LAYING CAST IRON WATER PIPE.

By

ALFRED E. HARVEY, '91.

THESIS

For the Degree of Civil Engineer in the College of Engineering.

UNIVERSITY OF ILLINOIS.
1894.
Introduction.

In this discussion it is the object of the writer to give some practical suggestions concerning the methods by which the best results may be obtained in the laying of cast iron water pipe, and to set forth such facts in regard to tools and materials as may be useful to those actively engaged in such work.

Tools.

Many of the tools used in the laying of water pipe are such as are commonly used in other work, while some are peculiarly adapted to this kind of labor.

The Shovel, Spade and Pickaxe are the essential tools for excavation. Their construction
and are too well known to all to warrant a description.

The Handspike is a bar of tough wood from 3½ to 5' long. At 1 from the lower end it is 3½" in diameter and tapers to a diameter of 2⅛" at either end. A limb of oak or ash dressed of the branches and cut to the proper length makes a cheap and effective substitute for the handspike. The handspike is used in moving and handling pipe.

Crowbars. The form best adapted for pipe work is a bar of steel with the lower one third of its length square, with a wedge shaped end. The upper part of the bar is either round or octagonal. The weight varies from ten to sixteen pounds.
The Sledge Hammer, Fig. 1, is used to strike the "hurdy" or pipe chisel in cutting pipe, also for driving sheet-piling, braces etc. It is double faced, weighs from ten to sixteen pounds and is attached to a handle from 26" to 30" long.

The Hand Hammer, Fig. 2, is used in caulking joints. It weighs from two and a half pounds to three and a half pounds. It is double faced and swung on a handle 10" long.

The Cold Chisel, Fig. 3, is a bar of 7/8" octagonal steel 8" long. One end is drawn to the form of a wedge 3" long. The edge of the wedge is ground so that the face form an angle of 45°. The chisel is used in marking pipe, cutting lead and is the first tool used in caulking a joint.
The Diamond Chisel, Fig. 4, (sometimes called Diamond Point) is a bar of octagonal steel 8" long, with one end drawn to the form of a truncated, four-sided pyramid 3" long. The smaller base of the pyramid is a parallelogram 3/8" x 3/8" and is ground flat at an angle of 30° with the axis of the tool. The long edge of the pyramid is ground till the point presents an edge 1/16" wide. The diamond chisel is used in cutting pipe in places where the pipe chisel cannot be used. Other forms of the chisel are the half round and triangular points. These are not commonly used on pipe work.

The Pipe Chisel, Fig. 7, is a wedge shaped block of steel weighing two or three
pounds. The edge 1 1/2" or 2" long is ground so that the face form an angle of about 75°. In cutting pipe it is held in position by means of a handle and struck with a sledge hammer.

The Yarning Iron, Fig. 5, has a handle of 7/8" octagonal steel. The blade is offset from the handle 3/4". It is 7/8" wide and tapers from a thickness of 3/4" at the handle to a thickness of 7/8" or 3/16" at the end. The yarning iron is used to drive the gasket of yarn into the joint.

The Set, Fig. 6, is of 3/4" octagonal steel 7" long. The end is offset 1/2" for 1" of the length and is so formed that the face of the tool is a parallelogram 1" long. The width of the face varies by 1/8" between 3/8"
and 3/4". The face is ground flat and form a slight angle with the axes of the tool. In driving the lead, the tools are used in succession from the thinnest to the thickest. A set of tools should contain six sets viz: 3/8, 1/4, 1/3, 1/2, 5/8, and 3/4" in thickness.

A handy caulking tool for use upon the lower part of large joints is a tool similar to the pipe chisel but instead of a chisel edge it is made with a flat face. This tool is held in position by one man while another strikes the blow. With it, joints in place that are almost inaccessible to one man may be successfully caulked.

The Sling, Fig. 10, is a stout rope two feet longer than twice the circumference of the
Pipe to be handled. The ends being spliced together, it is passed double around the pipe, and through itself, and loose end attached to the hook on the lifting tackle. A chain sling is sometimes substituted for the rope.

The Lifting Tackle ordinarily consists of a 3/4" hemp rope and two double pulleys and single pulley. There are commonly termed "blocks and falls".

The Melting Pot is of cast iron and large enough to hold three or four hundred pounds of lead. It is supported in a portable furnace of sheet iron. For convenience in moving from place to place the furnace is furnished with "ears" into which handle may be thrust or it may be
mounted between a pair of iron wheels.

