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QUESTIONS and ANSWERS

on the Practice

and Theory of

SANITARY  
PLUMBING



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# Questions and Answers

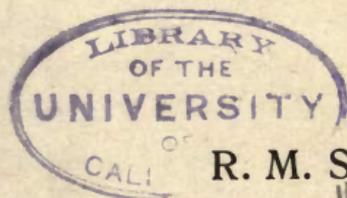
## On the Practice and Theory of Sanitary Plumbing

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**Eighth Edition**  
**Revised and Enlarged**

Including Many Valuable Rules and  
Formulae and "Tricks of the Trade."



BY

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"Questions and Answers on the Practice and  
Theory of Steam and Hot Water Heating."  
"Modern Plumbing Illustrated."  
"Hot Water Circulation Illustrated."  
"Mechanical Drawing for Plumbers."  
"The Starbuck Plumber's Estimate Book."  
"The Starbuck Examination Charts." etc.

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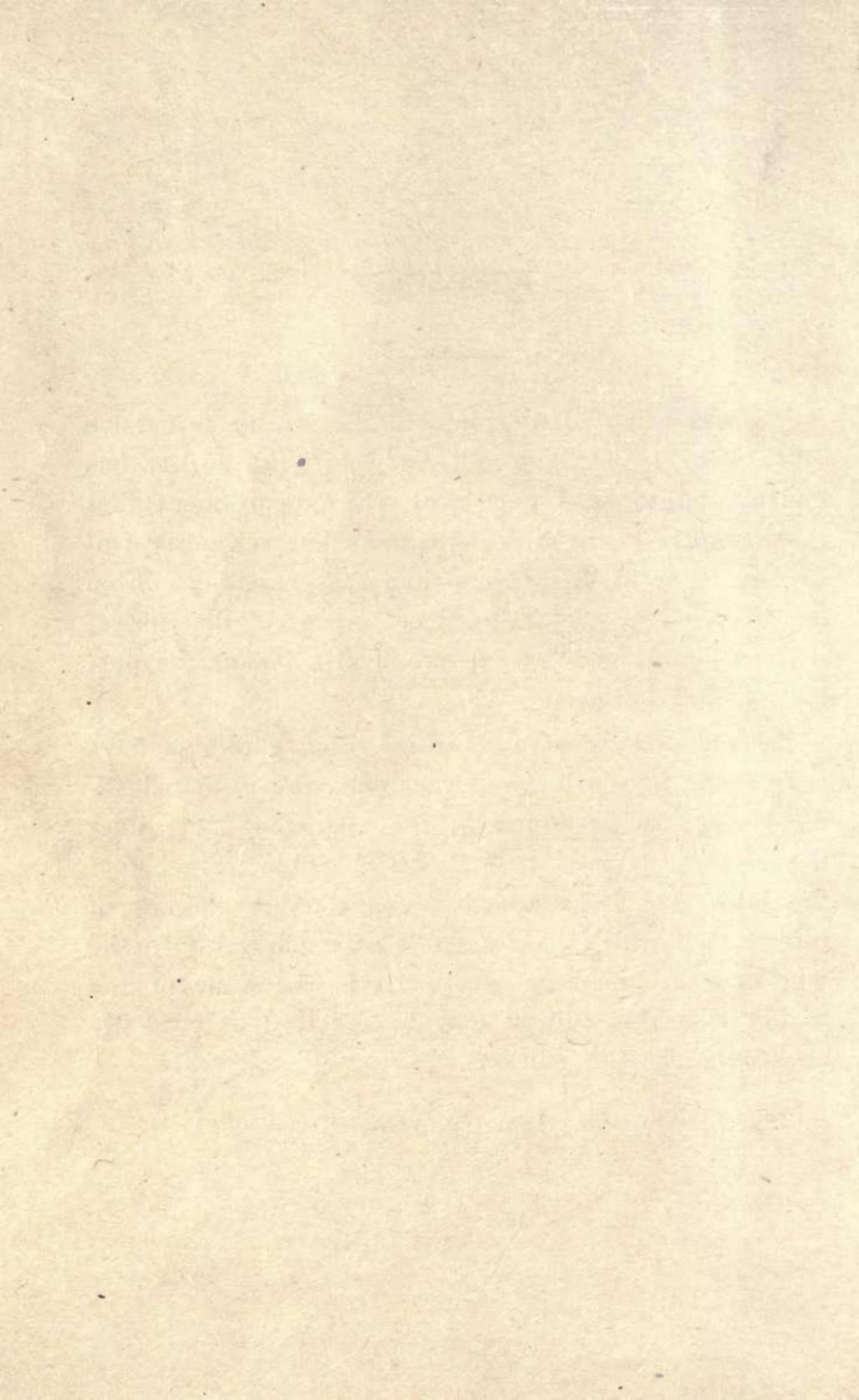
## PREFACE.

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In presenting to the plumbing fraternity successive editions of "Questions and Answers," the author has endeavored to keep pace with the advancement that is constantly being made, and to make each edition of greater value to his readers than the preceding edition has been. The original purpose to present the subject in as concise and brief and practical a manner as possible is still followed.

In the present edition, while some additions have been made to the body of the book, the principal additions are to be found in the appendix, and under the section devoted to "Practical Subjects." Under the latter has been added a considerable amount of information which should prove of much value to the workman in his daily work. It is the hope of the author that this edition may be received as cordially as have preceding editions.

Hartford, Conn., January, 1906.





## TRAPS.

**What is a trap?** ✓

A trap, as applied to plumbing, is a vessel containing a body of water, the purpose of which is to prevent the passage of sewer gas and foul odors from the sewer or cesspool into the house.

**What is the purpose of the house or main trap?** ✓

To prevent the entrance of gases from the sewer into the drainage system of the house.

**What is the use of the trap under each fixture?**

To prevent the entrance through the fixtures of gases and odors that form between the fixtures and main trap, or, if there is no main trap, to prevent such entrance directly from the sewer or cesspool.

**What is meant by the trap seal?** ✓

The depth of water between the outlet of the trap and the dip.

**What is ordinarily a safe depth of seal?** ✓

From 1 to 2 inch.

**Name different ways in which trap seals may be broken.** ✓

By syphonage, evaporation, capillary attraction, back pressure, and momentum, that is by the action of the waste itself as it passes off with considerable force. The trap seal may also be broken by being blown out by gusts of wind. The latter action may occur gradually, a few drops being blown out at a time.

**What qualities should a trap possess?** ✓

It should have a good seal, be non-syphonable, self-scouring, have no internal partitions, depend on no mechanical device, and have as few corners or places where filth may collect as possible.

**Why are traps with internal partitions dangerous?**

A flaw may exist in this partition above the water line through which gas may enter the house.

- ✓ Why are traps having mechanical seals now prohibited in most cities?

The mechanical parts give opportunity for the collection of grease and foreign matter in the trap and the mechanical seal is soon rendered imperfect.

- What are the two principal types of traps on which all other traps are based?

The S trap and the drum trap.

- What are the comparative advantages of the S and drum traps?

The S trap, being self-scouring, is cleaner than the drum trap, but when unvented, the drum trap is much less liable to syphonage. The drum trap may often be used to better advantage under the floor than the S trap.

- ✓ Is it the amount of water in the trap or the depth of seal that offers the most resistance to syphonage?

It is the amount of water.

- ✓ Is it the amount of water in the trap or the depth of seal that offers the most resistance to sewer gas?

The depth of seal offers the greatest resistance.

- ✓ What is the effect of the pressure of sewer gas on the trap seal?

It saturates the water in the trap with sewer gas, which is finally thrown off into the room.

- ✓ How is the pressure of sewer gas upon the trap seal prevented?

By back venting the trap.

- What precautions should be taken with traps in unoccupied houses during the cold months?

If the traps are of iron or lead, they may be salted, but if of earthen ware, after the water has been taken out, parafine oil should be used for a seal.

- With the ordinary iron sink, having the bell attached to the strainer, what should be done after the kitchen sink has been properly trapped below?

The bell of the sink strainer should be broken off, otherwise the sink will be double trapped and will not run off freely.

How should the trap which serves the drainage of the cellar bottom be protected in order to avoid any danger caused by evaporation?

The line on which such trap is placed should enter the main drain on the house side of the main trap, which is always sealed. Without the main trap there is no other protection than its own seal. It, however, should be supplied with a trap screw to be used during the dry season. Unless the trap screw with rubber gasket is made use of, it should be seen to that water is occasionally poured into the trap to renew any loss that may have occurred.

Name advantages and disadvantages of the main trap. ✓

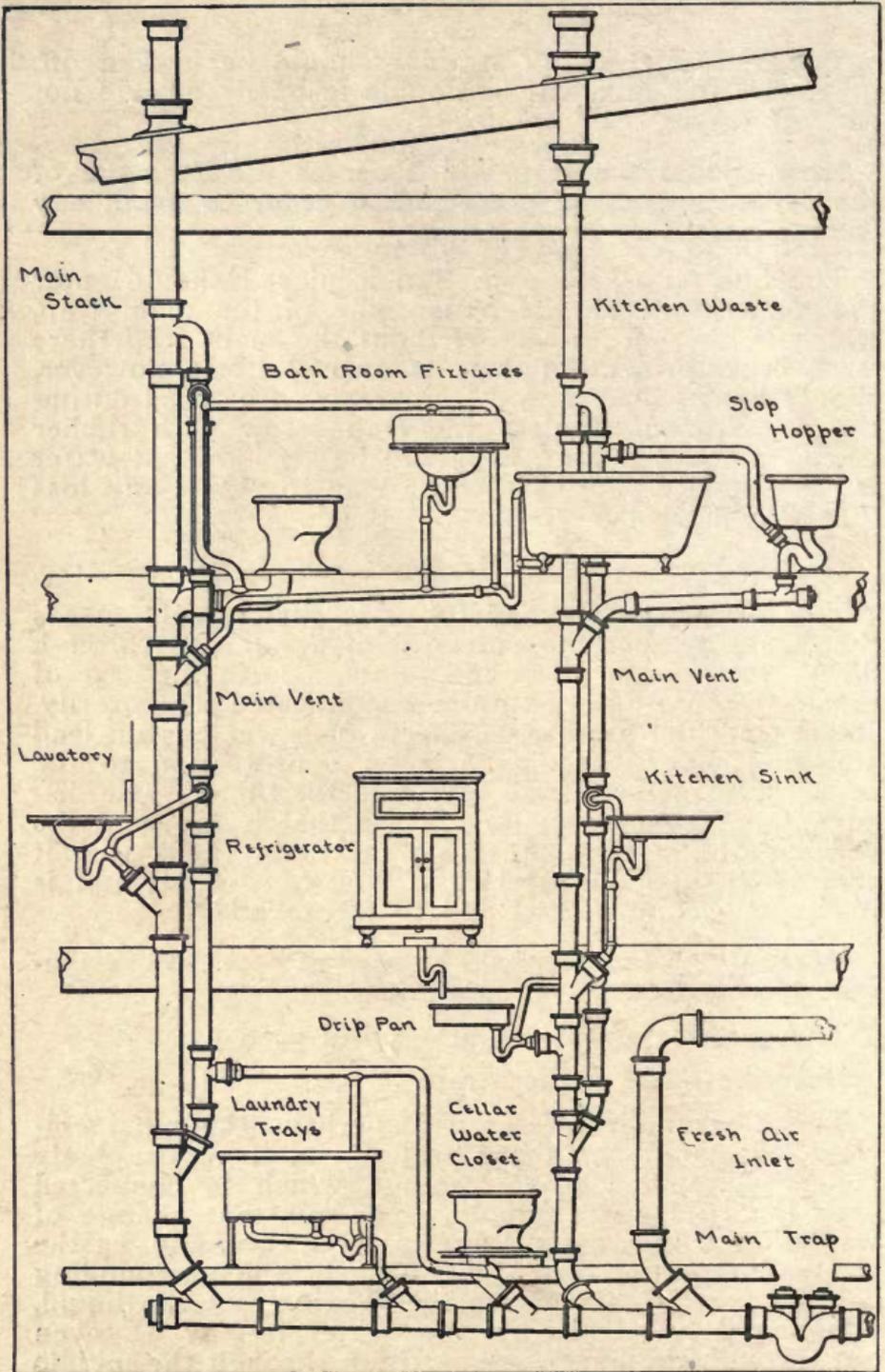
The advantage claimed for it is that it safe-guards the house against the entrance of sewer gas through flaws or cracks in pipes and joints, also in the case of repairs when a fixture trap is disconnected temporarily. It prevents the pernicious effects of sewer gas on lead and iron pipes. It also acts as a protection to the cellar drainage trap, and to conductor pipes. The disadvantages claimed in its use are that it prevents the venting of the sewer through the main stack, that it acts as an impediment to the flow of sewage, and is likely to become fouled and to freeze up.

What style of trap should be used in hotel and restaurant kitchens?

The grease trap should be used in such places.

Describe some grease trap.

The Tucker Grease Trap is perhaps the most efficient. It is of the drum trap form, its entire body being surrounded by a passage which is connected with the cold water supply. The constant change of water keeps this water jacket always cool, and, as the waste enters the trap, the effect of the surrounding cold surface is to separate the grease from the liquid, allowing it to rise to the top, where it may be taken out through the cover. A partition through the middle of the trap prevents the grease from being carried out through the waste as it rises.



PLUMBING FOR RESIDENCE.

**What trouble may arise from double trapping?**

The space between the two trap seals may become air bound and thus cause a slow passage of the waste, under which condition the stoppage of the waste is much more likely to take place.

**Why should traps be counter-vented?**

To prevent syphonage principally, to ventilate the plumbing system, and to relieve back pressure.

**From which side of the trap should the counter-vent be taken?**

From the sewer side of the trap.

**What would be the result if the counter-vent were taken from the house side of the trap?**

Syphonage could not be prevented, and the vent would become a by-pass for sewer gas.

**Does experience show that counter-venting lengthens or shortens the life of the plumbing system?**

Counter-venting lengthens it materially.

## COUNTER-VENTING.

### ✓ What is a counter-vent?

A counter-vent is a pipe through which a trap is supplied with air.

### Why should traps be counter-vented?

To prevent partial or total syphonage of the trap, and to ventilate the drainage system of the house.

### ✓ How does the counter-vent prevent the syphonage of a trap?

By supplying air to the crown of the trap no vacuum can be formed, and consequently syphonage cannot take place.

### From which side of the fixture trap should the vent be taken?

From the sewer side of the trap.

### ✓ Where should the vent from a fixture trap be carried?

Either into the main vent at a point higher than the top of the fixture, or directly through the roof.

### Why should the back air pipe enter the main line of vent pipe higher than the top of the fixture?

If entered below, in event of a stoppage of the waste pipe, the waste from the fixture would pass off through the vent.

### What should be the size of fixture vents?

The vent from a water closet or a slop sink should not be less than two inches, and the vent from all other fixtures should not be of smaller size than the waste pipe it serves.

### What kinds of pipe may be used for main vents?

Cities differ on this matter. Most of them allow either cast iron or galvanized wrought iron pipe, while others prohibit the use of wrought iron pipe entirely, and still others will allow the plain wrought iron pipe.

**What kinds of pipe may be used for fixture vents?**

Cities differ on this point also. Some call for lead, others allow lead and galvanized iron pipe, and in some places where cheaper work is done, plain wrought iron pipe may be used.

**In what different ways are water closets vented?**

They may be vented from the lead bend, from the vent hub attached to the T-Y, and where a cast trap is used, from the crown of the trap; also from the crockery.

**Why is it wrong to vent a water closet from the crockery?**

The vent being rigid, any settling of the floor or of the house, or any movement of the fixture itself, is likely to break off the vent horn.

**If the water closet is vented from the lead bend, from what part of the bend should the vent be taken?**

From the top section of the horizontal part of the bend, never from a point where the flush will throw matter into the entrance of the vent, or where the waste will settle into the vent pipe.

**Why should the use of rubber vent couplings be prohibited?**

Rubber soon loses its life and cracks, allowing odors and gases to enter.

✓ **How does venting effect evaporation?**

It increases evaporation by bringing in air upon the trap seal.

**How are the top and bottom connections of the main vent with the main stack usually made?**

The main vent is usually connected at the top with a T or back vent fitting, if of cast iron. If of wrought iron, through a tapped T. The bottom connection is usually made with a Y and eighth bend. Sometimes instead of re-entering the main stack at the bottom, the main vent pipe stops at the lowest fixture.

**What advantage is there in returning the main vent pipe into the stack below the lowest fixture?**

It makes the work rigid and allows any scale or rust from the pipe or condensation to pass off, thus preventing ultimate stoppage of the vent.

**Where should the main vent pipe be carried?**

Either through the roof or into the stack above the highest fixture.

**Why should the main vent pipe enter the stack above the highest fixture?**

If entered below the highest fixture, waste from that fixture, in passing down the stack, might lodge in the vent pipe.

**Why is the main stack carried through the roof?**

To relieve any pressure on the trap seals, to ventilate the plumbing system, and to furnish a supply of air to the fixture traps when the main vent is connected with the stack.

**Why is it wrong to run back air pipes into the chimney?**

The collection of soot might close up the vent, and a downward draft or pressure might force gases and foul odors into the house through chimney holes, etc.

**Why should a water closet located close to the stack be counter-vented?**

The action of fixtures above might cause at least a partial syphonage of the fixture unless prevented. (See Syphonage.)

**Why does the venting of a water closet located at considerable distance from the stack, make the syphonage of the trap less liable?**

With a long line of horizontal soil pipe, the waste would move slowly, and a slight obstruction in the pipe might cause the water to set back sufficiently to fill the long arm of the trap, and thus produce syphonage, which venting makes impossible. (See Syphonage.)

**Do you consider that a water closet located close to the stack, with no other fixtures entering the stack, needs to be counter-vented?**

No, for there is nothing that might cause syphonage of the water closet trap.

✓ What is to be understood by back pressure?

The pressure brought to bear on the sewer side of a trap seal.

✓ How can the effects of back pressure be overcome?

By counter-venting.

✓ What causes sewer pressure?

