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-

cumstances will permit, it is well to keep men on the bank to shovel back the material as fast as it is thrown out.

In soil that will allow it, tunneling will often save the public and individuals much inconvenience by carrying the trench under crosswalks, driveways, and railroad crossings, and the only tools needed are the tunneling-bars, mentioned in the list of tools, and long-handled shovels. A little practice and boldness in this detail will give very satisfactory results.

With cast-iron pipe, when the digging is good and the trench stands up well, it pays to put three, four, or half a dozen men at work digging bell-holes; that is, enlarged places in the trench, spaced so as to come about the joints of the pipe, and large enough to give a man room to swing his hammer and get at all parts of the joint without unnecessary fatigue. There is little or no danger of getting the bell-holes too large, and plenty of room for the calker will do not a little toward insuring tight and strong work. The bottom of the trench should be dug out eight or ten inches for a length of four feet beyond the joint, and the sides worked out on the same scale to give ample shoulder room. These directions will have a queer sound when one is trying to make joints in quicksand, and at such a time fixed rules amount to but little. No end of grit, plenty of hard work, with some little planning, will make joints in places that seem all but hopeless for the first half-hour.

In these cases, bell-hole digging and joint-making must be done together, and some suggestions upon this detail will be given later.

Neither stony nor rocky trenches offer any serious difficulties, and even in ledge-work it is simply a question of time

and money. If the bottom of the trench comes in rock which must be worked out by drilling and blasting, the ledge should be cut away to a depth which will allow sand six or eight inches in depth to be spread upon the rock, in which the pipe may be imbedded. If boulders are encountered which are too large to be taken out by the derrick, they should be well cleared from the confining earth by digging before applying powder or dynamite; this gives the explosive a fair chance, and digging is cheaper than drilling and blasting. Large pieces may some-

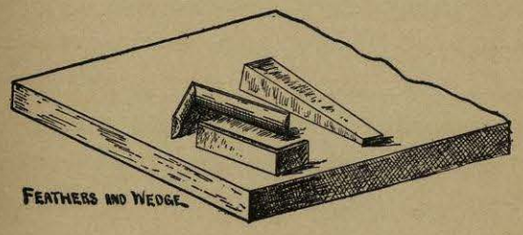

FIGURE 14.

times be worked off from a boulder or ledge which projects into the trench, without using explosives, by means of small hand-drills and "feathers and wedges." To do this, drill ¾-inch holes with a short steel drill and stone-mason's hand-hammer along the desired line of fracture, eight or ten inches deep and six inches apart; drop a pair of feathers made of ⅜-inch ½-round iron into each hole and drive the wedges between each pair. The "feathers and wedges" are shown in Figure 14.

In blasting, the nitro-glycerine preparation known to the trade as "forcite-powder" is comparatively safe and gives

better results than common gunpowder, for it will shatter rocks more thoroughly and with less tamping. To fire a 1¼-inch hole three feet or more in depth, take a whole forcite-cartridge, cut off perhaps half an inch in length, and set a percussion-cap pinched on to the end of a piece of fuse into this short piece of the forcite by boring out a small hole with a knife. Lower this into the hole and cover it with the remainder of the cartridge broken into small pieces between the fingers, and fill up the hole with earth tamped down with a stick.

Such a charge as that will let daylight into any rock that a pipe-gang is likely to encounter, but the blast should be carefully loaded with logs, timbers, or railroad-ties chained together, and covered with brush to arrest small pieces which may do damage if allowed to fly. This forcite-powder may be used to loosen a troublesome boulder, by simply poking a hole into the bank alongside of it and tucking in a little of the explosive folded in an envelope and held in place by a slight packing of earth, or a cracked and seamy rock may be thoroughly split by dropping an envelope full of the powder into one of the cracks, and firing by cap and fuse in the usual manner.

Rocks which appear in the bottom of a wet trench are unwelcome enough, but it will not do to leave them in such shape that a pipe will be supported by them in the middle, with the weight of the back-filled earth bearing on the ends, lying in soft ground. If the expense of getting out the rock, seems too great, the depth of the trench should be reduced until a firm and even bearing can be secured.

On all trenches that do not stand up well or that must be made wide to get out rocks, the long three-legged derrick,

illustrated on page 15, will be found exceedingly convenient, for its range is wide, and it can straddle fences in a right handy fashion.

PIPE-LAYING.

Cast-Iron Pipe.—When a hundred feet of trench has been bottomed out it is time to make up the derrick gang, and begin the work of putting the pipe into the ground. For six, eight, and ten inch pipe six men are enough, and they should be strong, active, and intelligent laborers. Men who are employed in this gang generally expect perhaps twenty-five cents per day more than the average digger, and good men in the place are worth it. It is not well to let the fellows who may be first chosen for this gang think that they are indispensable, and if one of them happens to be off a day, do not hesitate to take any good man out of the trench to fill the vacant place.