Pouring Pots of cast iron 8” in diameter are used in transferring the lead from the melting pot to the joint. The bail is made with a loop at the top (Fig. 9) to prevent the pouring hook from slipping to one side. A lug is cast in the side of the pot so as to form a hold for the pouring hook. A ladle with a vertical handle is sometimes used in pouring joints, Fig. 11.

The Clay Roll is a strand of rope coated with fire-clay till it forms a roll 1½” in diameter. It is placed around the pipe in front of the joint to hold the lead in place till it is cool. There are a number of patent pipe
Jointers on the market, but they have not yet displaced the clay roll to any great extent. A strip of asbestos pipe covering fitted with suitable clamps makes an excellent pipe jointer.

Pumps. For use in ditches, pumps should be compact so as to be easily moved from place to place, and of sufficient weight to stand firmly in place while in use. The pump in most general use is made with a diaphragm of rubber instead of a piston. The advantages of the diaphragm over the piston pump are, that there is less friction and wear in sandy water, that it holds the suction better, that it is easily repaired and is not so easily clogged by sand and gravel. While large
quantities of water can be obtained under pressure the water siphon may be used to advantage.

**Derricks.** The most common form of derrick used in pipe laying is the "A" derrick or "shear," Fig. 8. This is the most convenient kind of derrick for light work or on work where space is limited. A framed derrick set on wheels is sometimes used. It has proved satisfactory upon paved streets or upon smooth firm soil, but upon soft or broken ground or on repairs it is unsatisfactory.

The lifting gear of the derrick consists of a drum of wood 4" to 6" in diameter through which the axle of a large gear wheel is passed. A small gear wheel, mounted on
an axle which extends the width of the derrick imparts motion to the larger
wheel. The ends of the axle of the small
wheel are fitted with detachable cranks.
The block being hooked into the link at
the apex of the derrick, the loose end
of the rope is pulled taught by hand
and passed several times around
the drum.
Excavation.

The subject of excavation is an important one in the consideration of pipe laying. It is on this part of the work that the greatest profit or the greatest loss may be made. This work can not be governed by rigid rules but should be controlled by one who is familiar with such labor. The nature of soil varies so much in different cases that the subject can only be treated in a general way.

The trench is marked out straight under the direction of the foreman. The excavation is done in successive benches. The lighter men are used near the top while the heavier and higher priced men are worked in the bottom of the trench.
The pipe gang clean out the loose earth in the bottom, level it off to grade and dig the bell holes. If possible all the earth should be thrown on one side of the trench, leaving the other side free for work and for rolling pipe. A bench 12" to 18" wide is left between the loose earth and the trench. This takes the weight of the earth away from the edge of the bank and so reduces the liability of caving; it also gives the workmen a passage on that side of the trench. The side of the trench should be kept well trimmed and free from any masses of loose earth that are liable to cause caving of the banks. Caving of the banks is most liable to occur in sandy soil, in filled ground, or in soil
that is underlaid by veins of water or quicksand. The weight of the excavated earth is a frequent cause of the failing of the bank. The proper way to guard against this trouble is to leave a wide beam along the edge of the ditch. At the crossing of old ditches or at places where the new and old trench run near together the filling of the old ditch is very liable to cave and frequently requires some extra precaution in excavating.

Care should be taken not to disturb the earth within the banks. This is easily guarded against by a side cut of the shovel between the side of the trench and the earth to be removed. This not only separates the earth but leaves the sides of the trench neatly trimmed and materially lessens the labor.
A vein of water or quicksand flowing from under a solid stratum of earth will undermine its supports and allow it to settle. This can sometimes be prevented by rapid work from the time the water or sand is reached but in extreme cases braces or sheet-piling must be resorted to.

The thawing of frozen ground or violent rains are very disastrous to open ditches; it is therefore profitable to keep as little open ditch ahead of the pipe as possible.

Bracing. In deep trenches, especially where heavy pipe is to be laid, it is sometimes necessary to brace the sides of the ditch. The bracing should be arranged in such a way as not to interfere with the handling of the pipe, and in case the depth of the ditch is
more than six feet, it should be constructed
that it may be used as a scaffold from
which the earth may be passed to the top.
The material for bracing should be
of sound lumber; culls and second grade
lumber are costly in the end. For longi-
tudinal strips pine or oak planks 2" x 8" or
3" x 12" in size and eight or twelve feet
long are required. The braces of pine or oak
are 6" x 8" and not under any circumstance
should they be smaller than 4" x 6". They are
cut to fit the width of the trench.