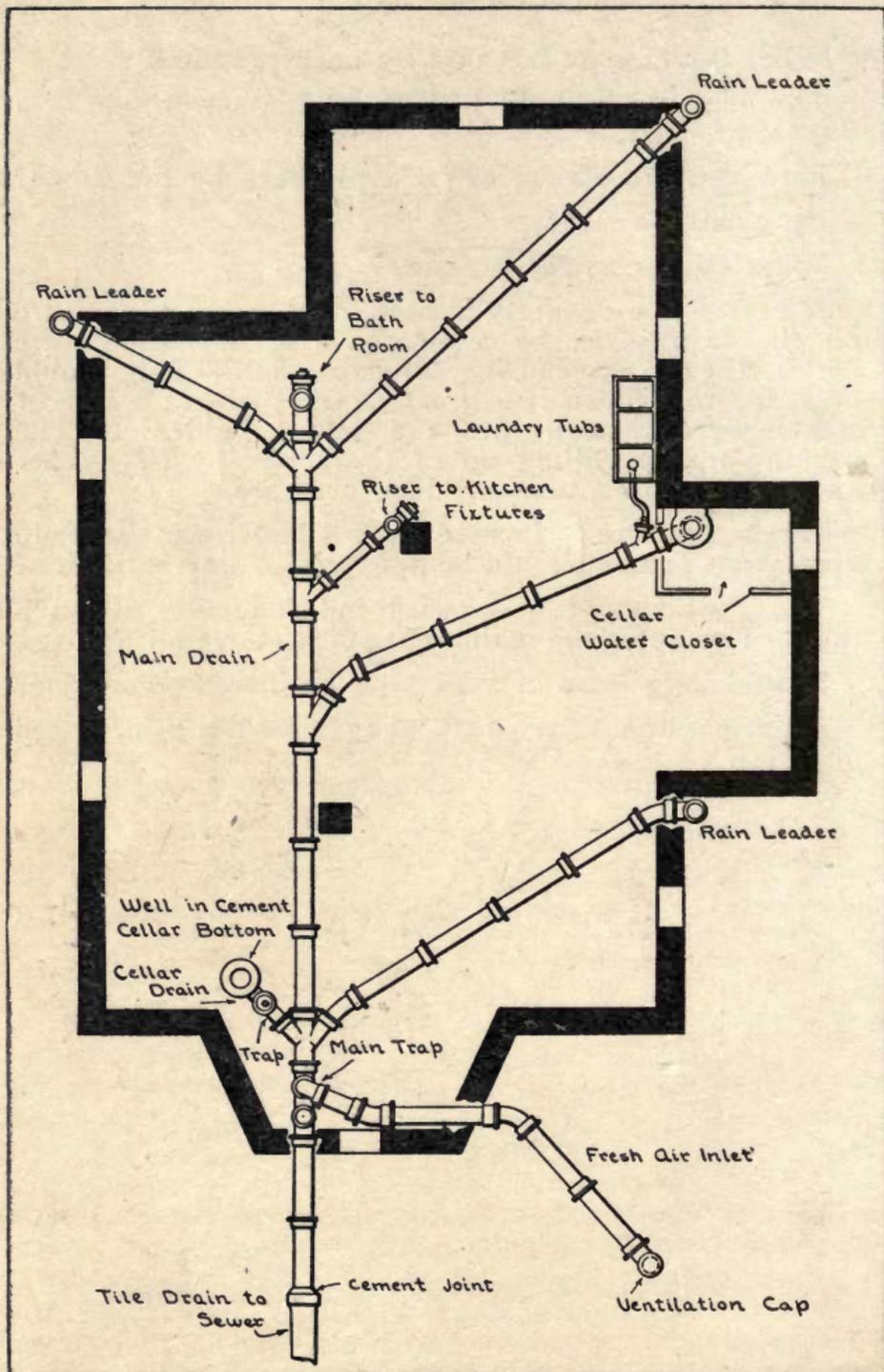
A sewer not properly vented may exert a pressure on the trap seals, by a sudden rise of temperature within the sewer, causing an expansion. This would be liable to happen if a great amount of hot water or steam were thrown into the sewer suddenly. The backing up and filling up of the sewer by tide water and other causes, also produce pressure.

When a fixture is located over 8 feet from the main vent, what course should be adopted for its ventilation?

The vent should be carried independently through the roof or enter the main vent stack above all fixtures.

Should long lines of vent pipe be increased in size?

After passing thirty feet, they should be increased one size.



CELLAR PLAN OF PLUMBING FOR RESIDENCE.

## SOIL PIPE AND DRAINAGE.

**What is the distinction between soil and waste pipes?**

Properly speaking, soil pipe is pipe into which the water closet discharges, and waste pipe that into which the waste from other fixtures is carried.

**Give weights of cast iron pipe.**

2 in. Standard C. I. Pipe weighs per ft.,	3½ lbs.
3           "           "           "           "           "	4½ lbs.
4           "           "           "           "           "	6½ lbs.
5           "           "           "           "           "	8 lbs.
6           "           "           "           "           "	10 lbs.
2 in. Ex. Heavy "           "           "           "           "	5½ lbs.
3           "           "           "           "           "	9½ lbs.
4           "           "           "           "           "	13 lbs.
5           "           "           "           "           "	17 lbs.
6           "           "           "           "           "	20 lbs.

**What sizes of waste pipe are required for the several fixtures?**

Water closet, 4 inches; bath tub, 1½ inches; kitchen sink, 1½ or 2 inches; refrigerator, 1¼ inches; wash trays, 1½ inches; lavatory, 1¼ inches; slop sink, 2 inches; urinal, 1½ inches; pantry sink, 1½ inches.

**Of what material should waste pipes be?**

Of lead, if of short length, and of cast iron where the run is of more than six feet.

**What is the smallest size of waste pipe usually allowed?**

One and one-fourth inch is the smallest.

**What is the least fall that should be allowed in running waste and soil pipes?**

One-fourth inch to the foot.

**What should be the size of the outlet from a trap into which two 1¼-inch pipes enter?**

Not less than 1½ inches.

Why should fixtures such as sinks, bath tubs, lavatories, etc., have independent entrance into the stack, rather than into the lead bend of a water closet?

To avoid the setting back of the sewage in the other wastes if the water closet should become choked, and to avoid any roughness on the inner side of the lead bend that a joint would make, which might result in collecting lint, etc., and causing stoppage.

What causes the gurgling sound frequently heard in the waste pipes?

A gurgling in waste pipes usually is the result of air lock or lack of ventilation.

Where should drip pipes from safes be run?

They should be run into some open place where they can be seen, but in no case should they enter soil or waste pipes.

What is a safe and what is its use?

A safe is a shallow pan, usually of lead, placed under a fixture, with a drip pipe attached, for the purpose of carrying off leakage from waste and supply pipes, valves, etc., thus preventing injury to the floor and ceiling below.

What are the proper weights of lead pipe permissible?

Different cities establish their own weights. The following is a list of weights that are desirable.

Supply.		Waste.	
$\frac{1}{2}$ in.	2 lbs.	1 in.	2 lbs.
$\frac{5}{8}$ in.	$2\frac{1}{2}$ lbs.	$1\frac{1}{4}$ in.	$2\frac{1}{2}$ lbs.
$\frac{3}{4}$ in.	3 lbs.	$1\frac{1}{2}$ in.	3 lbs.
		2 in.	$3\frac{1}{2}$ lbs.

How should connections be made between lead and cast iron waste or soil pipe?

By means of a brass ferrule wiped on to the lead pipe and caulked into the cast iron pipe.

How should connections be made between lead and wrought iron pipes?

By means of brass solder nipples which screw into the wrought iron pipe and are wiped on to the lead pipe.

**How should connections be made between wrought and cast iron pipes?**

By means of cast iron tapped fittings into which the wrought iron pipe may be screwed.

**How should cast iron pipe be supported?**

By means of wrought iron hangers attached to timbers overhead.

**What sizes of rod should be used in making hangers?**

This practice differs. The following is a safe rule to follow: For 4- and 5-inch pipe,  $\frac{1}{2}$ -inch rod; 2- and 3-inch pipe,  $\frac{3}{8}$ -inch rod.

**How often should cast iron pipe be supported?**

On horizontal lines each length of five feet should be supported by a hanger, and on vertical lines the pipe should be firmly supported on every floor.

**How should a vertical line of soil pipe be supported at its base where it runs to the cellar bottom?**

It should rest on a firm bed of brick or stone.

**Why is it wrong to enter a branch line into the main through a T?**

The waste flowing in through a T would strike the opposite side in such a way as to set back in the main each time, leaving a deposit that would finally produce a stoppage.

**What is the proper way to enter a branch into a main line of soil or waste pipe?**

Y branches should always be used.

**How should the main stack or any other vertical pipe enter the horizontal pipe in the cellar?**

Through a Y branch and one-eighth bend.

**How should all changes in direction of cast iron pipe be made?**

The use of all bends is admissable in changing the direction of pipe, with the exception of the quarter

bend. Where the change in direction is a right angle, a Y branch and one-eighth bend should be used.

Why is the use of the quarter bend prohibited on all cast iron soil pipes?

For the same reason that Ts are prohibited, they being more apt to cause stoppage than the Y and one-eighth bend connections.

Where should clean-outs be placed?

At each right angle turn, at the end of each horizontal line, and at intermediate points in long lines of horizontal pipe.

What is the least fall that should be given soil pipe?

One-fourth inch per foot.

Why should Y branches be used in preference to Ts?

Y branches permit the sewage to pass through without interfering with its momentum as Ts do, thus giving a much better wash to the pipe with less liability to choke up.

How far should soil pipe be carried from the house before entering the earthen drain?

It should be carried ten feet from the inside of the wall, or two lengths. Where the drain pipe is carried nearer the house, the sewage is liable to leak out and work back into the cellar.

What should be done when a stack opens near a window?

It should be carried five feet above the window.

Why should caps not be used on ends of soil pipe above the roof?

By diminishing the size of the opening, they are liable in cold weather to close up with hoar frost.

Is it right or wrong to enter a line of pipe into the main drain on the sewer side of the main trap?

It is wrong, for by such means the sewer gas may be transmitted directly into the house.

What benefit is derived from carrying the main stack through the roof?

It relieves the pressure of the sewer gas upon the trap seals, allowing a free circulation through the drainage and vent systems of the house.

**What advantage is gained by entering the rain leaders into the soil pipe?**

The rain during a storm acts as a heavy flush and aids in keeping the drain clean.

**What is the relative size of waste and vent pipes?**

They should usually be the same, excepting in the case of the water closet.

**Why should soil pipe be increased to four inches before going through the roof?**

During the cold weather pipes of less diameter than four inches are liable to become filled with frost.

**Why should all lead pipe joints on the drainage system be wiped?**

The wiped joint is much stronger and more perfect than the cup or overcast joint.

**Under what conditions should conductor pipe from the roof be allowed to enter the house drain?**

Where there is no house trap the rain leaders should be independently trapped. Where there is a house trap it is not necessary to trap them separately so long as they enter the main drain on the house side of the main trap.

**Describe the cellar drainage system.**

This drainage is used in cellars where the bottom is moist. Under the cement cellar bottom, and completely around the cellar, is laid a line of porous tile with loose joints, which drains into a well formed in the cement, water leaching in through the joints and through the tile. The hub of a cast iron trap is cemented into the bottom of the well, and the water collecting there, carried into the main drain. Where there is no main trap there should be a trap screw to close the opening in dry weather.

**How deep should the lead be in the hub of a four-inch soil pipe?**

About one inch.

**What is the result of too great depth of lead in caulking a joint?**

If there is too great depth, caulking will not expand the lower part of the lead. It is a waste of material as well.

✓ **Describe the process of caulking a joint?**

A good sized ring of oakum is first forced into the hub (not dropped in), and set with a caulking tool until it is hard. The melted lead is then poured, and after cooling, firmly set down with the iron, care being taken to caulk the inner and outer circle of lead.

**How is a horizontal joint made?**

After the oakum is firmly caulked, an asbestos rope is usually put around the joint, leaving a small opening at the top for pouring the melted lead. If no asbestos rope is handy, a cloth and ring of putty can be used, or even a cloth.

**In what way does the matter of climate enter into the question of the size of pipe through the roof?**

In the warmer parts of the country it is safe to carry small sizes of pipe through the roof, but in the colder sections it is necessary to increase them to at least four inches, to prevent closing up with frost.

**What are the principal tests that are applied to the plumbing system, for the detection of leaks and faulty joints?**

✓ The water, smoke, and peppermint tests. *air*

✓ **Describe the water test.**

After the rough work is completed, which includes the caulking in of all ferrules, solder up the ends of all lead pipes, and close all openings in soil and vent pipes by means of expansion plugs, known as test plugs, then through one of the plugs attach the water, usually by means of hose. The entire system is then filled with water until it flows over the roof end of the pipe. Each joint should then be carefully examined for leaks, any defects remedied, cracked fittings replaced, etc.

✓ **Describe the peppermint test.**

After the work is complete, to test the several fixtures and their connections, seal all traps and stop all

openings, then pour the liquid into the top of the stack, which will penetrate through the smallest opening and show leaks if any exist. The common mixture is about two ounces of oil of peppermint to one gallon of hot water.

✓ **Describe the smoke test.**

After closing all openings as described above, smoke is forced through the system by means of special apparatus, the escape of smoke showing where defects exist.

**Under what conditions can water be used as a final test?**

When the plumbing fixtures are all on one floor, all joints can be covered with water without overflowing, which is far better than the peppermint or smoke test besides being more easily done.

**What precaution should be taken where the soil pipe goes through the cellar wall?**

A place should be left in the wall when the wall is laid, with a cap stone covering the hole so that no unnecessary weight may come on the pipe.

**How can a stack be caulked when located in a recess?**

Leave the lower joint on the vertical pipe until the joints above are caulked. This will allow of turning the pipe around. Finally caulk the lower joint that has been left at a point that can be easily covered with the caulking tool.

✓ **Why for an ordinary house is a four-inch soil pipe better than a larger size?**

Water when running through a pipe of medium size takes on a spiral motion and gives a much better wash than it does in going through a larger pipe, where it simply runs river-like along the bottom of the pipe.

**What size of pipe is usually used between the house and the main sewer?**

Five-inch and six-inch pipe is generally used when a four-inch soil pipe is used inside the house, and larger sizes when the house pipe is more than four inches.

- ✓ What kind of pipe is generally used between the house and the sewer?

Glazed tile is generally used, and on the best work cast iron pipe is also largely used.

- ✓ How should the drain pipe enter the main sewer?

Above the center, to prevent the setting back of sewage in the house drain, and into a Y branch fitting, so that sewage from the house may more easily take the direction of the sewage in the main sewer.

- ✓ What precaution should be taken in running drain pipe?

After each joint is laid, a swab should be run through the pipe to take off any loose cement that may have squeezed through the joint. A lath is also effective in cutting off this superfluous cement.

**What is a cesspool?**

A cesspool is a receptacle sunk below the surface of the ground for the purpose of receiving sewage, where it is impossible or impracticable to enter a system of sewers.

**What precautions should be taken in locating the cesspool?**

It should be so located that the liquid leaching from it into the surrounding soil, may not contaminate the water supply, or leach into the cellar of the house. This would ordinarily necessitate locating the cesspool at a distance from the house, and if the latter is situated on an incline, the cesspool should be located at a lower point than either the house or the well.

**Describe the construction of the leaching cesspool.**

When properly made, the cesspool is usually built of rock or brick, firmly put together, but with loose, uncemented joints, the top being narrowed down so that it may easily be covered over. Earth is banked up around it so that the surface water may be led away. The inlet should project into the cesspool, so that solids may not drop from its end upon the sides.

**Describe the working of the cesspool.**

The joints being loose, the liquid portion of the sewage leaches into the surrounding soil, leaving behind

the solid matter, which should be removed from time to time. When the joints become filled, so that the leaching process does not proceed easily, or when the surrounding soil is thoroughly saturated, the cesspool should be removed to another point, or an overflow should be provided to a second cesspool.

**Should the cesspool be vented, and why?**

It should be vented in order that gas may not accumulate and back up into the house.

**Where the cesspool is used should the main trap and fresh air inlet be used or not, and why?**

These matters should be treated in the same way when the house enters a cesspool, as when it enters the sewer. It is our belief, however, that the use of the main trap and fresh air inlet is desirable.

## FRESH AIR INLET.

What is a fresh air inlet and what is its use? ✓

The fresh air inlet is a line of pipe run from the house side of the main trap and opening into the outer air. The use of this pipe is to prevent air lock between the fixture traps and the main trap, to bring into the system a supply of fresh air, and to aid in creating a circulation of this air through the plumbing system.

What should be the size of the fresh air inlet?

It should never be less than four inches when the main soil pipe is four inches. In most cases this size is large enough even though the main pipe is larger.

Why would it be wrong to take the fresh air inlet from the sewer side of the trap?

Because it would not only fail to prevent air lock but would not create a circulation of air through the system, and would vent the sewer in a dangerous place.

Where should the fresh air inlet enter the building?

Through the cellar wall at a point as far removed as possible from windows, doors, and cold air box to the furnace.

How far should the outer end of the fresh air inlet be carried from any door, window, or furnace box?

Fifteen or twenty feet if possible. This frequently necessitates running out into the yard or lawn before coming up through the ground.

Is the fresh air inlet used on systems having no main trap?

It is not, for the reason that in such a case there is a circulation from the sewer through the roof, and no danger of air lock. Moreover, if used on systems having no main trap, it would ventilate the sewer in a dangerous place.

Should drainage ever be entered into the fresh air inlet?

Never.

What effect does the fresh air inlet have upon the evaporation and cooling of the main trap seal?

By bringing in air upon the seal it increases evaporation and tends to cool the water in the trap, so that freezing is more apt to occur.

Why are bends in the fresh air inlet a benefit?

They make the entrance of air upon the trap seal less direct and therefore lessen the liability of freezing.

Describe the different ways in which the fresh air inlet is taken off the main pipe, and how run.