The first thing that a green lot of men must learn is to raise and carry the derrick, assuming that it be of the three-legged style referred to in a previous chapter. It is to be raised, first, just as a ladder should be, by footing the bottom and walking it into an upright position; then let one man grasp the pin of the middle leg with one hand and the leg with the other, a man at each of the other legs holding them firmly, and carry it straight away five or six feet; spread the other two legs the same distance, and the derrick stands alone, though perhaps not very firmly. A little study of the structure will now show that the legs may be spread as far apart as need be, provided always that lines joining the feet of the derrick form either an isosceles or an equilateral triangle, the line

joining the two outside legs being the base. In placing over the trench, the middle leg should stand on the side which has the largest quantity of earth piled upon it. The man who is to carry the third leg, as the derrick is moved along from pipe to pipe, should grasp the pin firmly when the time for moving comes, throw his weight towards the trench, and be careful to keep midway between his comrades who are carrying the outside legs, and they in turn should walk as close to the edge of the trench as practicable, resist the push of the derrick firmly, and keep about ten feet apart.

A man at each leg, another to carry the rope, and two men in the trench, make an ordinary derrick gang; for handling 16-inch pipe more men will be needed in hoisting and placing. The smaller sizes of pipe can be brought from the side of the road to the trench by means of the carrying-sticks. These sticks thrust into a pipe give good lifting hold, and two stout fellows at each end, shoulder to shoulder, will carry 4-inch easily, and 8-inch without overwork. Skids of 4x4 spruce thrown across the trench may support the pipe while the derrick is put in place over it; a sling of rope is then to be passed around the pipe enough nearer to the bell than to the spigot end to cause the spigot end to fall easily into the trench when the pipe is lifted by the tackle from the skids. As the skids are removed to allow the pipe to be lowered into the trench, let one of the gang bunt the pipe with the end of the skid to clear the pipe from sticks, stones, and dirt. This is not enough, however, and it should be the duty of the men in the trench to look through the pipe as it comes down to them and make sure that no one has, either maliciously or carelessly, left therein an old hat, or a pair of boots or overalls. These

remarks are not in jest, for just such combinations of what the doctors might call incompatibles have been made.

As the pipe is lowered, one of the trenchmen enters the spigot into the preceding bell, his comrade assisting as best he can, but before the pipe rests on the ground it is well to swing it like a ram against the pipe already laid to make sure that the joints ready for calking are all "home." As soon as the pipe rests on the bottom, the foreman should straddle the trench at a convenient point ahead of the derrick, *align* the pipe just laid, and look back over the line for joints which may be improved.

The trenchmen should carry bars with them to throw the pipe, and not try to use shovels for levers. Attention should be given to vertical alignment, as well as horizontal, and if grades are not given by an engineer, and no use is made of a carpenter's level on the pipes, the vertical alignment may be kept within bounds by keeping the joints of the same width at the bottom as at the top. If the bell end of a pipe when it rests on bottom is found to be too low, raise it with the derrick, throw rather more than enough loose dirt under it, and then drop the pipe down hard on this two or three times. As soon as the pipe is in position a few shovelfuls of earth should be thrown on to the centre of it to hold it, and if the trench is bad, the section between the joints may be half-filled at once, as this will support the bank and counteract any tendency to caving. With 4 and 6 inch pipe and a troublesome trench, two or three lengths may be put together on the bank, the joints made on dry land, and then with two derricks and careful slinging three lengths may be put into the trench at once without straining the joints. The few joints that must

be made in the trench may, in quicksand, seem at first like hopeless cases, but persistence and no thought of ultimate failure have conquered the worst cases that have come in the experience of the writer. In such instances it is useless to attempt to get the sand down so as to make the joint right through without stopping to dig out again. Let the calker stand on the pipe while a good man with a shovel, perhaps a lot of sod, and some pieces of plank, clears away and holds back the stuff so that the joint may be yarned if not poured. If the sand rises as soon as the shoveling ceases, let the calker do all he can by quick work, and then rest while another attempt with planks, sod, pails, and shovels is made to make room for him. In general, whatever means are employed to make and maintain room for joint-making in quicksand, let the preparations be thorough; let the plank be driven as deep as possible and well braced, sods provided in large quantities; have pails or a good ditch-pump, and good strong men who are not afraid to "pitch in."

In order to locate gates or special castings in a particular spot, or to bring a joint into a more accessible location, it is frequently necessary to cut pipe.

For this use an 8 or 10 pound sledge and the long-handled cutting-off tool illustrated in Chapter I.; put a skid under each end of the pipe, placing one directly under the line of cutting and get a firm and even bearing on the ground for its whole length. A line for the cutter to follow may be had by winding the end of a tape-line about the pipe and marking along the edge with chalk, but a little practice will enable one to guide the cutter as the pipe is slowly rolled on the skids, so as to make a square cut. The blows of the sledge should

be rather light for the first time around, and then when the cut is well marked so that it may be easily followed, the blows may be swung in with vigor.

The pipe should at some stage of the work be carefully inspected for cracks, which are oftenest found at the spigot end. If a crack in a spigot end is very slight and so short as to be more than covered by the bell, we may not think it worth while to cut the pipe, but a long crack obliges us to waste nearly twice its length of pipe, for the cut must be made at least six or eight inches above the visible end of the crack, and even then the jar of cutting may cause the crack to run still farther into the sound metal.