At the place where the walls are to be
supported the planks are placed against the
side of the ditch opposite to each other and
three or four of the braces are placed between
them and driven tight with the maul.
In deep ditches it is sometimes necessary to put in two courses of bracing, one above the other. In such cases it is best to back the plugs by several pieces of sheet piling set vertically so as to unite the two sets of bracing.

Sheet Piling is made of sound pine plank 2" x 8" or of oak 1" x 8". The lower end of the plank is beveled on one side so as to be easily driven, Fig. 13, and is sometimes cut at an angle so that in driving it will be crowded closely to the one previously driven, Fig. 14. There are a number of kinds of lap sheetpilings on the market. Fig. 15 illustrates one of the most common forms.

Sheet piling is used in working through sand or wet ground. The trench is excavated
to as great a depth as is practicable, then a set of braces with two or three pieces of sheet-piling set vertically behind each plank, is put in place as described in the paragraph on Bracing. After the bracing is firmly in place the sheet-piling is set behind the plank edge to edge and driven with a wooden maul. As the excavation progresses the piling is driven deeper so that the lower end is always below the bottom of the ditch. In driving sheet-piling a wrought iron or steel cap should be placed over the end of the plank to keep it from splitting. Fig. 12 shows a section of a ditch partly braced and partly sheeted.

In arranging sheet-piling or bracing, care should be taken that it will interfere with
the lowering of the pipe as little as possible. In some cases the pipe may be lowered into the trench at a point ahead of the bracing and dragged back under the braces; or one end may be lowered between the braces, the pipe hanging at an angle, and swung forward till the upper end clears the brace at the rear, then the pipe may be lowered into place.

Before removing the sheet-piling the trench is filled up to the braces, which are then taken out. The filling is then continued till there is no danger of caving, after which the "sheeting" may be pulled by means of a chain, block and lever.
Handling Pipe.

In moving the smaller sizes of pipe a handspike or a bar of wood thrust into the end will form a sufficient hold. In case 8" or 12" pipe it is to be moved the ends are first lifted and four or five bars of wood 5' long are placed under it at intervals; then by placing a pair of men at each bar the pipe can be lifted and carried considerable distance with comparative ease. Care should be taken to instruct the men to keep one hand as close to the pipe as possible. This will prevent the pipe from rolling and pinning the men or causing them to lose their hold. Pipe larger than 12" is rolled from place to place. Pipe should be distributed along the line with all the
spigot ends toward the beginning of the work at the turning end for end, of all the pipe in a long line would involve considerable labor. When necessary to turn heavy pipe, end for end, it is most readily done by rolling upon a block of wood so that it balances and turning it as on a pivot.

Pipe, in sizes from 4" to 14", may be rolled to the side of the ditch and dropped into the trench about one foot ahead of the position it is to occupy. A rope whose ends extend to the top of the ditch is laid so that the spigot end of the pipe will fall upon it. By this the end of the pipe may be raised by the men on the bank, while it is guided into place.
by a man in the ditch and shoved "home" by means of a hand-shrike thrust into the bell end.

Pipe larger than 14" is lowered into place with a derrick. If an "A" derrick is used, the pipe is rolled upon heavy timbers which are laid across the ditch and extend back far enough to rest upon firm ground. The derrick is then moved forward over the pipe. The sling is passed around the pipe at the point where it will balance and is attached to the tackle. When the pipe is lifted clear of the timbers they are pulled to one side after which the pipe is lowered into the trench. The derrick should be set so that the pipe will hang so close to the one placed before it, that it will have
to be swung forward to allow the spigot to enter the bell. This will cause the pipe to drag backward so that the spigot will be forced "home," that is, to the back of the bell. The same result may be obtained by paying it back with crowbar or if a strain is taken upon the tackle so that a part of the weight of the pipe is carried by the derrick.

Caulking Joints

Before joining the pipe together the bell and the spigot should be thoroughly cleaned, wiped and examined for breaks and flaws. If the pipe are accurately cast and the spigot is touching the back of the bell the joint will be an annular ring. but if it is not an annular ring
The spigot must be wedged over into its proper place. After the joint is properly centered strands of mailing yarn are twisted into cords 1/2 in diameter and pushed or driven into the joint with the yarning iron till only the space required for the lead (2 to 3") is left between the yarn and the face of the bell. The purpose of this gasket is to occupy the space where lead is not required and to prevent the lead from running past the spigot into the bore of the pipe. The clay roll is placed around the ends at the top and pressed close to the joint so that no opening is left through which the lead may escape. The ends are turned back so as to form a triangular opening into which the lead is poured. The lead should
not be forced so fast as to confine any of
the gas formed by the heating of the gun
or by moisture in the joint. Gas so formed
will blow the roll out of place and burn
the men with flying lead. A section of
the joint after it is run will appear
as in Fig. 16.