It is often taken from the vent hub of the trap, sometimes from a T next to the trap, and sometimes from a Y and bend next to the trap, the latter being the better plan, as it brings the air in less directly. This course is fast being adopted in the principal cities. It is sometimes carried up through the roof.

Why is it often poor policy to carry the fresh air pipe through the roof?

If there is only one stack in the house and that is four inches, the weight of air in that stack and in the fresh air inlet may balance each other, with the result that there is a poor circulation or none at all.

With the main trap not vented, what might be the effect upon the action of syphon water closets in the house?

Owing to air lock, syphonage would be very uncertain, and there would very likely be disagreeable gurgling sounds when there was a discharge from fixtures.

## WATER CLOSETS.

Name different kinds of water closets that are considered sanitary.

The washout water closet, the washdown, syphon, syphon jet, washdown-syphonic action water closets, and lowdown styles.

What qualities should a sanitary water closet possess?

It should be well trapped; the trap should have a good seal; all surfaces exposed to soil should be well scoured; the flush should be abundant, and noiseless, without undue waste of water. The trap seal should not be hidden, and no mechanical devices should be used with the exception of the tank, in the action of the water closet.

Why should cistern or tank water closets be used?

In order that there may be no direct communication between the water closet and the house drinking water, also that a better flush may be supplied.

Explain the action of the syphon water closet.

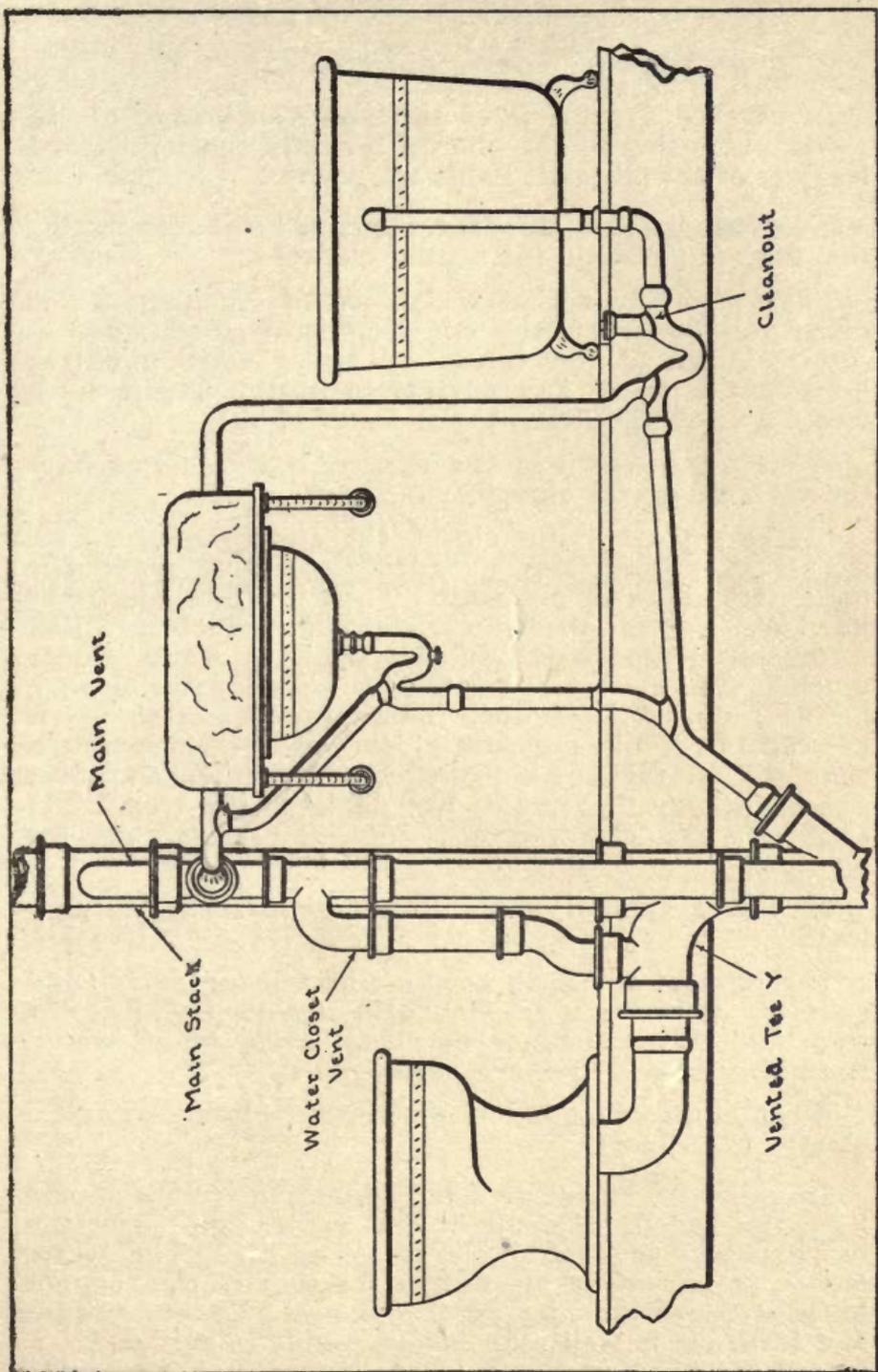
An explanation will be found under "Syphonage."

Name some of the advantages of the modern styles of water closets over the old styles.

Dead ends that are neither supplied with ventilation nor water, are avoided. Sections of pipe that in the old closets between trap and bowl, were unprotected, in the new closets are covered with water; a better flush is secured, better ventilation, and a greater degree of cleanliness, with less odor.

How are modern water closets set?

The best plan is to use a brass flange to which the lead bend is soldered, using a rubber gasket between the flange and the base of the closet. In some cities it is allowable to flange the lead bend off on the floor, and to use a ring of putty between the closet and the lead for the joint.



PLUMBING FOR BATH ROOM.

**Why is the latter course objected to?**

In case of a settling of the floor, shrinkage of the wood, or rotting of the floor, a break in the joint and a leakage of sewer gas is liable to follow.

**Why are rubber ells recommended for connecting the flush pipe with the water closet?**

They do away with the liability of cracking, which often follows when the coupling is of metal, and is rigid. When of this latter style, any settling of the house or floor, or any movement of the fixture itself will crack off the horn of the water closet.

**What advantage has the syphon water closet over the washout water closet?**

In the syphon water closet, the energy of the flush is exerted without loss, producing complete syphonage under atmospheric pressure. This, in addition to the bowl wash, gives the trap a cleansing which no other water closet receives. In the washout water closet, much of the energy is wasted in removing the deposit before the trap is reached. This same loss of energy is noticed in the old pressure closets, where the water is sent around the bowl. It effects the bowl, and does good work at that point, but neglects the trap. The syphon water closet is also more noiseless than the washout.

**Why is a syphon water closet comparatively noiseless?**

The inlet of the flush to the closet being sufficiently submerged, meets a resistance in the deep seal of the trap, and this resistance or check being under water, the noise is in a measure destroyed.

**What is the objection to dark water closets or water closets in cellars?**

Every water closet or other plumbing fixture should have the benefit of sunlight and ventilation. The sun in particular is destructive to germ life. The water closet, or any plumbing fixture for that matter, cannot be kept too clean and pure, and a supply of sunlight and fresh air is well nigh indispensable to this end.

**Why would an unvented water closet be more apt to syphon if at considerable distance from the stack?**

With the long line of horizontal pipe the waste would move slowly, and a slight obstruction in the pipe might cause the water to set back sufficiently to fill the pipe and trap, and when this volume of water finally moved off, syphonage would be very liable to occur.

**Why should water closets situated near the stack be vented?**

If there were fixtures on the floor above, a heavy fall of water from them would to a certain extent exhaust the air in the stack as it passed down. The air in the stack not following so fast as the water, this partial vacuum is not supplied with air quickly enough to prevent a few drops of the water closet seal being forced out by atmospheric pressure. If this is continued for a long time the entire seal will be destroyed.

**Is it necessary to vent a water closet that is situated on the top floor, close to the stack, with the stack passing through the roof?**

It is not, for there is nothing to produce syphonic action.

**How would you decide which valve was leaking in a water closet tank, with both valves under water?**

As a rule, if the tank was full, with the ball submerged, and running into the overflow of the tank, the supply valve would be the one to look to, but when there is a leak through the closet, with the tank only partially filled, the flush valve should receive attention.

**Why should not an earthen water closet be salted, and what should be used?**

In the case of earthen water closets, the salt is liable to pass through the earthen bowl and show on the outside. Parafine oil should be used.

**At what height should water closet tanks be set?** ✓

As near six feet from the floor to the bottom of the tank as possible, for the best results.

**What should be the size of water closet tanks?**

The seven-gallon tank is the best size, although many use the five-gallon tank.

**In what other ways is the flush tank operated besides by the pull and chain?**

By the weight of a person on the seat, and by opening and closing of the door. These methods are used principally in public buildings, to avoid dangers arising from the use of the closet by ignorant persons who do not understand the principle of modern plumbing work.

**How large a space should be required for a water closet?**

Although a good, liberal room is always desirable, where there is a shortage of room a space two feet by four feet is as small as should be considered.

**Why should water closets be prohibited that are not exposed to the sunlight?**

No plumbing fixture should be located where sunlight never enters, for the sun's rays are the best possible destroyers of almost all kinds of germ life.

**How does the low-down water closet act?**

In the low-down water closet we do not have the benefit of the head of water that we have in the ordinary tank closet. To overcome this, it becomes necessary to increase the size of flush pipe in order to produce syphonage in the closet. With this increased size, even though we do not get the head as from the elevated tank, we are enabled to quickly throw a quantity of water into the closet, sufficiently great to fill the trap, and thus make the syphon operative.

## LOCAL VENTING.

✓ What is a local vent? ✓

A local vent is a line of pipe connected at the rear of the water closet and under the seat, for the purpose of carrying off the noxious odors incident to the use of the fixture.

Is the local vent strictly a sanitary measure?

It is not. No ill effects result if it is not used, and it is put in simply for the sake of comfort.

What material should be used for local vents?

Copper or galvanized sheet iron is usually used.

Where should the local vent be carried?

Into a heated flue if possible, above all openings. If there is no heated flue at hand, then through the roof.

Why is it better to enter the local vent into a heated flue than to carry it through the roof?

The heat of the flue creates a circulation by aid of which the odors are carried at once into the open air through the chimney. If carried through the roof the upward tendency is small, and often the tendency will be downward.

Why should the local vent enter the flue above the highest opening?

Otherwise the foul air might be driven through some chimney hole into other rooms of the house.

What are the two principal methods of running local vents where there are a number of closets in the house?

One method is to carry each vent separately from the water closets to the flue. Another method is to run the several vents into one main local vent, which is carried into the flue.

What advantages are claimed for the method of separate vents?

Where each vent branches into one main vent it is very often the case that noises, conversation, etc., can

be overheard in different parts of the house. When this method is followed, especially in double tenement houses where closets back up to each other on opposite sides of the partition, the germs of contagious diseases may be carried through this vent from one tenement to another.

**In what way is a draught sometimes created for the local vent?**

If there is no heated flue at hand, or if the vent has to be carried through the roof, a gas jet can be kept lighted at the bottom of the vertical pipe. This warms the air and creates an upward draught.

**What sizes of pipe are permissible for local vents?**

Not less than two-inch pipe should be used for a single water closet. Where two, three, or four vents enter a main vent, the latter should be increased to at least three-inch.

**Name some general requirements of local venting.**

Pitch all vents toward the fixtures they serve in order to take care of any condensation, and to assist the draught; use as few turns as possible.

**How should chimney connections of local vents be made?**

The local vent pipes should run either into a piece of cast iron pipe, or a copper pipe, as they will not rust out. This piece of pipe should be cemented into the chimney. Care should be taken that the pipe does not project beyond the inner face of the chimney, as soot might eventually partially or entirely close the end.

## **SOLDER, SOLDER JOINTS, ETC.**

**What is solder?**

Solder may be called a cement, and is used for joining various metals together, such as tin, copper, lead, etc.

**Of what is solder, used by plumbers, composed?**

It is composed of lead and tin in different proportions, according to the purpose for which it is used.

**Give the proportions of different solders used in plumbing work.**

Wiping solder, 3 parts lead, 2 parts tin.

Bright solder, 1 part lead, 1 part tin.

**Are the above proportions definite in the case of wiping solder?**

No, each plumber will temper his solder to suit himself—some working it finer than others.

**What is a good test for wiping solder?**

A good test in general is to pour a little of the melted solder upon a cold surface. If it cools, leaving a mottled appearance, it is about right, if it leaves a granulated appearance, it is too coarse, or if a very bright appearance, too fine.

**Give the melting points of the two solders named above.**

Wiping solder melts at about 450 degrees; bright solder at 375 degrees.

**What are the melting points of lead and tin?**

Lead melts at 612 degrees; tin melts at 442 degrees.

**Why does overheating spoil wiping solder?**

It burns out the tin, since tin is consumed at a lower temperature than lead. This makes the solder too coarse.

**When solder sticks to the wiping cloth, what does it show?**

It shows that there is too much tin in the solder.

**What is the result if solder contains too much lead?**

The solder will be coarse, and the joints liable to be porous.

**What is the result if the solder contains too much tin?**

The solder will be too fine, will stick to the wiping cloth, and will run off from the underside of the joint, making a good joint a difficult matter.

**When the cloth scratches in wiping, what should be done?**

Rub into the cloth a little powdered chalk.

**How should a joint be treated after it has been wiped, to give it a mottled appearance?**

While it is cooling, blow upon it. Many spit upon it while they are blowing, with a sort of spray.

**What is the proper width of a 4-inch joint?**

About  $1\frac{1}{2}$  inches.

**In case of a rough place on a joint so situated that it cannot be rewiped, how can it be smoothed up?**

With a hand torch, it can be softened, and the imperfect part be wiped over.

**How should a bursted lead pipe be wiped?**

With a soft dresser, carefully beat back the extended pipe, until it has been reduced to its original shape, and the burst is entirely closed. Then properly soil and scrape as large a surface as the joint is to cover, being careful to extend it where the pipe has not been strained enough to injure it. After greasing, a good joint can then be wiped, in the shape of a patch, which will make the pipe at this place stronger than ever.

**What substances make wiping solder worthless?**

Zinc particularly, and antimony also.

**What method is followed in purifying solder in which these substances are present?**

Heat the solder to a high temperature (red hot) and add sulphur. The sulphur combines with these im-

purities and causes them to rise to the surface, where they are skimmed off, after which a little rosin is thrown in.

**Why should wiping solder be well stirred when being used or made?**

The tin being much lighter than lead, tends to rise to the top, leaving the lead at the bottom.

**Why is grease rubbed on pipe that has been scraped, previous to wiping?**

The grease closes up the pores of the lead, thus preventing the bright surface from oxidizing, which action would occur in a short time, and would prevent the perfect union of solder and lead.

**How would you restore solder that had been purified by heating to a high temperature?**

By adding tin.

**What is the usual length of wiped joints?**

Usually  $2\frac{1}{4}$  or  $2\frac{1}{2}$  inches.

**What are the proportions of branch joints?**

A good rule is to measure one inch in each direction.

**Explain the manner in which a joint is prepared for wiping.**

After the two ends, or the branch and the main pipe, have been fitted, the pipes are scraped until the surface which the joint is to cover is bright. Grease is then rubbed onto the bright lead. Around the outside limits of the joint, soil is either put on, paper pasted on, or other means adopted for preventing the solder from catching on the pipe beyond the joint.

**What are cup joints?**

Cup joints are made by flaring one end of the pipe, dropping the end of the other pipe into this flaring end, and dropping solder into the space thus formed.

**What is an overcast joint?**

An overcast joint is one made in the shape of a wiped joint, but made with a soldering iron.

**How is wiping solder tested for the proper heat?**

Plunge a piece of dry pine or a piece of paper rolled up, into the melted solder. If it chars quickly the solder is hot enough to work, and should be watched closely from time to time, so that it may not become too hot.

**How is ornamental work wiped onto sheet lead or lead pipe?**

First cover the work with soil, then mark out such figures as it is desired to show. After scraping and applying tallow, wipe over the surface with rich solder.

**Why is the top part of a joint wiped first?**

The tin being easier to melt than the lead, is naturally kept in a more fluid condition, and by continually piling on the solder around the top part of the joint, the lead by preference hangs, or sticks, while the more fluid part of the solder, which is the tin, runs to the bottom. The result is that the solder at the top of the joint becomes coarser and sets quicker, and should be wiped first. It will be noticed that the bottom of a joint is apt to be brighter than the top, and frequently a little teat will form at the lowest point.

## HOT AND COLD WATER SUPPLY.

How high can water be raised by atmospheric pressure?

Theoretically, a little more than thirty-three feet, but practically, the friction of the pipes, bends, etc., tends to reduce this height, so that it is not usually safe to count on more than twenty-eight feet, and sometimes not more than twenty-five feet.

✓ Describe the method of supplying a cistern hot water boiler.

This style of boiler receives its supply from a tank situated above the boiler, usually in the attic.

✓ Describe the method of supplying a pressure hot water boiler.

This boiler is supplied directly from the city water main. Being usually under a very heavy pressure, it must be made extra strong.

Which hot water boiler is more susceptible to syphonage, and why?

The pressure boiler is more likely to syphon, and for the following reason: The boiler is always at a point higher than the street main.

What is a vacuum valve?

