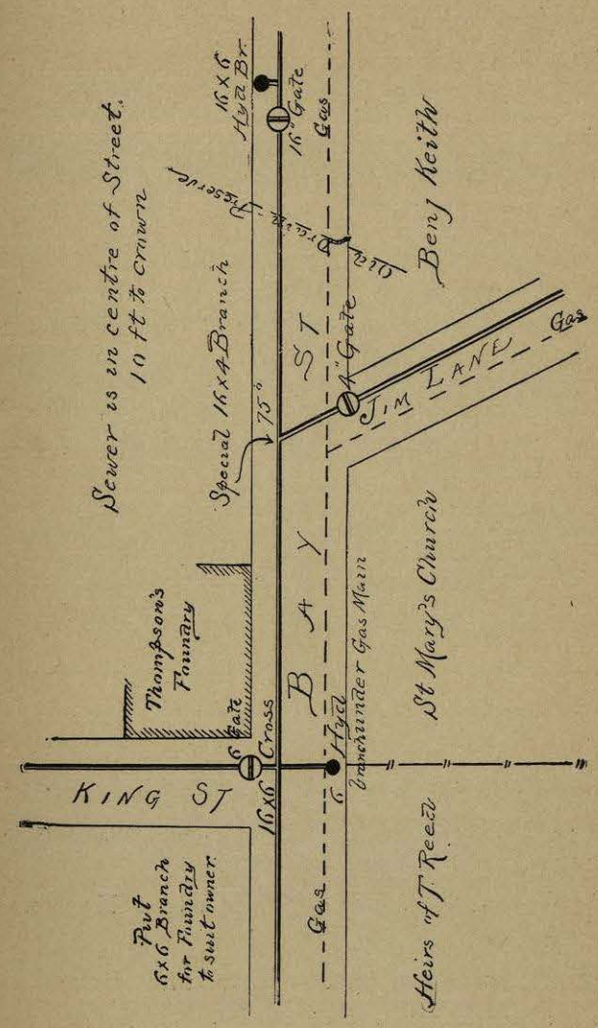

FIGURE 11.

We must have a line of some kind—sash-cord or clothes-line are first-rate for the purpose—so that we can fasten one end of it to a point in the ground nearly over the branch, say 18 inches to the right of it. Now let a man take the ball or coil of line and stretch it in the direction in which the branch points, as nearly as can be judged. Suppose the line is to swing to the right, let one laborer drive his pick into the ground close to the line, on the right of it, and 12 or 15 feet from the fastened end. Keep the line stretched, swing it to the right again, and have another pick driven into the ground 25 or 30 feet from the fastened end.

When a hundred feet or more of the line have been stretched in this way, set a half a dozen men to picking a rut along the left side of the line. Make them follow the line; don't let them walk backwards, and see that they all pick on the same side of the line; it is safe to say that half of them won't if you let them alone. The sections may be measured by laying down a shovel-length four times, or, if the digging is sandy, 15 feet is not too much.

The width of the trench may vary from 28 to 36 inches, depending on the size of the pipe, though if the soil is known in advance to be sandy, and likely to cave, it may be cheaper to start the trench four feet wide on top, and slope it towards the bottom, rather than to use bracing.

The depth to which pipe may or must be laid is controlled by more than one consideration.

In northern latitudes protection from frost is first to be thought of, and the amount of covering required for this depends upon the nature of the ground, the size of the pipe,

and the quantity of water flowing during the hours of minimum flow.

In loose, gravelly and stony ground the temperature will frequently fall below 32° Fah. for a depth of 5 or 6 feet, and hydrant-branches and service pipes have frozen under such conditions. In compact earth, free from large stones, the ground is not frozen more than three or four feet, and under good sod the distance is even less than that. These figures will hold good, I think, as far north as the isothermal line of Portland, Me.

Any section of a main pipe-line which is sure of a good circulation may be laid at any convenient depth without regard to temperature, and examples may be cited of main pipes which cross bridges without any protection from freezing except that afforded by the current of water constantly moving through them. Exact information upon this point is desirable.

There is a sort of unwritten law, in New England at least, that the axis of all pipes should be five feet below the surface.

If the amount of work on hand justifies the employment of not less than forty or fifty men, it will require the attention of one capable man whose duty shall be those of a foreman of the trenching gang.