These objects are to be attained in caulkling
a joint: to drive the lead firmly into place
so that it will not be blown out by the
pressure; to form so close a union between
the lead and the iron that no water can
pass between them; to condense the lead so
that no part of the metal is spongy or contains
bubbles of air. The first is gained by forcing
the lead into the recess A. Fig. 16., the second
by driving it so that it is wedged between
the surface B and C Fig. 16., the third by driving the lead up successive sections using the narrow set first and following it with the wider one till the set used is equal to the joint in width.

The first tool used upon the lead is the chisel, (applied as in Fig. 17.) turning up the lead next to the pipe. The lead next to the pipe is then driven back and into the recess A (Fig. 18) with the \( \frac{1}{8} \) set which is followed by the thicker sets in succession, driving in the soft lead outside the joint and forcing the entire mass back till it is tightly wedged between the surfaces B and C Fig. 19. In caulking a joint the lower half should be done first, for, being in the most inaccessible position, the work is not so likely to be
so thoroughly done. This is compensated for, in a degree, by completing the work upon the bottom, then by hard driving of the lead on the top forcing the pipe down against the lead in the lower half of the joint.

The explanation of the caulking of a lead joint as given above may apply to the standard form of pipe joints used by Philadelphia, Providence, Rochester and Chicago.

On the standard form of joint as used in Boston as shown in Fig. 20, such lead as may have been run into the semi-circular recess will be sheared off by the caulking of the joint, so that the lead is only held in place by close adhesion to the iron. In the standard form of pipe used in New York a deep joint with no recess is depended upon to hold the
lead in place. Fig. 21. In neither of these forms of joints can the lead be driven as a wedge as was shown in Fig. 19. But it must be driven hard so as to take advantage of any roughness of the iron.

Under some circumstances it is impossible to run hot lead into a joint. In such cases wedge of cold lead 2½" wide and long enough to reach around the pipe are driven into the joint. By some coils of lead pipe are considered superior to wedges. If the hot lead fails to fill the joint at all points wedge or plug of lead are driven in to complete the joint. This should be permitted only on small pipe to be used under low pressure. Cold working with cold lead should be discouraged under all circumstances.
and not permitted except in emergencies, because with the greatest care the results are uncertain.

Cutting Pipe.

In placing special castings or upon repairs it often happens that pipe is to be cut to special lengths. In the future this will in all probability be done with a pipe-cutting machine which is now upon the market but has not as yet come into general use. The methods of cutting pipe by hand will be in use for many years to come.

When the pipe is not laid in the trench but is loose so that it may be turned so as to bring all sides convenient for work, the only tools needed are the pipe-chisel and
The sledgehammer. The "harrow" is held by one man while another strikes the blows with the sledge hammer until a light cut is made entirely around the pipe which is rolled as the work progresses. This is repeated till the cut has a depth of \( \frac{1}{4} \) or \( \frac{3}{8} \), then the blows of the sledge are harder till a crack is started in the metal. This is extended along the line of the cut by keeping the chisel just ahead of it till the pipe is broken entirely around.

In case the pipe to be cut is in the part of a pipe already laid, the sledge hammer can not be swung to strike a blow upon the bottom of the pipe, so a portion of the cut must be made with a diamond chisel and a hand hammer. The chilled
metal on the surface is first broken and sealed off with a coarse diamond point after which a finer, sharper point is used in making a cut around the bottom of the pipe. In doing this the chisel is held at an angle of about 45° with the surface, and struck a series of blows with the hand hammer. This sometimes cuts out fragments of metal, but oftener throws up a ridge of metal on either side of the cut. In making such a cut it is sometimes necessary for one man to hold the tool while another strikes the blow. A convenient tool for such work is one similar to the pipe chisel but with a diamond point instead of a chisel edge. The cut on the top is made with the pipe chisel. The crack
is started as described in the previous paragraph and extended by wedging cold chisels in on the top and sides.