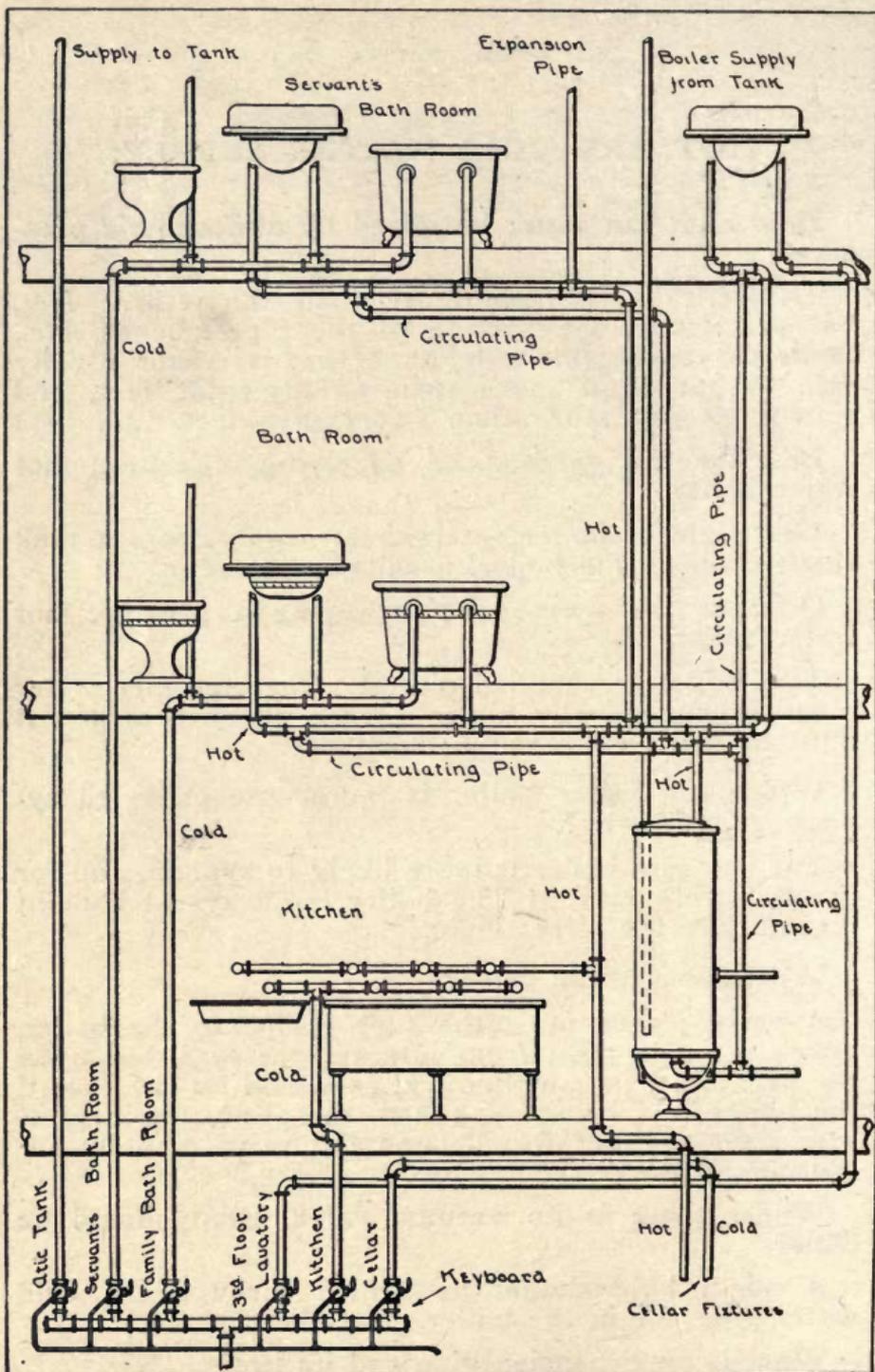
A valve placed upon the supply pipe to the boiler, which is made tight from internal pressure, but upon the pressure being withdrawn, as would be the case if the boiler was being syphoned, the atmospheric pressure from without would open the valve, and by admitting air break the syphon.

Where there is no vacuum valve, what should be done?

A small hole should be drilled through the cold water pipe within the boiler, near the top.

What is an expansion pipe and its use?

In plumbing, it is a pipe taken from the highest point on the circulation and led above the source of supply,



TANK SUPPLY SYSTEM FOR RESIDENCE, WITH CIRCULATION AND KEYBOARD.

with its end over the tank, or above the roof. Its object is to relieve the boiler from any undue pressure that may arise.

**Why does a boiler collapse?**

By letting cold water suddenly into a hot boiler, a sudden contraction of the water takes place, leaving a partial vacuum, and with the resistance within removed, the pressure of the atmosphere from without crushes in the sides.

**What is the advantage of a circulating system on the hot water?**

By a continuous circulation the water in passing the fixtures is hot. Otherwise the cold water would have to be drawn out of the pipes whenever a faucet was opened, before hot water could be secured.

**At what intervals should half-inch pipes be clipped up where there is no other support?**

Once in eighteen to twenty-four inches.

**Name different ways of securing a water supply in the country.**

By gravitation, syphonage, hydraulic ram, windmill, steam pump, and house pump.

**For what reason is compression work preferable to self-closing or Fuller work?**

By the slow closing of compression work there is less danger of water hammer than in the quick closing of self-closing and Fuller work.

**If street pressure is not sufficient to force water to the top of the house, how can the result be accomplished?**

By means of the water lift or pumping engine.

**In running circulation, how should the pipes be arranged?**

Hot water pipes should be above and cold water pipes below.

**Where should the return pipe be connected on a street pressure circulating system?**

At the bottom of the boiler.

**How should lead pipes be supported?**

By strips of board where possible, to prevent sagging.

**What should be the relative difference in temperature to insure good circulation?**

Although the slightest difference in temperature creates a circulation, to be really practical, there should be a difference of seven degrees.

**How should hot water pipes be distributed?**

In piping the kitchen boiler it is a good plan to run the pipes to the kitchen sink first, making the other fixtures secondary, the kitchen sink being the most important fixture in the house. The laundry tubs take second place in line of importance, and where it can be done, it is well to run independent lines to these two points as direct as possible.

**Where and how should water pipes be run within the house?**

If possible, all pipes should be centrally located, and near a chimney that is in use, on account of the warmth thus obtained. Where it is found necessary to run pipes on the outer wall, a board should always be placed between the pipe and the wall to prevent pipes from being frosted as well as to have a place to fasten the pipes.

**What is the object of a sediment cock on the boiler, and where is it placed?**

It is used in emptying the boiler for repairs, or in drawing off the sediment that has collected in the bottom of the boiler. It is connected into the cold water pipe between the boiler and the range. Very often the end of the sediment cock is connected by a waste pipe into the drainage system.

**What is the object of the double boiler?**

To furnish hot water at a greater height than it can be carried by the city pressure, as well as to furnish it to the lower floors.

**What means are employed to protect pipes from frost?**

Where pipes are outside of the house in an exposed place, they may be kept from freezing through the winter, even though they are above ground, by first building a box the length of the pipe exposed, and filling it with horse manure, then laying the pipe through it. The heat of the manure will last through the season. Short pieces of lead pipe can be protected to quite an extent by imbedding them in rosin. Sawdust is also very good if it can be kept dry. In running pipes through the ground they should be covered first with sand. This is a much better protection than clay or gravel. In running long lines of pipe in the country, one of the best protections possible is to lay it at the bottom of a running stream. In running through grass land, it is safe to place the pipe a foot nearer the surface than in the street.

**What causes the chattering frequently heard when a faucet is opened?**

It is the vibration of some part that is loose within the faucet. Oftentimes it is simply the packing that is loose.

**Why is the cold water pipe taken to the bottom of the boiler through a tube?**

That the cold water may at once be taken to the coldest part of the boiler, and not mix with the hot water.

**What precautions are sometimes taken with pipes running between floor and ceiling, to prevent damage from bursts and condensation on the pipe?**

They are sometimes laid in lead or tin troughs.

**Why does the flow pipe give out oftener than the return?**

The constant expansion and contraction in the flow pipe, due to heat, weakens the pipe in time, and even at a constant heat, where there is no expansion or contraction, a heated pipe is not as strong as a cold one.

**What is the usual cause of the bursting of a water front?**

Stoppage, due to the collection of rust, is probably the most common cause.

**Why should a room holding the tank that supplies the house with water, be ventilated?**

Water very quickly absorbs any impurities that may be in the air, and ventilation, of course, is an efficient means of purifying the air of a room.

**What is a good size for the supply tank to the cistern boiler?**

A good size is twenty-four inches, by sixteen inches, by fifteen inches.

**To pipe range boiler when range is on floor above boiler.**

The location of range above boiler is to be avoided whenever possible, as such an arrangement is directly opposed to the principles of circulation. Where obliged to make such connections, the following will give good results. Carry the flow pipe from the range as many feet up as it is desired to drop below the water front in inches, the pipe forming a loop. It is not usually possible to carry the pipe as high as this, but the nearer such height can be obtained, the better the result. At the top of the loop an air cock should be placed, or a pipe connected leading to some nearby fixture. To supply the house fixtures, it is well to take the supply from the top of the loop.

#### **Leading small pipes.**

In leading a joint, particularly if on small pipe, always put the lead onto the male end rather than inside the fitting. If otherwise, the lead is liable to be forced into the pipe and obstruct the opening. Many times a small pipe is completely closed up by carelessness of this nature.

#### **Water hammer.**

This is a very common trouble and it may arise from a number of causes. The most common cause is a sag in the flow pipe, which should always have a constant rise. Water hammer may be caused by an obstruction in the pipe, which may result from rust, dirt, the gasket in a union, etc. Very often the water front becomes choked up with rust and sediment. Still another matter to be considered is the relative size of range and boiler, as too much heating surface is liable to

raise the temperature to the steam point, when hammering is apt to be caused. In the latter case a temporary relief may be obtained by opening the hot water faucet at one of the fixtures, thus allowing a sufficient quantity of cold water to enter the boiler to reduce the temperature. Often relief can be obtained by running a line of circulating pipe above the boiler.

## PUMPS.

**Explain the action of the ordinary suction pump.**

When the pump boxes are raised in the barrel of the pump, they exhaust the air to a certain extent, leaving behind a partial vacuum. When this happens there is nothing to counteract the atmospheric pressure, which is exerted on the surface of the water in the well. This pressure at once forces water up into the pump, from which it passes out through a spout.

**What are the pumps most commonly in use?**

The suction pump, the lift pump, and the force pump.

**Theoretically, how high can water be drawn by suction?**

A trifle over thirty-three feet.

**Practically, how high can water be drawn by suction?**

Not much over twenty-eight feet, and very often circumstances will not allow it to be drawn much over twenty-five feet.

**What causes make this difference in the height to which water can be raised?**

At the sea level, atmospheric pressure is greater than at the top of a mountain. Then too, the pump boxes are not so perfect as to leave a perfect vacuum, and atmospheric pressure is counterbalanced to some extent by the friction of the water on the pipe, by bends in the pipe, and by long horizontal runs.

**Can water be drawn from as great a depth on a high elevation as on a lower one, or not, and why?**

It cannot be drawn so great a distance, for atmospheric pressure is less on the higher elevation.

**Explain the action of the lift-force pump.**

In this pump there is a check valve opening upward in the delivery pipe. There is also a valve in the piston. As the piston travels up, a partial vacuum is created, and water enters the pump as in the case of

the suction pump described above. When the piston travels down, it compresses the water, thereby closing the lower valve and forcing the water through and above the piston. As the piston now travels up, the weight of the water closes the piston valve and the water is lifted. The lifting of the water forces open the check valve in the discharge pipe which has been kept closed by the weight of the water standing in this pipe. The water which has been lifted, is now forced through this check valve into the discharge pipe. As soon as the force which keeps open this valve is withdrawn, the weight of water in the discharge pipe keeps the valve closed until water is again raised on the next stroke.

#### **Explain the action of the force pump.**

In the force pump as in the lift-force pump, there is a check valve in the delivery pipe, but the piston of the force pump is solid. Water enters the pump by means of suction. When the piston travels down, it closes the lower valve and compresses the water in the pump, forcing it into the discharge pipe, and forcing the check valve open. When this pressure is withdrawn, the weight of the water closes the check valve until compression again forces more water into the discharge pipe.

**Name different ways in which a water supply may be procured where there is no city pressure.**

By means of gravitation or by means of syphonage from a spring or other supply above the point of delivery; by means of the hydraulic ram, when the source of supply is lower than the point of delivery, and a fall can be secured from the source of supply to the ram; and by means of the pump worked either by hand, by windmill, or by engine.

#### **What is the purpose of the air chamber?**

The purpose of the air chamber is to destroy the shock on the supply pipes occasioned by the sudden opening and closing of valves.

**In what way does the air chamber prevent this shock?**

Water is nearly non-compressible, but air is compressible. Consequently, when a column of water

strikes an air cushion such as the air chamber really is, the air contained in it compresses somewhat, using up thereby the force of the water.

✓ **How may an air chamber be destroyed?**

Unless the air in an air chamber is occasionally renewed, each successive discharge of water results in the absorption of a small portion of air by the water, which is carried out with the discharge, and thus lost. In time, the air chamber will completely lose its air.

**How may this fault be remedied?**

By placing an air cock in the bottom of the air chamber. Occasionally the water should be shut off, and the water which has taken the place of the air in the air chamber, drawn off through this cock. When this has been done, air fills into the chamber through the cock, which may then be closed.

**When is the deep well pump required?**

When the supply is more than twenty-five to twenty-eight feet below the surface.

**What are the chief differences between deep well and surface pumping?**

As previously stated, water cannot be drawn by suction much over twenty-eight feet. Consequently in the deep well pump, the working parts of the pump, that is, the barrel and the valves, must be placed below the surface, so that they shall be within about twenty-eight feet of the supply. The deep well pump must furthermore be a force pump in order to send the water above the surface to the point of delivery. In surface pumps, that is, where the point of delivery is not over twenty-eight feet from the supply, the suction pump may be used. With the surface pump, it does not much matter whether it is directly over the well or at a distance, but in the case of the deep well pump, it must be directly over the well, in order that the pump rod may be worked. Owing to the heavier work that it is called upon to perform, the deep well pump is usually made much stronger and heavier than the surface pump.

**Explain the main principle on which the hydraulic ram acts.**

The principle is, viz.: If a quantity of water is set in motion down an inclined tube, and its escape from the

lower orifice is suddenly stopped, the momentum of the moving mass of water drives up a portion of its own volume to an elevation much higher than that from which it first descended.

**Describe the mechanism of the hydraulic ram.**

From the spring or pond which acts as the supply, a pipe called the drive pipe is laid downward to the ram. As the water rushes down this pipe it endeavors to escape through a weighted valve, but its passage is suddenly checked, with the result that the momentum stored up in the water of the drive pipe, forces a considerable amount up into the air chamber and into the delivery pipe, which is supplied at the bottom with a check valve, as in the force pump. The proper working of the weighted valve makes the ram self-acting. To accomplish this result, the valve is loaded with a weight just great enough to throw it off its seat, when the water in the drive pipe is at rest, so that when there is additional force exerted, the valve closes.

**Only in what location is the hydraulic ram applicable?**

Only when the ram can be located below the supply.

**Is the hydraulic ram economical in the use of water?**

It is not, and is used generally only in places where the waste of water is of no moment.

**On what does the work which a ram can perform, depend?**

On the amount of fall between the source of supply and the weighted valve of the ram.

**What is the least amount of fall necessary to the working of a ram, and what fall is usually preferable?**

A fall of only sixteen or eighteen inches is sufficient to operate the ram, but a fall of five to ten feet is preferable.

**What are the relative sizes of drive and delivery pipes for the hydraulic ram?**

The delivery pipe is usually of only half the diameter of the drive pipe.

**What is the height to which the ram will deliver water, and the amount?**

The ram, when properly set, will deliver about one-seventh of the water issuing from the source of supply, to an elevation five times as great as the distance from the source to the valve, or one-fourteenth to an elevation ten times this distance, and so on, in the same proportion.

**How should the bottom of a suction pipe be arranged in the well?**

The lower end should be stopped to prevent sand from entering, and about four inches from the end holes should be drilled. In some cases a return bend is placed at the bottom of the suction pipe, which gives a downward instead of an upward suction at first. What is termed a mushroom strainer is also sometimes used.

**How would you proceed in repairing a pump?**

The first thing in repairing a pump is to see that the lower box holds water. When this is accomplished, if the pump runs down, it is evident that there is a leak somewhere in the pipe, and we must proceed to find it. By placing the ear to the pipe, after the water has been drawn into the pump, a hissing sound will be heard if there is a leak, which should be traced up. It sounds plainer as the leak is approached. A good plan is to clasp the pipe in the hand. When the leak is covered, the hissing stops. When iron pipe is used, it is much harder to locate the leak on account of the sound being telephoned through the pipe for a long distance, the sound being nearly as distinct at one point as another. With iron pipe, rub soap around each joint until the sound stops. The pump and pipe must always be charged to produce this hissing sound, which is caused by the air rushing in to fill the vacuum formed by the water in dropping. By looking into the top of the pump, bubbles will be seen to rise when pumping, if there is a leak. Having gotten the lower box and pipe tight, if the pump throws a small stream, then look to the upper box, for it is probably worn so that it is too loose, and the water escapes past it. If the brake flies back forcibly, it shows that the pipe is stopped, or that the water cannot be raised so far.

### Describe the construction of a driven well.

Fasten the point to a short piece of pipe provided at one end with a cap firmly screwed on. After boring with the auger to a convenient depth, place the point in the hole. Now let the helper rest a piece of timber on the cap to take the blows of the sledge used in driving down the pipe. When the pipe has settled into the ground sufficiently, screw on another short length of pipe. The pipe should be often turned with the tongs, to keep it loose in the ground. As water is reached, the pipe generally drives more easily for a short distance, when the driving becomes difficult again, because of the hard pan which generally lies below each vein of water. When this is reached, drop a plumb bob into the pipe and note the depth of water by the moisture on the string. If the vein of water is not of sufficient depth, then drive down to the next vein, which is liable to be some ten feet lower, although this depth would differ in different localities. When sufficient water has been found, attach an old pump to the pipe, and pump out the sand until sufficient clean gravel has collected about the point to act as a strainer and protection for the point. The iron pump with a round seat for the lower valve is the best pump for this use, because there is less opportunity for sand to lodge in the valve.

## **THEORY.**

### **What is atmospheric pressure?**

As usually spoken of, it is the pressure exerted by the atmosphere on an area of one square inch, or, in other words, it is the weight of a column of air one square inch in cross section. At the sea level this column of air, that is, the earth's atmosphere, is computed to be about forty-five miles deep, giving a pressure of fifteen pounds per square inch.