The right man in this position will have no lack of work. He can keep the time for the whole gang, lay out the trench in advance, see that the damage from the excavated dirt is reduced to a minimum, keep private driveways open, look after the bracing of the trench if this be found necessary, see that the trench is dug to the line and grade given, keep the unoccupied side of the road as free as possible, and, finally

pick out the fellows who are trying to shirk and get rid of them.

Time-keeping, if one wishes to know with exactness the cost of the whole or any portion of a season's work, is an

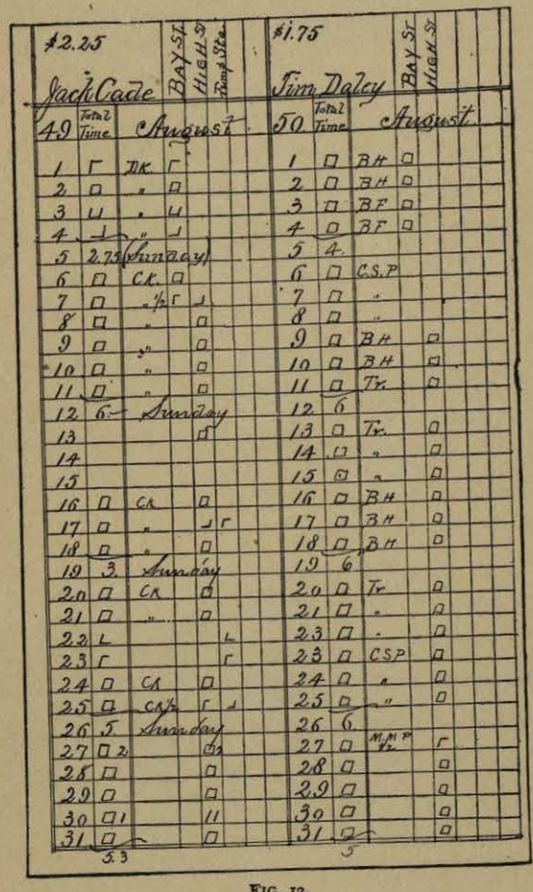

FIG. 12.

important detail, and a convenient and well-designed time-book is almost indispensable to good results. A sample page

from the time-book in use by the writer will illustrate one method which has been well tried and is not found wanting (see Figure 12).

With the aid of this book we have been able to tell with satisfactory exactness at the end of a season's work where every dollar of the pay-rolls has been expended.

For example, the page here given tells us that Jack Cade is number 49 in the gang; that he is paid $2.25 per day; that on the first day of August he worked only during the forenoon, in the derrick-gang on Bay Street; on the second he made a full day in the same position; on the third he did not begin until the middle of the forenoon, finishing out the day. As pay-day comes once a week the space belonging to Sunday is utilized to put down the footing of total time for each week. On Tuesday, the seventh, Cade during the forenoon worked on Bay Street and on High Street after dinner, and Ck. shows that he was employed in calking joints. In Tim Daley's record B. H. stands for "bell-hole digging," B. F. for "back filling," Tr. for trenching, and C. S P. (construction service-pipe) shows that Daley was taken from the main pipe gang on those days and sent to dig service-pipe trenches.

In working through the streets of a town, especially in the portions occupied by well-kept estates, it is well to remember that a man with a newly-painted fence or a bit of smooth grass-plot is very unwilling to allow gravel or clay to be thrown against his fence or on to his lawn, even if the street be narrow and the workmen cramped for room. A few hemlock boards do not cost much and may save considerable growling, for if they are judiciously placed against the fence they will protect both it and the lawn. Under these conditions, however,

there is some danger, if the dirt reach nearly to the top of the fence, of straining the structure and throwing it out of line. If this happens the fence must be straightened and the bill paid.

When tunneling is impracticable driveways and cross-streets may be kept in constant use by opening the trench half way across the space, leaving just driving room, and then digging on as usual. When the pipe-line is brought up to the undisturbed portion, the last two or three joints may be made without waiting for others, then enough of the trench immediately filled to furnish new driving room, and the undisturbed portion dug out by the derrick gang in quick time.

Bracing, if done to any considerable extent, is expensive work, but as it is not right and does not pay in Massachusetts to expose men to risk of injury, bracing the trench is sometimes not to be avoided.

If the tendency to cave is only slight and the trench is not more than five feet deep, sufficient support may be given by single planks running along just below the edge of the trench and held in place by short pieces of 4x4 joist, which are cut a little longer than the distance across the trench between the planks, and then driven in place with sledges.

In loose gravel or sand this sort of bracing amounts to little or nothing, for the stuff will run out from under the planks and finally tumble everything into the ditch.