**Note on Special Construction.**

**Blocking.** It is generally specified that large pipe shall be laid upon blocks and wedged. This blocking gives the pipe a solid bearing and tends to keep it from settling to one side. The blocks are at least two in number. They are made of 4"x8" or 4"x12" timbers cut in lengths equal to the diameter of the pipe. The wedges are triangular blocks of hard wood placed as in Fig. 22 and spiked to the block. The blocks must be placed so as not to interfere with the caulking of the joints. One block is placed just back of the bell and the other not
Concrete Backing. All bends on pipe larger than 14" in diameter are backed by blocks of concrete or masonry to take the thrust caused by the changes in direction of the flow. On large bends not so protected, the joints are liable to be drawn apart. The blocks should be the same thickness as the diameter of the pipe and extend from the bell to within 14" of the spigot. The width should be from 24" to 36". The same provision should be made for backing all "T's" whose branches exceed 16". In all cases a clearance of 14" is left in front of the joint so that in case it should spring a leak, it can be recaulked. Brick or stone masonry is sometimes used instead.
of concrete. Brick masonry has no advantage over concrete. Bubble backing is slightly cheaper than concrete. Strips of iron are sometimes substituted for masonry backing. If properly designed they answer every purpose. Fig. 23. shows bend backed with concrete.

**Sleeved Joints.** When the ends of two joints of pipe are to be connected and both ends are spigots the joint must be made with a sleeve. This is a ring of iron from 8” to 18” in width and large enough to pass over the pipe to be connected and leave a 1/8” joint. On making the union the sleeve is passed over one of the pipes and after the ends are fitted together it is slipped back till it covers the joint. Fig. 24. Both ends of the sleeve are then
yarned and caulked as ordinary joints. In making these joints there is necessarily a slight space left between the ends covered by the sleeve. If the pipe can first be "entered" at the opposite end from the sleeve and swung into place as in Fig. 24 the space may be very small but increase as the length of the piece decreases. The space need never be greater than the depth of the bell of the pipe plus \( \frac{1}{2} \) for clearance.

If it can be avoided a sleeve should not be placed near the low-pressure side of a large valve, for in case the gate is shut the water hammer may drive it forward and close the space left between the pipes within the sleeve and at the same time...
draw the joint upon the opposite side. Fig. 25.
If it is necessary to place a sleeve in such a position the gate must be thoroughly strapped and braced.

Buckling Pipe is a method of uniting two lines or ends when one or both are bell ends. This kind of a union is made by “entering” the spigots at the fixed end, and raising the middle joint until it can be “entered,” Fig. 26, after which the spigot is lowered into place. This method can only be used upon pipe less than 12” in diameter.

Manholes are frequently put in near large valves to give access to their interior. The opening is an elliptical hole 18” x 12” closed with a cast iron cover. Fig. 27. The cover is sometimes fitted with a rubber gasket but it
is better to play the edge and after it is in place run the joint with lead and after screwing up the bolts a little tighter caulk it as an ordinary joint.

In setting a hydrant a plank about one square foot in area should be placed under the bell to prevent the settling. Another of the same size should be placed back of the lower part of the hydrant and the earth well tamped back of it. This is to prevent the water hammer from forcing the hydrant off of the connecting pipe. The space from the top of the connecting pipe to a point 6" above the waste hole and for a distance of 1" on every side of the hydrant should be filled with broken stone or coarse gravel so as to drain the hydrant quickly in
frezing weather. In cities the hydrants are frequently set in brick chambers.

_Frozen Earth._ It is sometimes desirable to carry on the work of pipe laying in cold weather, but frozen ground is an obstacle that is to be overcome. It may be dealt with in three ways: by breaking it out with the pickax, by thawing it with fire, or by thawing it with quicklime. There is very little difference in cost between the three methods but the best progress will be made by using fire. Quicklime is used when it is not desirable to build a fire. It is applied in the following manner. A ridge of earth four or five inches high is thrown up on each side of the proposed trench. The space between them is
covered three inches deep with lime and flooded with water and covered with boards, straw, earth or any thing to retain the heat. In twelve hours this will remove from eighteen to twenty four inches of frost.

**Equipment.**

The outfit required for a gang of twenty men engaged in pipe laying would be as follows:

- Pickaxes 10.
- Pipe chucks 3.
- Shovels 20.
- Sledge hammer 1.
- Caulking hammer 2.
- Ax 1.
- Site (two each size) 12.
- Melting pot 1.
- Cold chucks 4.
- Pouring pot and hooks 1.
- Yarning stone 2.
- Shibare 3.
- Diamond chucks 6.
- Derrick, blocks, falls, and sling.