### **Why is the atmospheric pressure less at the top of a mountain than at the sea level?**

Because the depth of the atmosphere is necessarily less at the top of the mountain.

### **How does atmospheric pressure affect the boiling of liquids?**

The temperature at which a liquid boils, rises as the atmospheric pressure increases. Therefore water will boil at a lower temperature at the top of a mountain than at its base.

### **How does atmospheric pressure apply particularly in plumbing work?**

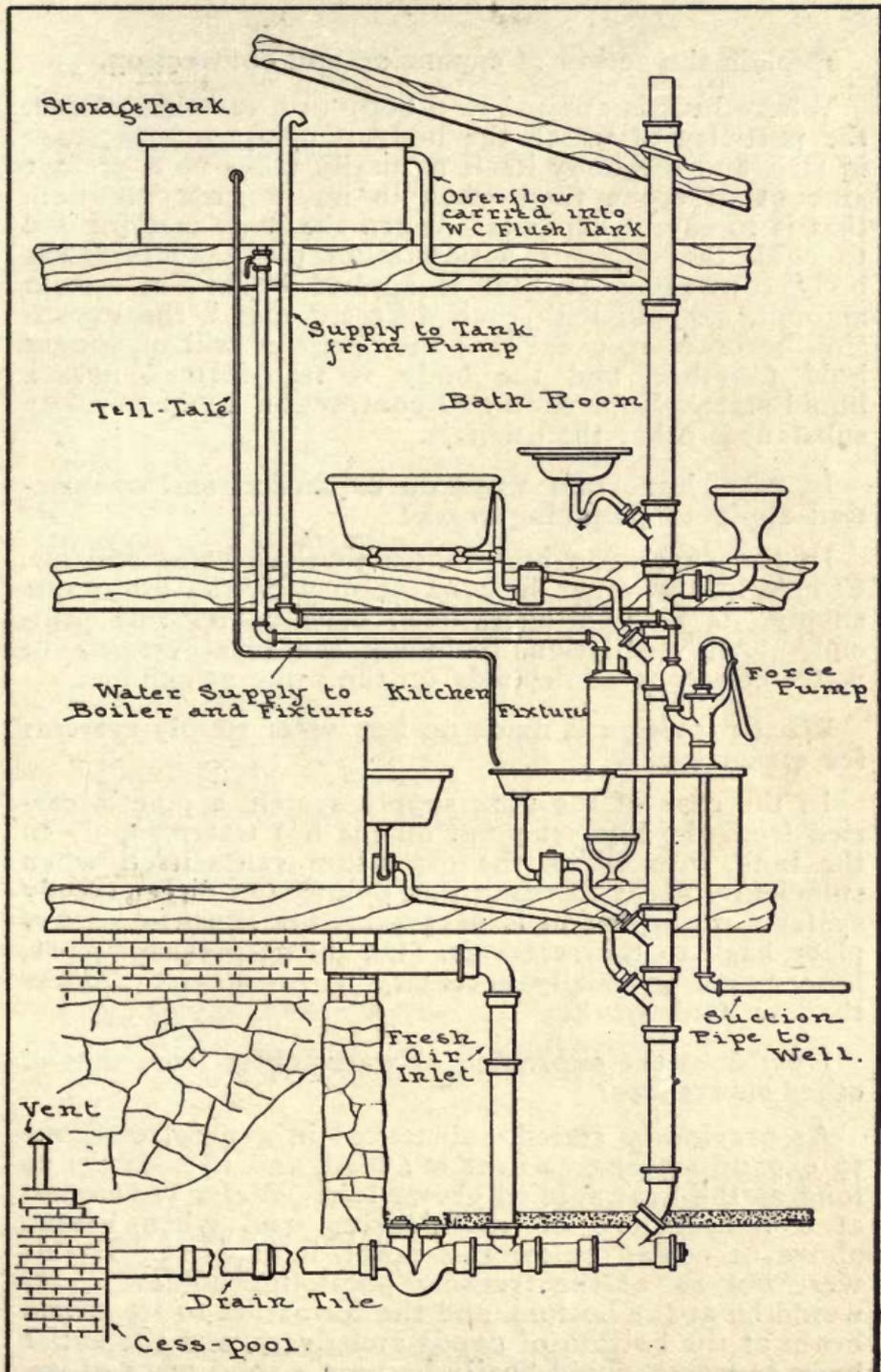
It applies in pump work, and whenever syphonic action occurs, also on certain devices acting in the manner of the vacuum valve.

### **Describe the vacuum valve.**

The vacuum valve under normal conditions is closed by the pressure of water from within. When a vacuum forms within the vessel to which the valve is attached, the pressure of the atmosphere exerted on the outer face of the valve, forces air into the vessel, thus breaking the vacuum, and preventing disastrous results which might otherwise occur.

### **What is meant by a pressure of one atmosphere?**

A pressure of one atmosphere is a pressure of fifteen pounds. In like manner a pressure of four atmospheres would mean a pressure of sixty pounds, etc.



COUNTRY PLUMBING—DRAINAGE SYSTEM UNVENTILATED.

**Explain the action of expansion and contraction.**

Where heat is applied to a body of a metallic nature, the particles of which the body is composed, increase in size, and the body itself naturally takes up a greater amount of space than when in its normal condition, that is to say, it expands. When the body is subjected to cold, the opposite action takes place, that is, the body contracts. If heat is applied beyond a certain amount, varying with each different metal, the expansion becomes so great that the particles will no longer hold together, and the body is transformed into a liquid state. Expansion and contraction apply to many substances other than metals.

**In what important ways do expansion and contraction apply to plumbing work?**

In the expansion and contraction of water and air. Circulation, whether in connection with the hot water supply, or heating operations, depends on this principle. All ventilation, including the local venting of water closets, also depends on the same principle.

**What provision is made on hot water supply systems for expansion?**

In the case of the tank supply system a pipe is carried from the highest point on the hot water supply to the tank, into which the expansion vents itself when sufficiently great to reach this point. On direct supply systems no provision is necessary, for expansion takes place back to the reservoir. On direct pressure work, however, it is usually necessary to use heavier boilers than on tank work.

**How does the expansion of water differ from that of other substances?**

As previously stated, substances in general continue to expand as long as heat is added, and to contract as long as the heat applied grows less. Water is heaviest at a temperature of 39.2 degrees, and when heated above or cooled below this point, it expands. If this were not so, at the freezing point, the coldest water would be at the bottom, and the formation of ice would begin at the bottom of ponds and rivers, and the entire body of water would finally become a solid mass of ice.

**Does heated air rise or fall, and why?**

It rises, because it is lighter than cold air, that is, it is more expanded.

**In what way is this fact applied in plumbing?**

Local vents from water closets are entered into heated flues, in order that the warm air rising in the chimney may create a draught or suction which will draw out through the vent and into the chimney, the foul odors of the water closet. It applies in ventilation also.

**Is hot water lighter or heavier than cold water, and why?**

It is lighter, because when heated it is more expanded.

**In what way is this fact applied in plumbing?**

The heated water being lighter than the cold, naturally rises. This gives us the fundamental principle of all circulation work.

**What is a vacuum?**

A vacuum is a portion of space from which the air has been entirely exhausted.

**How may a vacuum be formed in plumbing work?**

A stoppage in the waste of a fixture may cause the waste to back up and fill the pipe. When it runs out it may go with a sufficient rapidity to exhaust the air and produce a partial vacuum in the waste, resulting in syphonage. One or more fixtures may throw enough waste suddenly into a waste pipe to nearly fill it, and as this volume of water flows by a branch waste pipe serving another fixture, the air in that branch may be exhausted, forming a partial vacuum. In fact, in every case where syphonage of traps occurs, or the syphonage of boilers, a vacuum must have been formed, and usually in some such manner as we have just shown.

**What is evaporation?**

It is the slow passage of a liquid into the form of vapor.

**What causes increase evaporation?**

Increase of temperature, increased exposure of surface, and wind blowing over the surface.

**In what way is the effect of evaporation felt on the plumbing system?**

In the evaporation of trap seals.

**How does the ventilating system affect the evaporation of trap seals?**

It increases it, by bringing in air upon the seals.

**How does the fresh air inlet affect the evaporation of the seal of the main trap?**

It increases it, by bringing in air upon the seal.

**Which is more affected by evaporation, the drum trap or the S trap?**

The drum trap is affected to a less dangerous degree, for its seal is usually greater, and, in addition, the vent taken from the drum trap usually brings in the air upon the seal in a less direct manner.

**What is condensation?**

Condensation is the passage of a body from the vaporous to the liquid state. It is the opposite of the action of evaporation.

**What provisions are made necessary on the plumbing system because of condensation?**

All fixture vents should pitch toward the traps which they serve, and the main line of vent should be carried into the stack below the lowest fixture, in order that the collection of condensation may be carried off.

**What is distillation?**

It is the separation of two liquids from each other, or the separation of a liquid and substances which it holds in solution. Distillation is formed by heating the liquid and condensing the vapor which is formed.

**What is meant by hydraulics?**

Hydraulics is the conducting and raising of water through pipes.

**What laws govern the pressure of liquids?**

1. Pressure exerted upon a liquid is transmitted undiminished in all directions, and acts with the same

force on all equal surfaces, and at right angles to those surfaces.

2. The pressure at each level of a liquid is proportional to its depth.

3. With different liquids and the same depth, the pressure is proportional to the density of the liquid.

4. The pressure is the same at all points on any given level of a liquid.

**What is the buoyancy of a liquid?**

The pressure of the upper layers of a body of liquid on the lower parts causes the latter to exert an equal reactive force in an upward direction. This is called the buoyancy of the liquid.

**Does the pressure of a liquid depend on the shape of the vessel which contains it?**

It does not.

**What is fluid friction?**

In flowing over any surface, for instance the sides of pipe, a fluid meets with more or less resistance from the surface. This resistance is known as friction.

**What are the laws which govern the friction of fluids?**

1. Friction does not depend in the least on the pressure of the fluid upon the surface over which it is flowing.

2. Friction is proportional to the area of the surface.

3. At a low velocity (not more than one inch per second for water), friction increases with the velocity of the liquid.

4. Friction increases with the roughness of the surface.

5. Friction increases with the density of the liquid.

**Is the friction of water greater in small or in large pipes, and why?**

Friction is greater comparatively, in the small pipe, for a greater proportion of the water comes in contact with the sides of the pipe than in the case of the large pipe.

**How does the compressibility of air and water compare?**

Air is extremely compressible, while water is almost incompressible.

**In what way is the compressibility of air made use of in plumbing?**

In the operation of air chambers.

**In what way is the incompressibility of water made use of?**

In the operation of the hydraulic ram.

**What is capillary attraction?**

Capillary attraction is the power which liquids have of rising in very small tubes to a height above the level of the liquid in which such tubes are dipped.

**In what kind of tubes will capillary attraction take place?**

Only in tubes which the given liquid will moisten.

**Why will not capillary attraction take place in large tubes?**

Because in the large tube there is proportionately a less amount of surface in contact with the water, and in addition, there is a much heavier body of water which this force of attraction must lift.

**Give common examples of capillary attraction.**

The absorption of water by sugar and sand, the rising of sap in trees, the taking up of water by the sponge, etc.

**How may capillary attraction endanger the trap seal?**

If pieces of lint, sponge, or rags lodge in such a manner as to hang over the dip of the trap into the seal, unless soon renewed, the seal will be carried away drop by drop.

**Why does water that has been heated freeze more readily than cold water?**

Because by heating the water the air has been driven out.

Of what is water composed, and what are the proportions?

Water is composed of oxygen and hydrogen; one part oxygen, two parts hydrogen.

What other points are noticeable in pure water?

It is colorless, tasteless, and free from odor.

At what degree does water reach its greatest density?

At 39.2 degrees. It expands from this point, whether it be colder or hotter.

At what temperature does water freeze?

At 32 degrees.

At what temperature does boiling begin?

At 212 degrees.

Does water expand in freezing?

It does.

What force is exerted by frost?

A force of 30,000 pounds per square inch.

Name some freezing mixture.

Two parts of pounded ice and one part of common salt.

Why does the presence of oil in water prevent freezing?

Oil is a poor conductor of heat, and prevents heat from leaving the water.

Why does water burst a vessel by freezing as well as by heating?

At certain temperatures of heat and cold, water expands.

Will water absorb gases, and under what conditions is absorption greatest?

Water will absorb gases, and to the greatest extent when the pressure of the gas upon the water is greatest, and when the temperature is lowest, for the elastic force of the gas is then less.

**Why is water called hard?**

Because it is charged with foreign matter and will not readily dissolve substances immersed in it.

**What makes water hard?**

Generally from being impregnated with sulphate of lime. There are other impurities taken from the earth that have a similar effect.

**Why is rain water soft?**

Because it is not impregnated with the salts of the earth.

**What is the object of filters?**

Filters are designed to clear and purify the water of any foreign substance that may be in it. The most effective filters are of manufactured stone, the water being forced through them under pressure.

**Why does water take a spiral motion when running?**

Because in rubbing against the sides of the pipe, it is diverted from the forward motion, while the water in the center of the pipe flows faster, there being less friction there.

**What is specific gravity?**

Specific gravity is the relative weight of one body to another, which is taken as a standard. For solids and liquids, water is the standard. For gases, air is the standard.

**Of what is air composed, and in what proportions do those elements exist?**

Air is composed of oxygen and nitrogen; about one-fifth oxygen and four-fifths nitrogen. It also contains a small amount of carbonic acid gas.

**Why is it necessary that there should be so much more nitrogen than oxygen in the air, when nitrogen is detrimental to life?**

It is necessary in order to dilute the oxygen. Otherwise fires would burn out too quickly, life would be too rapidly exhausted, etc.

**What is the effect on animal life of oxygen and nitrogen?**

Oxygen tends to assist and preserve life, while nitrogen destroys it.

**How much air is consumed by a person in one hour?**

A human being consumes about 15 cubic feet of air per hour.

**What is centrifugal force?**

It is that force which tends to make the particles of an object that is revolving fly away from its circumference.

**How is centrifugal force applied in plumbing?**

In the centrifugal trap. The inlet being taken off as near a tangent as possible to the body of the trap, gives the waste a swirling motion which thoroughly scours the trap.

**What is gravitation?**

The natural force which tends to draw everything toward the center of the earth.

**What is fusion?**

The passage of a body from a solid into a liquid state, as, for instance, the melting of lead.

**What is a flux?**

A substance or mixture used to help the joining of two metals, as rosin, borax, etc.

**What is an alloy?**

Any compound of two or more metals, as copper and zinc, to form brass.

**What is superheated steam?**

It is steam removed from contact with water, and heated until it resembles a gas, when it becomes dangerous.

**Describe the principle of circulation.**

To illustrate, we will take a piece of ice, and place it so that it is exposed to heat. We would call the ice solid matter, but if we could magnify it or any other

substance sufficiently, we would find it composed of innumerable small particles or molecules, each one in constant motion. Now, as the ice is heated, these molecules commence to expand, and the vibrations increase in rapidity. In a short time these vibrations increase to such an extent that the particles no longer hold together, but separate from the solid, and form water. As the heat continues, expansion also continues, each heated molecule striving to rise, which of course, forces the colder molecules to drop, and fill the space thus left vacant. Up to this point, the action has been exactly what takes place in the circulation of hot water. At last, however, the water has become so heated that expansion is even stronger than atmospheric pressure, the molecules separate from the original mass, and being lighter now than the air itself, pass off in the form of steam. Being lighter than the air, they of course rise, and here again we have circulation, that is, circulation of steam. These principles then, underlie all circulation work.

What should be the relative difference in temperature between the hot and cold particles of water to create a practical circulation?

Seven degrees.

Explain the bursting of lead pipe by frost.

Water expands from 39.2 degrees F. until it reaches the boiling point. Therefore water is at its greatest density at 39.2 degrees F. It also expands in cooling until it reaches 32 degrees F. The water will then remain at 32 degrees, and will gradually solidify until all of the latent heat is extracted, when we have ice, the water having expanded about 9 per cent. during solidification. Below this temperature the ice contracts in volume. This being the fact, in time it releases its hold on the inner surface of the pipe, and the water still remaining in a liquid state, works its way into this space. This again expands as before, and so on, until finally the pipe, which can no longer stand the strain, bursts.