Water-pipes are seldom laid to a depth which requires the thorough bracing and sheet-piling of deep sewer-work, but a simple sketch and a few words of explanation will make plain the vital points involved in the construction of ordinary sheet-piling. After excavating to a depth of four feet, a trench

which must go four feet deeper, in quicksand, for example, it may be braced as indicated in Figure 13. Lay the 4x6 stringers B along the bottom of the trench and put a 10-foot

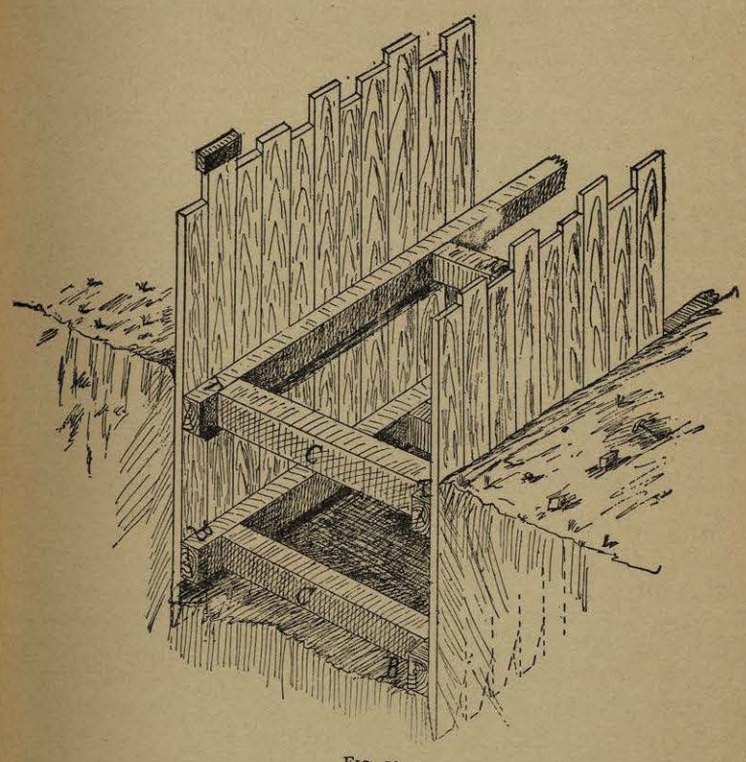

FIG. 13.

plank between each end and the bank. Cut cross-braces C long enough to drive in hard, and then fix the top stringers T in the same manner; the next is simply driving plank to make the sheet-piling complete.

It is not always easy to cut sticks of just the right length to be used for cross-braces C, and screw-jacks are economical in time and labor if much sheet-piling is to be done. We may use short jacks and a piece timber shorter than the width of the trench by the length of the jack, or, in narrow trenches, jacks of sufficient length to enable one to dispense with a timber brace may be preferred.

The one thing needful to make sheet-piling thoroughly effective is to keep the ends of the plank as much below the bottom of the trench as is possible, and to this end each plank should be driven frequently if only a little at a time. If the ends of the plank are chamfered and pointed, so as to help to throw them back against the bank and sideways against the plank last driven, better work can be done than with square-toed plank. If the amount of driving is considerable it will pay to protect the ends of the planks by a wrought-iron cap. Driving is to be done with wooden mauls, six inches or more in diameter and twelve inches long, bound with rings of wrought iron.

CHAPTER III.

TRENCHING AND PIPE-LAYING.

Caving—Tunneling—Bell-Holes—Stony Trenches—Feathers and Wedges—Blasting—Rocks and Water—Laying Cast-Iron Pipe—Derrick Gang—Handling the Derrick—Skids—Obstructions Left in Pipes—Laying Pipe in Quicksand—Cutting Pipe.

A TRENCH which is troublesome on account of caving grows worse the longer it is open; if, therefore, the trenching gang is a good distance ahead of the pipe-layers, and water and quicksand are found within two or three feet of the surface, it is wise to send the diggers ahead on to dry ground, or make some other arrangement, so that the last two or three feet in depth of the wet trench will not be opened until pipe can be dropped into it. When caving occurs in wet, heavy ground some warning of the impending trouble is given by cracks in the surface, running nearly parallel to the side of the trench; but in sandy gravel the drop comes without warning and men may be seriously injured. In any case the tendency to caving is increased by the weight of the excavated material piled up on one edge of the trench, and, if cir-