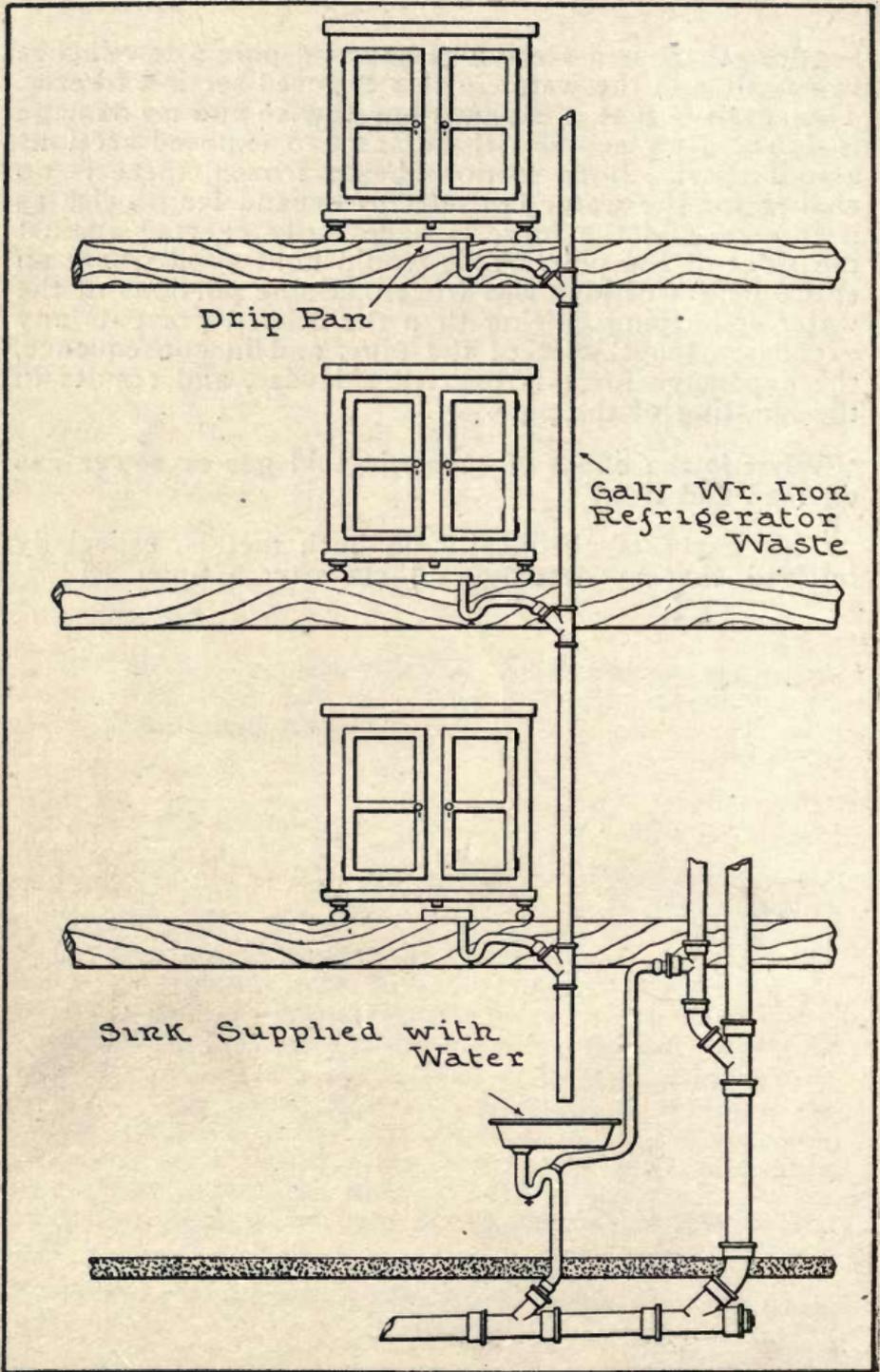
Why does one frosted pipe burst while another does not?

For the reason that the ice in one is allowed to expand, while in the other it is not. For example, we will

suppose there is a section of exposed pipe a few inches in length, and the water in this exposed section freezes. The result is that it expands lengthwise and no damage is done. Now suppose there are two exposed sections a foot apart. Both sections being frozen, there is no chance for the water between to expand lengthwise as it freezes, and the force is necessarily exerted against the sides of the pipe. This would hold good where an entire length of pipe was frozen. Some portions of the water solidifying quicker than the others, prevents any expansion lengthwise of the pipe, and in consequence, the expansive force is exerted sidewise, and results in the bursting of the pipe.

**What is the effect of carbonic acid gas or sewer gas on lead and iron?**

This gas acts chemically on both metals, especially on lead, thereby destroying them after a time.



CONNECTIONS FOR LINE OF REFRIGERATORS.

## SYPHONAGE.

**Explain the syphon.**

The syphon consists primarily of a bent tube, one arm being longer than the other. The syphon is used for transferring liquids from a high point to a lower point. In order to start the syphon, the air in the long arm must first be exhausted. As soon as this vacuum is formed, atmospheric pressure forces the water up the short arm and into the long arm, through which it passes out. This action continues unless broken by other means, until the short arm no longer dips into the water.

**How may the action of the syphon be destroyed?**

By admitting air into the long arm of the tube, not further from the crown of the tube than the length of the short arm.

**In what way is syphonage a great benefit in plumbing work?**

It is the principle underlying the action of many plumbing fixtures and devices.

**In what ways is syphonage a detriment to plumbing work?**

In the syphonage of traps and boilers.

**Name different plumbing devices depending on syphonage for their action.**

The syphon water closet, the waste-preventive urinal, the syphon lavatory, the syphon tank, the automatic tank, the syphon cesspool, and the syphon system of water supply, are among the principal devices.

**Show in what way syphonage is applied to the syphon jet water closet.**

A separate passage runs from the flush entrance to the bottom of the closet trap. Through this passage a powerful jet is forced, whenever the closet is flushed. This jet sends a quantity of water quickly into the outlet or long arm of the trap, where it is retarded by a

bend in the outlet leg. These two causes fill the long arm full of water, and as this passes out, the air is exhausted as we have seen above, atmospheric pressure sends the contents of the closet bowl over, and we have syphonage.

### **Explain the syphon tank.**

At the base of the syphon tank valve, there is a large flap valve connected with the tank lever. When this lever is pulled, enough water quickly enters the flush pipe to fill it, the air is expelled, and the syphon is started, continuing until the end of the short arm is out of water.

### **Describe different ways in which fixture traps may be syphoned.**

The outlet beyond the trap may have little pitch, so that the waste sets back and fills up the pipe. When this finally moves out, it forces the air out, leaving a partial vacuum behind, with the result that atmospheric pressure forces over the contents of the trap. This same result may occur when there is a slight stoppage in the waste outlet. When this gives way and the water passes out, syphonage is liable to occur. Syphonage may also occur from the wasting of other fixtures past the entrance of a fixture waste. If the amount of waste passing through the main is sufficient to partially expel the air, a partial vacuum will be formed, and syphonage will occur.

### **How may a boiler be syphoned?**

The danger of boiler syphonage applies chiefly to the pressure boiler. We may consider the cold water supply from the street main to the boiler as the long arm to the syphon. Now, if there is a bad break in the street, the water, if not quickly shut off, is liable to run out of the supply pipe to the boiler. This leaves a partial vacuum behind, and syphonage occurs.

### **Explain how syphonage may be applied in procuring a water supply.**

In the first place, the spring, pond, or other supply must be at a point higher than the point at which the water is to be delivered. Then, with the short arm dipping into the source, and the line of pipe to the point of delivery acting as the long arm, the syphon

will act as a smaller one would. In starting it, the air in the long arm must be exhausted, and if there are rises in the ground that the pipe must follow, air cocks should be placed at the crown of each rise of the pipe, so that by their occasional use, air lock can be destroyed.

**Can a liquid be syphoned from a lower to a higher point or not, and why?**

It cannot, for the reason that when both arms of the syphon are full, the contents of the long arm being heavier, will not be drawn over by the weight in the smaller arm. In other words, the suction, by means of which syphonage acts, will always be down the long arm, not up.

**How is syphonage prevented in plumbing work?**

By ventilation, or, as it is more commonly called, by back or counter venting.

**Explain the action of the intermittent syphon.**

The automatic syphon tank is nothing more than an intermittent syphon, the great difference between different makes being found in the manner in which the water is retarded in the long arm of the syphon.

**Explain the action of the automatic syphon tank.**

In the intermittent syphon, the supply is constant, and when it has reached the proper height, the water falls over the crown of the syphon, down into the long arm, where the water is retarded sufficiently to produce syphonage. This continues until the short arm is out of water. The supply being continuous, the tank in a given time fills, and syphonage again acts.

## MISCELLANEOUS.

### What is a dead end?

A dead end is a part of the drainage system that is without ventilation. If the entire plumbing of a house is without ventilation, the entire system may be considered a dead end. Strictly speaking, we also consider as a dead end an unventilated projection of main waste pipe beyond the entrance of the branch.

### What is a tell-tale pipe, what is its object, and where should it be carried to?

A tell-tale pipe is usually used where a storage tank is used. It runs up to within a few inches of the top of the tank, with its lower end dripping into a sink or other place that is exposed to view. When water has been pumped into the tank in sufficient quantity, it overflows down this tell-tale pipe, showing to the operator of the pump that the tank has been sufficiently filled.

### What is a by-pass?

A by-pass on the drainage system permits the air from the sewer or cesspool to evade the seal of the trap by passing around it and escaping into the room, instead of passing through it.

### Why should all plumbing be open work?

When enclosed there is more danger of leakages remaining undiscovered, there is always a collection of filth in corners and about the sheathing, no matter how much care is taken, and the air confined in these enclosures is very apt to be impure.

### Why are the lead and iron pipes of a ventilated plumbing system longer lived than those of an unventilated system?

The ventilation prevents the accumulation of gas, carrying it off constantly into the air.

### What is meant by air lock?

The confining of air between two traps. Air lock may occur both on the drainage and on the hot and cold water supply system.

**How should a refrigerator waste be connected?**

A refrigerator should never be connected directly with soil or waste pipes, even though trapped, but should drip into an open pan with an air space between pan and refrigerator. This pan should then be trapped and counter-vented before entering a soil or waste pipe.

**What extra precaution should be used on refrigerator work, in case of evaporation of the trap seal, when the refrigerator is not in use?**

A trap screw should be soldered into the bottom of the pan, to be closed during the months when the refrigerator is not in use.

**How are Ts read?**

Hold the T with the branch up, and the large end to the left. Then read the large end first, small end next, and branch last, as  $1 \times \frac{3}{4} \times \frac{1}{2}$  inch.

**What is the principle of the oxyhydrogen and airohydrogen flame?**

These flames are produced by the mixture of proper proportions of oxygen and hydrogen gases, which mixture is highly explosive. The most intense flame is the oxyhydrogen, but for most work the airohydrogen flame is all that is necessary. It is made by forcing air into the supply of hydrogen at a point near where it is ignited, there being sufficient oxygen in the air to produce the explosive result.

**How can hydrogen be produced?**

Mix one part of sulphuric acid with about five or six parts of water, always pouring the acid into the water, rather than the water into the acid, as there is danger of its flying into a person's face, if wrongly handled. Into this mixture put scraps of zinc. The chemical action between these two substances very soon produces the hydrogen gas. In using this gas, provision should always be made for expansion. Otherwise the gas is dangerous, and liable to burst the vessel containing it. It is a gas that should be handled with great care at all times.

**How should a gas meter be read?**

From the dials always take the figures the index hands have passed. Assuming on the high dial the hand is between 3 and 4, on the second dial, between 4 and 5, on the third dial, between 8 and 9, you would read 348; adding two cyphers for the hundreds, it would read 34,800. To ascertain the amount of gas consumed in a given time, deduct the previous register (as given on the gas bill), from the present register.

**Why are wooden sinks and wash trays prohibited in most cities?**

They are considered unsanitary, as they soon commence to decay and absorb the water. If water is not kept in them constantly, they are liable to shrink and leak.

**Why is a pipe that has been heated, more easily bent than when cold?**

The heat expands the particles or molecules of which the metal is composed, and there being less density, they pass by each other more easily.

**What is the danger in overheating a pipe?**

Overheating expands the metal to such an extent that the particles either lose their strength or are consumed by the heat.

**What is carbonic acid gas?**

It is the gas most dangerous to health, it being most common, and should be guarded against by means of proper ventilation. It being one of the heavy gases, it naturally falls, and will be found in the lower strata of air in a room. For this reason the ventilation of public buildings and living rooms should be from the lower part of the room near the floor. By placing the ventilation near the floor, we not only assist in correcting this evil, but by drawing in the cold air from the lower section of the room, the heated air of the upper sections is forced to fall, to fill this space. Thus a proper circulation of air in the room is established. Years ago, when houses were heated from fireplaces, headaches were seldom known, which was largely due to this same manner of ventilation.

**How does cold act upon sewage?**

It causes the grease contained in the sewage to separate from the liquid portion. The grease being lighter than the water, naturally rises to the surface.

In what plumbing device is this principle put to use?  
In the grease trap.

How should a tank be made which is to hold acid?

A tank that is to hold acid continuously, should be made of lead, burned together, and not soldered, as in time the acid destroys the solder.

How many cubic inches does a gallon contain?

A gallon contains 231 cubic inches.

What is the weight of a gallon of water?

8.33 pounds.

What is the weight of a cubic foot of water?

62.5 pounds.

How many gallons of water are contained in one cubic foot?

7.5 gallons.

What are proper heights for setting plumbing fixtures?

Kitchen sink, 2 ft. 7 in.; wash trays, 2 ft. 8 or 9 in.; wash bowl slab, 2 ft. 6½ in.

## PRACTICAL SUBJECTS.

How would you get at a leak in a lead pipe, if the leak was underneath or on the back side of the pipe?

A good way is to set two lamps under the pipe some six feet apart, if possible, and when the pipe has become hot so that the particles of the lead are expanded, roll the pipe over, bringing the leak on top, where it can easily be repaired.

How can lead pipe that has been cut in two, be lengthened so that there will be no need of putting in a short piece of pipe?

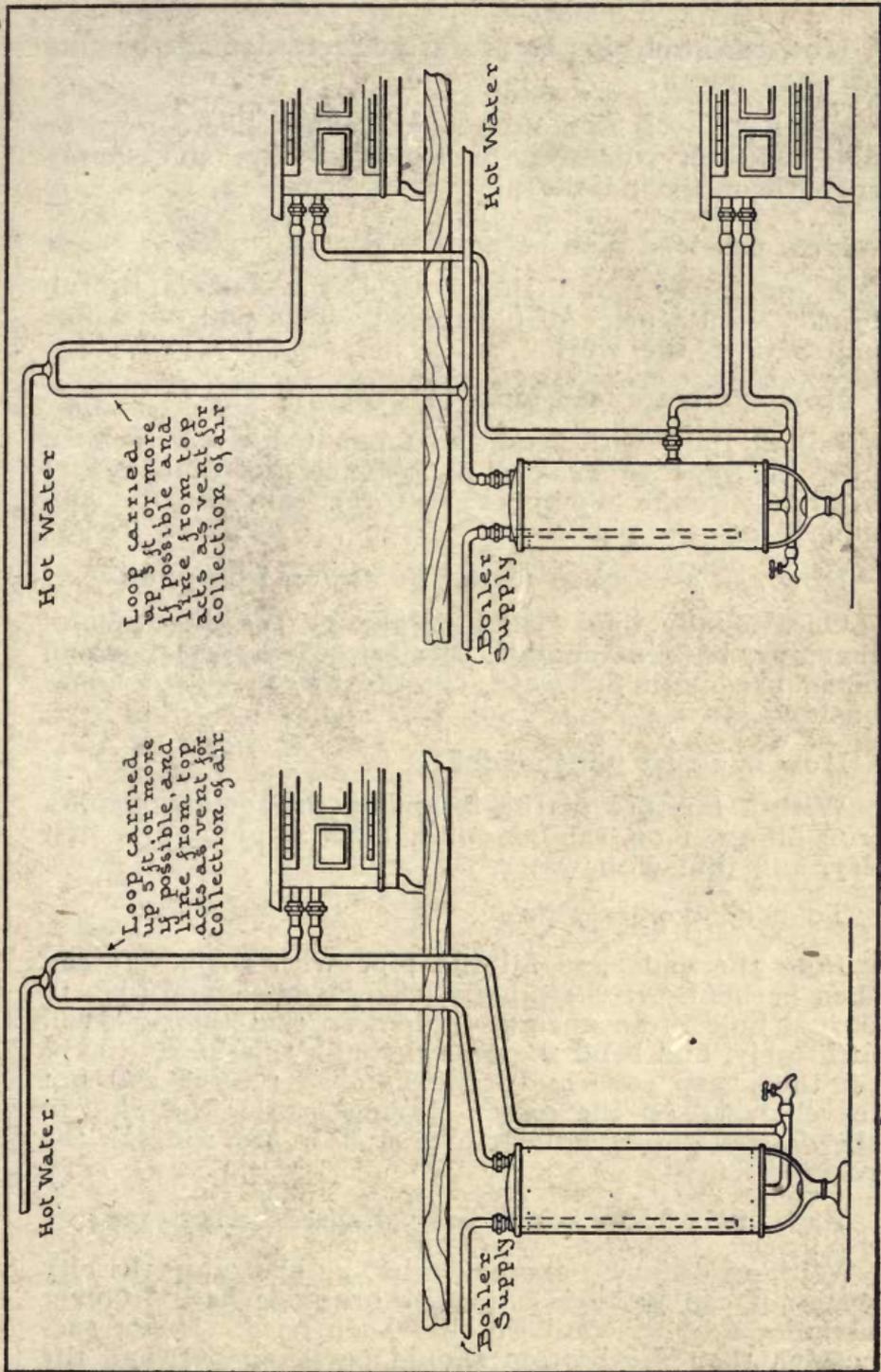
Form as small coils as the pipe will permit, one coil upon another. After the pipe has been coiled tightly in this form, straighten it out, and it will be found to have gained considerably in length. To make it still longer, repeat this operation. It should be understood that the coil is not made in the shape of a spiral spring, but flat, in the form of a mat.

How would you bend a piece of  $1\frac{1}{4}$  or  $1\frac{1}{2}$  inch lead pipe without the aid of sand or pipe bender?

With a dresser, flatten the pipe considerably and carefully bend it so that the flattened sides are parallel with the direction in which the pipe is bent. Flatten the pipe with the dresser wherever it shows signs of cockling, and having secured the proper bend, smooth the pipe where rough with the dresser.

How can a lead lining to a tank be soldered, if the wooden bottom is wet?

Lead is a metal that oxidizes very rapidly, unless covered by some substance which will exclude the air. As an example, after scraping a piece of lead bright, breathe upon it and it becomes discolored at once, on account of the carbonic acid gas with which the breath is charged. The moisture from the hand has a like effect, as well as steam from wood which is wet. In soldering over wet wood, it will be found of great help to insert a piece of paper between the wooden bottom and the lining, which absorbs the moisture caused by the heat.



BOILER HEATED BY RANGE ON SAME

BOILER HEATED BY RANGE ON

**How can lead pipe be protected from damage by rats between floors?**

A good way is to roll up sheets of tin, like conductor pipe, without soldering or locking them, and simply snap them around the pipe.

**How can lead pipe be polished?**

A good way, after the work is finished, is to rub briskly with a piece of old carpet. This will put a fine polish onto the work.

**How can large lead pipes be bent?**

Fill the pipe with sand and tamp it down well; then heat the pipe to expand the particles of lead before bending. Some plumbers heat the sand before running it into the pipe.

**How can a crooked thread be cut on iron pipe?**

Occasionally one wishes to change the direction of the pipe, but not enough to allow of a special fitting being used. In this case, cut the thread with a loose bushing.

**How is a rust joint made?**

With a mixture of the following proportions: 5 lbs. iron filings, 1 oz. salammoniac, 1 oz. sulphur; mix first dry, and thin with water.

**To bend copper pipes.**

Plug the ends and fill the pipe with rosin. It can then be bent. If the pipe is large, it is a good plan to bore a hole in an upright timber, so that the pipe will fit loosely, and bend the pipe through this hole. Shave off the sharp corners of the hole so that it will not leave marks on the pipe. Having gotten the pipe in the desired shape, hold it over a slow fire and run the rosin out.

**How can a boiler which has collapsed be restored?**

With an ordinary copper boiler, by attaching the city water, it can be forced into its original shape. Never hammer a boiler until this has been tried. If not successful, then the bottom should be taken out, and the cylinder forced into shape on a mandril.

**To make a putty joint on a leaky supply pipe.**

First have the pipe thoroughly dry, and then paint it over with some quick drying gold size. Then mix with white lead sufficient powdered red lead to stiffen it. Place a layer of this mixture around the pipe, three-eighths to one-half inch in thickness, and with some good strong cotton cloth, which has been painted with the gold size, neatly bind the red lead to the pipe, then bind it securely with twine, commencing at the end and winding closely toward the center.

**In case it is necessary to cut a thread a little smaller than standard, how can it be done?**

By inserting a narrow strip of tin between the die and pipe on one side. This will force the opposite side of the die to cut a little deeper.

**How should leaking gas pipes be treated?**

On new work, a little ether is usually forced through the system by aid of the force pump, and the leaks detected from the odor of the ether, an ordinary gauge having been previously attached and a pressure of from five to eight pounds been reached. On old work, where there is only the gas present, the first test of a suspected joint would be with a match or candle. If not successful in locating the leak, then cover the joints with a thick lather made from shaving soap. A very fine leak will soon cause a bubble to form which locates the leak. Shaving soap is better than common soap on account of its strength.

**How can nickel pipes be set tight when there are no special tools at hand?**

It is always well to have in one's kit a number of sizes of brass pipe, sawed in halves, lengthwise, and about two and one-half inches in length. On the inside of these rub a little rosin. They can then be put around the nickle pipe and clasped with a wrench, without defacing the polished work. If a vise is handy, two hard wood blocks having a groove in each to fit the pipe, can be used, rosin being first rubbed into the groove. These blocks should be eight or ten inches long.

**How should a putty joint be made?**

Although not a very desirable joint there are occasions when it has to be adopted. Select a good piece of cotton cloth about three inches in width, and after a sizeable joint of putty has been formed around the pipe, wrap carefully with the strip of cloth, and with a piece of twine securely fasten both edges of the joint. Now, having the putty confined so that it cannot squeeze out of either end, it can be wound as tightly as desired, and can be left to harden.

**How would it be possible to shut off the flow of water in a pipe which was not supplied with a stop cock?**

This result might be attained by freezing the water in the pipe at such point as it was desired to shut it off. This can be done by packing around the pipe a mixture of fine ice and salt, or by packing the pipe with ice, using perhaps a bushel of it, and pouring onto this a pint of ammonia. In a short time the pipe will be frozen solid, and after the necessary repairs have been made, the pipe may be thawed out.

**To make a deep seal trap for rain leaders.**

In trapping rain leaders, a special trap can be formed with quarter bends, which will give a much deeper seal than the ordinary trap. As there is no chance ordinarily to renew the seal during a prolonged drought, this form of trap would seem much the safer, as the seal of the common trap often becomes broken from evaporation. The leader trap should always be used if there is no main trap provided, and each leader should be independently trapped. This deep seal trap may be made by caulking together three quarter bends if it is a P trap, or four quarter bends if it is a running trap.

**To start a hard thread.**

This can often be accomplished by heating the fitting and then running into the thread a little beeswax. This will penetrate the thread thoroughly and usually enable the joint to be unscrewed.

**Forty-five degree measurement.**

To get a 45° degree measurement, add to the distance between the centers of the two parallel lines of pipe, 5

inches for each foot of such distance, and at the same rate for fractional parts of a foot. This will give a close approximation to the true measurement.

#### **To wipe a joint with paper. .**

In an emergency, when it is impossible to procure the regular wiping cloth, a good joint can be made with paper. Fold the paper several times, grease it well with tallow, and with care a fair joint may be wiped.

#### **Paper lining for wiping cloths.**

If the wiping cloth is so thin that the heat of the metal burns the hand, it is a good idea to line the cloth inside with paper. This will make a good non-conductor, and will help to keep the shape of the cloth.

#### **To take a dent out of lead pipe.**

To take a dent out of lead pipe that cannot be removed by the drift plug, solder on securely to the indentation a strip of lead or tin, and after warming the pipe pull gently, being careful not to pull out a piece of the pipe. While working out the dent in this way, the dresser may be used to help the work along.

#### **To make an insertable joint on a line of soil pipe.**

When it becomes necessary to break out a section of soil pipe, and there is no chance to raise or lower the pipe, cut off a short piece of pipe of the next larger size than the pipe in question, and into this caulk a piece of pipe of the same size as that broken out. The larger size now virtually becomes a long hub, and can be slipped up onto the pipe above, and dropped down into the hub below. By being careful the upper joint can be securely caulked.

#### **To pour a wet joint on soil pipe.**

Occasionally it becomes necessary to pour what is termed a wet joint. When this occurs, get the joint as near tight as possible by driving home the oakum. Then put into the hub a teaspoonful of powdered rosin. Oil may be poured in if the rosin is not obtainable. This acts to prevent the hot metal from flying.

#### **To finish lead pipe work.**

Rub with fine sandpaper, being careful to rub with the grain of the pipe. When this is done, cover at once with shellac.

#### **Wash tray cement.**

A good strong cement for mending wash trays is made of litharge and glycerine, made into a paste. This cement, when it sets, becomes exceedingly hard.

#### **To connect pipe when short of room.**

It happens occasionally that pipes have to be put in where there is not room enough for either a union or right and left coupling, as for instance in the making of some coils. In such a case, saw an ordinary coupling in halves, and with a file true up one end of one of the half couplings. Then cut a long thread on the pipe, and after tapping out the coupling, screw it onto the long thread, with a gasket on the face of the half coupling. After screwing up the long thread sufficiently to get the pipe in the right position, turn it back, making a tight connection at the other end. Turning it back is apt to leave a questionable joint on the long thread, which is made tight by running the half coupling and gasket down onto the fitting that the long thread makes into.

#### **To bend brass pipe.**

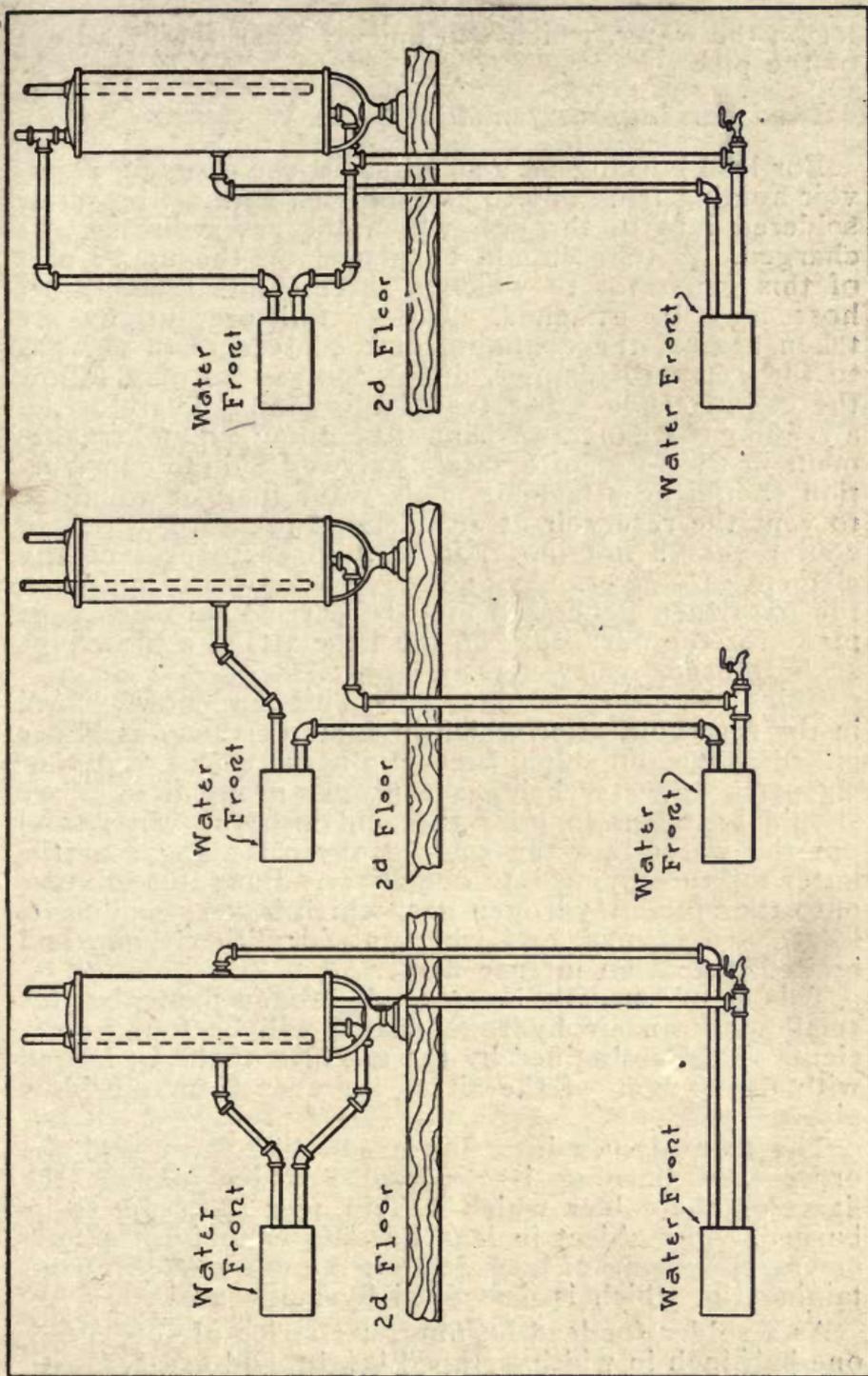
Secure the pipe in a vise between two blocks of wood and apply the torch at the point where the bend is to be made. When the pipe has been well heated, bend it at the proper angle. Previous to heating the pipe, fill it with sand and plug the ends.

#### **Rubber cup for plaster of Paris.**

For mixing plaster of Paris, a rubber bowl or cup will be found very handy, something after the shape of a rubber forcing cup, such as used by plumbers. After using, the old plaster left in the bowl is quickly cleaned off, merely by working the rubber.

#### **To wipe a wet joint.**

When everything is in readiness for wiping, plug the ends of the pipe with bread. By quick work a joint can be wiped while the bread is soaking up the moisture, the only point being to finish the joint before the bread becomes saturated. After completing the joint,



THREE METHODS OF HEATING KITCHEN BOILER BY TWO RANGES

let on the water, which will quickly wash the bread out of the pipe.

### Lead burning on a small scale.

For lead burning on a small scale, use a strong reservoir holding from one to two gallons, with a trap screw soldered into it, through which the reservoir may be charged. A tube should be placed on the upper part of this generator to which a three-eighths inch rubber hose may be attached. Unless full precautions are taken against the confining of the pressure of the gas to the extent of danger, disastrous results may follow the use of crude apparatus of this kind. Therefore, if a regular gas generator cannot be obtained, an arrangement in the form of a safety valve of simple construction should be attached. This valve may be weighted to vent the reservoir at any desired pressure, which of course should not be made so high as to present any element of danger. As another precautionary measure, the gas when generated may be carried into gas bags made for the purpose. To the hose attach a blow pipe such as used by jewelers.

Chips of either old or new zinc are now placed in the reservoir, after which in some earthen vessel are mixed water and sulphuric acid, one part acid to five or six parts of water being the proper proportion. Care should be taken to pour the acid into the water, and not the water into the acid, as there is danger of the latter mixture flying into one's face. Pour this mixture onto the zinc. Hydrogen gas, which is very explosive, is at once formed, and when mixed with oxygen and ignited, forms an intense flame.

This should usually be an oxyhydrogen flame, but for small work an airohydrogen flame will be found sufficient. This is obtained by the mixture of the hydrogen with the oxygen of the air as it issues from the blow pipe.

The flame issues in a fine needle-like form, and the process of burning is accomplished by playing the flame on the solder which is held over the seam to be burned. The object in lead burning is to form a tank or vessel entirely of lead without the use of solder containing tin, which is destroyed by many acids.

As a solder for lead burning, use strips of sheet lead, one-half inch in width, scraped bright, and greased with tallow.

Do not attempt to light the gas until the pressure has driven the air out of the reservoir. In this work, do not attempt to burn corner seams, but shape the lining so that the seams come squarely on the bottom or on the sides. It need scarcely be added, that apparatus especially constructed for the purpose, is preferable to that which has been described, and that the above simply represents a method in which small work can be done which will not warrant a great outlay for apparatus.

#### **Lead burning with a soldering copper.**

When the hydrogen flame cannot be had, lead can be burned together with the soldering copper on small work. Use a 32 oz. hatchet copper and heat to a cherry red. Retin the copper as fast as the tinning burns off. Use narrow strips of sheet lead well greased with tallow, just as when burning with the hydrogen flame.

**To repair a leak in a lead pipe where the water cannot be wholly shut off, and there is no pressure.**

A little back of the point where the joint is to be made, prick a slanting hole through the pipe with a marking awl. Through this hole run a small wire out through the end opening of the pipe. To this wire fasten a string, and pull through the hole quite a quantity of string, which should be well greased with tallow. Then lay this string back and forth or coil it evenly about the fingers so that it will not snarl. When enough is thus coiled to fill the pipe, push it into the opening, and tamp it until it plugs the opening as well as possible, after which the joint can be wiped. After the wiping is finished, take the string where it comes through the hole, give it a sharp twitch which will break up the plug of string, and allow its entire length to be pulled out. After this beat the hole up tight and put on a drop of solder. By pricking the hole slanting, the string can be more easily pulled out and the water will not fly out in one's face.

#### **To string lead pipe.**

To string lead pipe overhead, it is well to erect a temporary stage, directly under the line of pipe, of barrels and planks. Then let the helper take the coil of pipe between his knees, and uncoil only as fast as the plumber can clip it up, the helper at the same time

taking the weight of the pipe. This enables the plumber to keep his line straight, and kinks in the pipe are thereby avoided. It is much harder to make a good looking job after the pipe has become kinked than it is to keep it right by the above method.

#### **To stop a leak on the bottom side of a lead pipe.**

First scrape the pipe bright, and rub on tallow. Then pour from the ladle onto the wiping cloth some fine solder heated quite hot, and quickly press the melted metal up against the leak. Previous to applying the solder, have the pipe well heated.

#### **To remedy a faulty draught.**

It will often be found that where stoves enter the same flue on different floors, the stove on the first floor has an excellent draught, while the one above will have almost none. This is caused by the stove on the first floor getting the advantage and cutting off the draught of the stove above. To remedy this trouble, allow the upper pipe to go to the back of the chimney, cutting off the top part of the pipe in the chimney. This splits the current from the lower stove, and allows the upper draught to get an upward start.

#### **To support lead tank lining.**

Tank linings having large area, frequently have to be supported to prevent the sag that would in time follow owing to the weight of the metal. On the sides of the tank, before the lining has been put in, gouge out enough shallow bowls to give the desired support, then when the lining is in place, beat it into the bowls, and in the center of each bowl put in a strong brass screw. Finally, scrape the inside of the bowl and wipe it flush with the surface.

#### **Substitute for a groover.**

It sometimes happens that in lining a tank, a piece of copper has to be grooved and there is no groover at hand. In this case, turn a common monkey wrench up to the width of the seam desired, which works very well as a substitute.

#### **Spanish windlass.**

The Spanish windlass, as it is called, will often be found handy where lead pipe of a large size has to be

rolled over, as may be the case where it is desired to bring a leak at the bottom of a pipe to the top. After heating the pipe as explained elsewhere, take a strong cord, tying the two ends together, and making the loop quite short. Bring the double cord or loop around the pipe and shove a stick of soft wood through one of the loops so that the end of the stick will just catch and hold the other loop firmly against the pipe. With this arrangement the desired work can be done, as the harder it is pulled, the tighter the grip becomes.

#### **To make a cup joint on horizontal pipe.**

Cut the pipe off on a slant and swedge out one end, enough to let the opposite end drop into the cup. Then with a sharp pointed soldering copper, a good cup joint can be made. By using a long pointed copper there is not so much heat at the extreme end, and the solder will be less liable to run away from the work.

#### **Square bend in lead pipe.**

A nice square bend can be made on a piece of lead pipe if necessary, by cutting out a V shaped piece at 45 degrees, the cut running only through the bore of the pipe, after which the pipe is bent and burned together. Other than square bends may be formed by cutting out a piece at the right angle.

#### **To plug a range boiler.**

The great trouble in plugging a boiler in which a leak has occurred, is to get thickness enough for more than one thread. To overcome this, after the hole has been reamed out, drive in carefully a tapering punch, thereby forcing a heavy burr into the boiler, which will give a chance for additional threads if it is done carefully.

#### **To prevent rain leaders from freezing and bursting.**

The freezing and bursting of rain leaders can be avoided by running a small steam pipe into the leader pipe, with a valve near the main connection. Whenever ice is found to have formed, a jet of steam will quickly relieve the trouble.

**To run a joint where there is not room for an asbestos rope.**

Cut out a ring of pasteboard, the inner circle just the size of the outside diameter of the pipe; then cut through one side of the ring so that it may be slipped over the pipe and against the hub where the joint is to be made. With the slit in the pasteboard at the top, the use of a little putty will complete the device, so that the joint can be successfully poured.

#### **To wipe a joint on block tin pipe.**

Prepare the joint as for lead work, and use bismuth solder instead of ordinary wiping solder. Heat the solder until it is of the consistency of a thick porridge. Having warmed the pipe, make the joint quickly, remembering that it must be made the first time, as it cannot be wiped and rewiped as on lead pipe. If the workman is fairly skillful, he will have ample time in which to wipe the joint.

#### **To make a joint on lead-lined soil pipe.**

This pipe must sometimes be used, for instance when certain kinds of acids enter the drainage system. In connecting a piece of such pipe into a hub, the iron pipe should be cut off beyond the end sufficiently to allow for beating the lead over the end of the iron pipe. When placed in the hub, the hot lead will make a perfect joint, and the iron be protected from the action of the acids.

#### **To finish galvanized piping.**

Go over the piping after its completion, with fine sand paper, being careful always to rub one way.

#### **Coils for beer work.**

Use  $\frac{3}{8}$  in. block tin pipe. Never use lead pipe, as lead poisoning is sure to result from the strong action of the beer on the lead.

For a coil of 10 in. diameter, cut off 12 ft. of pipe.

For a coil of 12 in. diameter, cut off 25 ft. of pipe.

For a coil of 14 in. diameter, cut off 30 ft. of pipe.

These lengths will allow ample tail pieces to connect to.

A handy device for bending small pipes when usual facilities are not at hand.

Obtain a tee of sufficient size to slip onto the pipe to be bent. Into the side opening of the tee screw about three feet of pipe. Slip the tee onto the pipe to the point where the bend is to be made, and use the pipe into the side opening of the tee as a lever or as a support to bend against. A sharp bend at the exact point can be obtained.

### **Shelac to hold bi-transit waste packings.**

The plumber is often bothered by the slipping off of these packings. To avoid this, use cut shelac as follows. Before putting on the packing, wipe a little of the shelac around the inside of the rubber, and let it dry. Then cover the brass work with shelac, and give the rubber a second coating. Then slip the packing at once into place. This will hold for a long time. Better results can be obtained, however, from shelac cut in turpentine, which will withstand water as long as the rest of the work holds together. It takes two or three weeks to cut shelac with turpentine, but a bottle of it will be found very useful.

### **An easy method of setting up work for wiping.**

The plumber is often bothered in setting up his work preparatory to wiping. For instance, in wiping a brass ferrule, he will often have to drive a round stick into one end of the ferrule to give a support on which to rest the work. The following will avoid some of this work. Go around the end of the pipe where it meets the ferrule or where it meets the pipe to which it is to be joined, with a large hot soldering copper, burning the lead together. Sometimes a small drop of solder is used to start the lead flowing, but not more than a drop should be used, as the nearer the burned joint comes to being lead, the longer it will withstand heat. As solder melts much easier than lead, the lead joint will hold the work firmly while the joint is being wiped.

### **An easy method of bending brass pipe.**

Fill the pipe with sand, well rammed, and plug the ends. Place the pipe on the end of the bench, allowing one end to overhang. Set a furnace under the point where the bend is to be made, and cover it on top with a piece of sheet iron, a shovel or other con-

venient manner, to confine the heat. Watch carefully that the pipe does not become overheated. As it heats, the weight of the overhanging pipe will cause it to bend until it reaches the floor, if of sufficient length. With a little care sharp right angle bends can be very neatly made in this way. When heated brass is very brittle, but in this case the pipe itself acts as a tell-tale. When the bend is complete allow it to cool. If the overhanging part is too short to give sufficient weight to carry itself down, a weight may be attached to the end.

#### **To repair leak on range boiler.**

On this work it is much better to make the joint inside the boiler. Ream out the hole where the leak is, removing any inside bur. Next lower a string into the boiler through the top opening of boiler, and with a bent wire draw the string through the hole that has been reamed out. Attach to the string a bolt with brass washer and rubber washer fitting tight to the bolt. With a little patience the bolt can be drawn through the hole by means of the string. A nut outside will set the bolt up and make a tight joint with the rubber washer. This gives the advantage of the inside pressure to make the joint tight.

#### **An aid in brazing.**

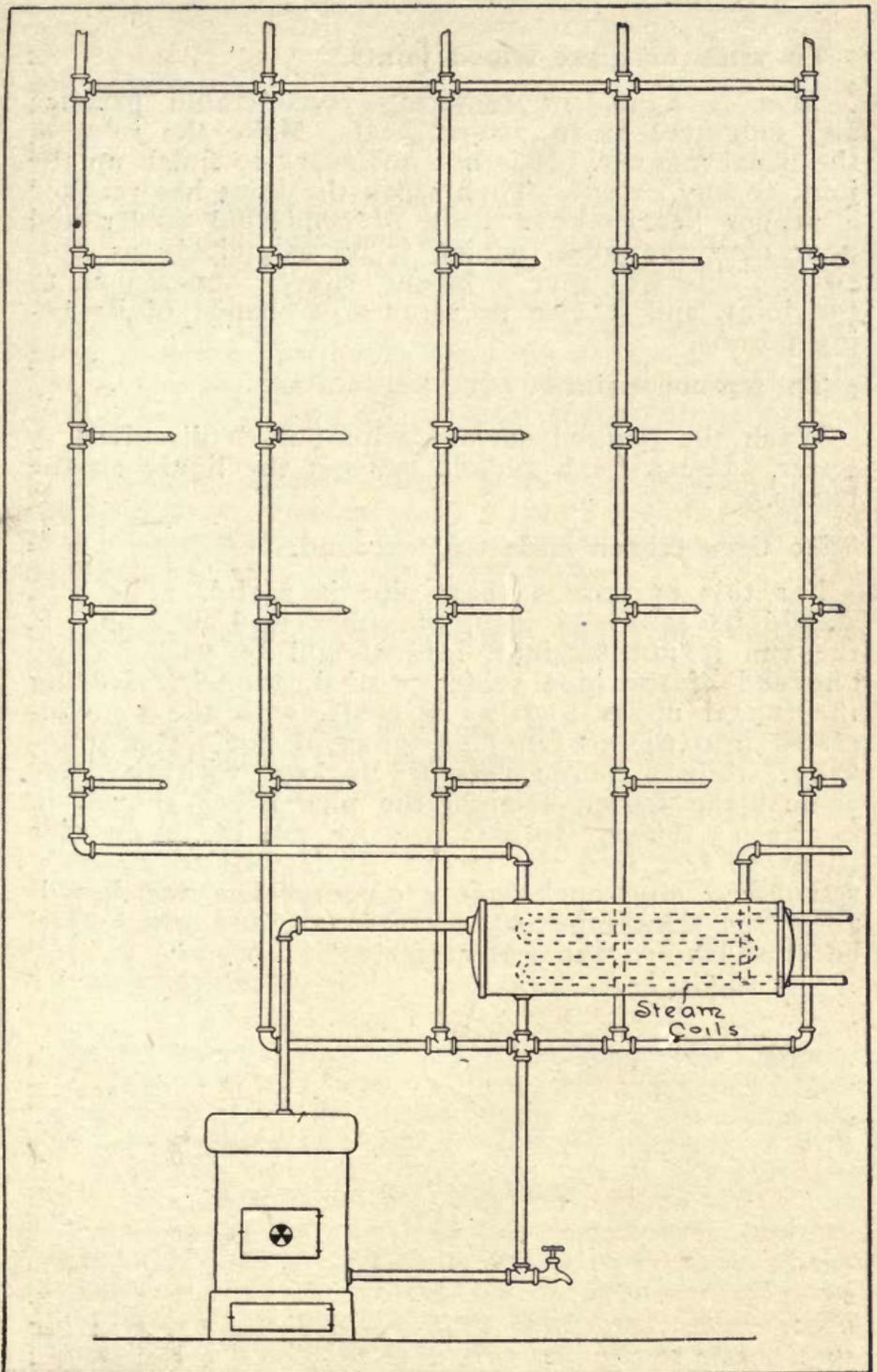
Occasionally the plumber is called upon to do a little brazing. He will find that a little powdered tin sprinkled on the seam just as the spalter reaches the melting point, will make the solder flow much more freely.

#### **To hold heat in wiping large joints.**

In wiping a large joint, it is important to keep the metal at the proper heat. A bag of hot sand placed inside the pipe will help in keeping this heat.

#### **To keep pipes from freezing.**

Build around the length of the exposed pipe a series of boxes one outside another, with air spaces of about one inch between the boxes. Rough boards are as good as better material for this purpose. The air spaces afford the best of protection to the pipe.



**To wash or glaze wiped joints.**

This is a matter requiring considerable practice and judgment as to proper heat. Make the joint in the usual manner. It is not necessary to finish up the joint to any extent. Then when the joint has reached a proper heat, take a ladle of semi-fluid solder and pour over the joint, wiping it off as quickly as possible. This will give a bright, silvery appearance to the joint, and it also prevents any chance of its being porous.

**To remove paint.**

Wash the painted surface with potash dissolved in water. Use a swab and do not get the liquid on the hands.

**To thaw frozen main underground.**

For this purpose a thaw pipe is useful. The pipe should be  $\frac{1}{8}$  or  $\frac{1}{4}$  inch, of either lead or iron. If the run is not straight, lead should be used. Onto one end of the pipe solder a small tunnel. Holding the tunnel up as high as possible, with the pipe inserted into the frozen pipe, pour in hot water gradually, while a gentle pressure is kept with the pipe against the frozen section, the pipe being shoved in as the ice thaws. In this way ice can be thawed for 40 or 50 feet into the street. It is well to attach a round-way stop cock before commencing, which will allow the thaw pipe to pass through, and which may be closed when the water starts.

## RECIPES.

**To keep plaster of Paris from setting too quickly.**— Sift the plaster into the water, allowing it to soak up the water without stirring, which would admit the air, and cause the plaster to set very quickly. If it is desired to keep the plaster soft for a much longer period, as is necessary for some kinds of work, add to every quart of water one-half teaspoonful of common cooking soda. This will gain all the time that is needed.

**To remove grease stains from marble.**— Mix soft soap  $1\frac{1}{2}$  parts, Fuller's earth 3 parts, potash  $1\frac{1}{2}$  parts, and boiling water. Cover the grease spots with this mixture, letting it remain a few hours.

**To keep paste from spoiling.**— Add a few drops of oil of clove.

**To make a cement that will hold when all others fail.**— Melt over a slow fire equal parts of rubber and pitch. When wishing to use it, melt and spread it on a strip of strong cotton cloth.

**Bath for cleaning sheet copper that is to be tinned.**— Pour into water sulphuric acid, until the temperature rises to about blood heat, when it will be about right for pickling purposes.

**To tin sheet copper after it has been well cleaned.**— Take it from the bath. If there are any spots which the acid has failed to remove, scour with salt and sand. Then over a light charcoal fire heat it, touching it with tin or solder, and wipe from one end of the sheet to the other with a handful of flax, only going so fast as it is thoroughly tinned. If the tinning shows a yellowish color, it shows there is too much heat, which is the greatest danger, as tinning should be done with as little heat as is necessary to make the metal flow. When this is done, rinse off in clean water and dry in sawdust.

**To give copper a red appearance as seen on bath boilers.**— After the copper has been cleaned, rub on red chalk and hammer it in with a planishing hammer.

**To tin soldering copper with salammoniac.**— It will be found very handy to have a stick of salammoniac in one's kit for tinning purposes. After filing the heated copper bright, touch the copper with the salammoniac and afterward with a stick of solder. The solder will at once flow over the entire surface. In this there is but one danger, the too great heating of the copper, in which case the burned salammoniac will form a hard crust over the surface. Tin with as little heat as possible. Salammoniac will be found of great value in keeping the soldering copper in shape by frequently rubbing the tinned point with it.

**To Keep Soldering Coppers in Order While Soldering with Acid.**— In a pint of water dissolve a piece of salammoniac about the size of a walnut. Whenever the copper is taken from the fire, dip the point into the liquid, and the zinc taken from the acid will run to the point of the copper and can then be shaken off, leaving the copper bright.

## RULES.

To find the contents of a square tank: Multiply length, breadth and height in feet together; the result by 7.4; this will give the number of gallons in the tank. Or multiply the length, breadth and height in inches and the result by .004329.

To find the contents of a cylinder: Multiply the diameter in inches by itself, this by the height, and the result by .3400; this gives the number of gallons.

To find the circumference of a circle: Multiply the diameter by 3.14.

To find the area of a circle: Square the diameter and multiply by .7854.

To find the pressure per square inch exerted by a column of water, multiply the head in feet by 0.434. The result will be the pressure in pounds.

To find the head in feet, the pressure being known, multiply the pressure per square inch by 2.31.

To find the contents of a barrel: To twice the square of the largest diameter, add the square of the smallest diameter and multiply this by the height, and the result by 2618. This will give the cubic inches in the barrel, and this divided by 231 will give the number of gallons.

To find the lateral pressure of water upon the side of a tank, multiply in inches the area of the submerged side by the pressure due to one-half the depth.

Example.—Suppose a tank to be 12 feet long and 12 feet deep. Find the pressure upon the side of tank,  $144 \times 144 = 20,736$  inches area of side,  $12 \times .43 = 5.16$ , pressure at bottom of tank; pressure at top, 0; average, 2.6; therefore,  $20,736 \times 2.6 = 53,914$ , pressure on side of tank.

The rule of 6-8-10, to ascertain if an article is square: Measure off six inches on one side of the angle, and on

the other measure 8 inches. If the article is perfectly square it will measure exactly 10 inches across from point to point. This rule holds good in feet.

Rule for finding the size of a pipe necessary to fill a number of smaller pipes: Suppose it is desired to fill from one pipe a 2-,  $2\frac{1}{2}$ - and 4-inch pipe. Draw a right angle, one arm 2 inches in length, the other  $2\frac{1}{2}$  inches in length. From the extreme ends of the two arms draw a line. The length of this line in inches will give the size of pipe necessary to fill the two smaller pipes — about  $3\frac{1}{4}$  inches. From one end of this last line, draw another line at right angles to it, 4 inches in length. Now, from the end of the 2-inch line to the end of the last line draw another line. Its length will represent the size of pipe necessary to fill a 2-,  $2\frac{1}{2}$ - and 4-inch pipe. This may be continued as long as desired.

Discharge of water: The amount of water discharged through a given orifice during a given length of time and under different heads, is as the square roots of the corresponding heights of the water in the reservoir above the surface of the orifice.

To find the number of gallons in a foot of pipe of any diameter: Multiply the square of the diameter of the pipe in inches by .0408.

To find the number of gallons of water that will drain from a roof: Multiply the number of square feet of roof by the average number of inches of rainfall per month, and the product by .623. The result gives the number of gallons which will drain from the roof in a month. When the roof is not flat or very nearly so its area should be considered as the area which it actually covers.

To find the power necessary to raise water to any given height: Multiply the number of cubic feet required per minute by the number of feet through which it is to be lifted. Then multiply this result by 6.23 and divide by 33,000, which will give the nominal horse power required. If the amount of water required per minute is in gallons, the multiplier will be 8.3 instead of 6.23.

To find the capacity of a cistern or well: Multiply the square of the diameter in inches by the decimal .7854. Multiply this result by the depth in inches, and divide this by 231. The final figure gives the contents in gallons.

Example.—Cistern, 10 ft. deep, 5 ft. in diameter. The square of 60, the diameter in inches, is 3,600.

$$3,600 \times .7854 = 2,827.44.$$

$$2,827.44 \times 120 = 3,392.93 \text{ cubic inches in cistern.}$$

$$3,392.93 \div 231 \text{ (cubic in. in gal.)} = 1,469 \text{ gallons.}$$

To find the thickness of lead pipe necessary for a given head of water: Multiply the head in feet by the size of pipe required, expressed as a decimal, and divide the result by 750. The quotient represents the thickness required, in one-hundredths of an inch.

Example.—What thickness should half-inch pipe have for a head of 50 ft.?

$$50 \times .50 = 25.$$

$$25 \div 750 = .033 \text{ inch.}$$

To find the diameter of pipe to discharge a given amount of water per minute, in cubic feet: Multiply the square of the quantity in cubic feet per minute by .96. The result equals the diameter of the pipe in inches.

To find the head which will produce a given velocity of water through a pipe of a given diameter and length: Multiply the square of the velocity, expressed in feet per second, by the length of pipe multiplied by the quotient obtained by dividing 13.9 by the diameter of the pipe in inches, and divide the result obtained by 2,500. The final amount will give the head in feet.

Example.—The horizontal length of pipe is 1,200 feet, and the diameter is 4 inches. What head must be secured to produce a flow of 3 feet per second?

$$3 \times 3 = 9; 13.9 \div 4 = 3.475.$$

$$9 \times 1,200 \times 3.475 = 37,530.$$

$$37,530 \div 2,500 = 15 \text{ ft.}$$

Doubling the diameter of a pipe increases its capacity four times.

To find the velocity of water flowing through a horizontal straight pipe of given length and diameter, the

head of water above the center of the pipe being known: Multiply the head in feet by 2,500, and divide the result by the length of pipe in feet multiplied by 13.9, divided by the inner diameter of the pipe in inches. The square root of the quotient gives the velocity in feet per second.

Example.—The head is 6 feet, length 1,340 feet, and diameter 5 inches. What is the velocity of water passing through the pipe?

$$2,500 \times 6 = 15,000.$$

$$1,340 \times 13.9 = 18,626 \div 5 = 3,725.2.$$

$$15,000 \div 3,725.2 = 4.03.$$

The square root of 4.03 = 2 feet per second.

To find the weight of any length of lead pipe, when the diameter and thickness of the lead are known: Multiply the square of the outer diameter in inches, by the weight of 12 cylindrical inches, then multiply the square of the inner diameter in inches by the same amount, subtracting the product of the latter from that of the former. The remainder multiplied by the length gives the desired result.

Example.—Find the weight of 1,200 feet of lead pipe, the outer diameter being  $\frac{7}{8}$  inch, and the inner diameter  $\frac{9}{16}$  inch.

N. B.—The weight of 12 cylindrical inches, 1 foot long, 1 inch in diameter, is 3.8697 lbs.

$$\frac{7}{8} \times \frac{7}{8} = \frac{49}{64} = .765625.$$

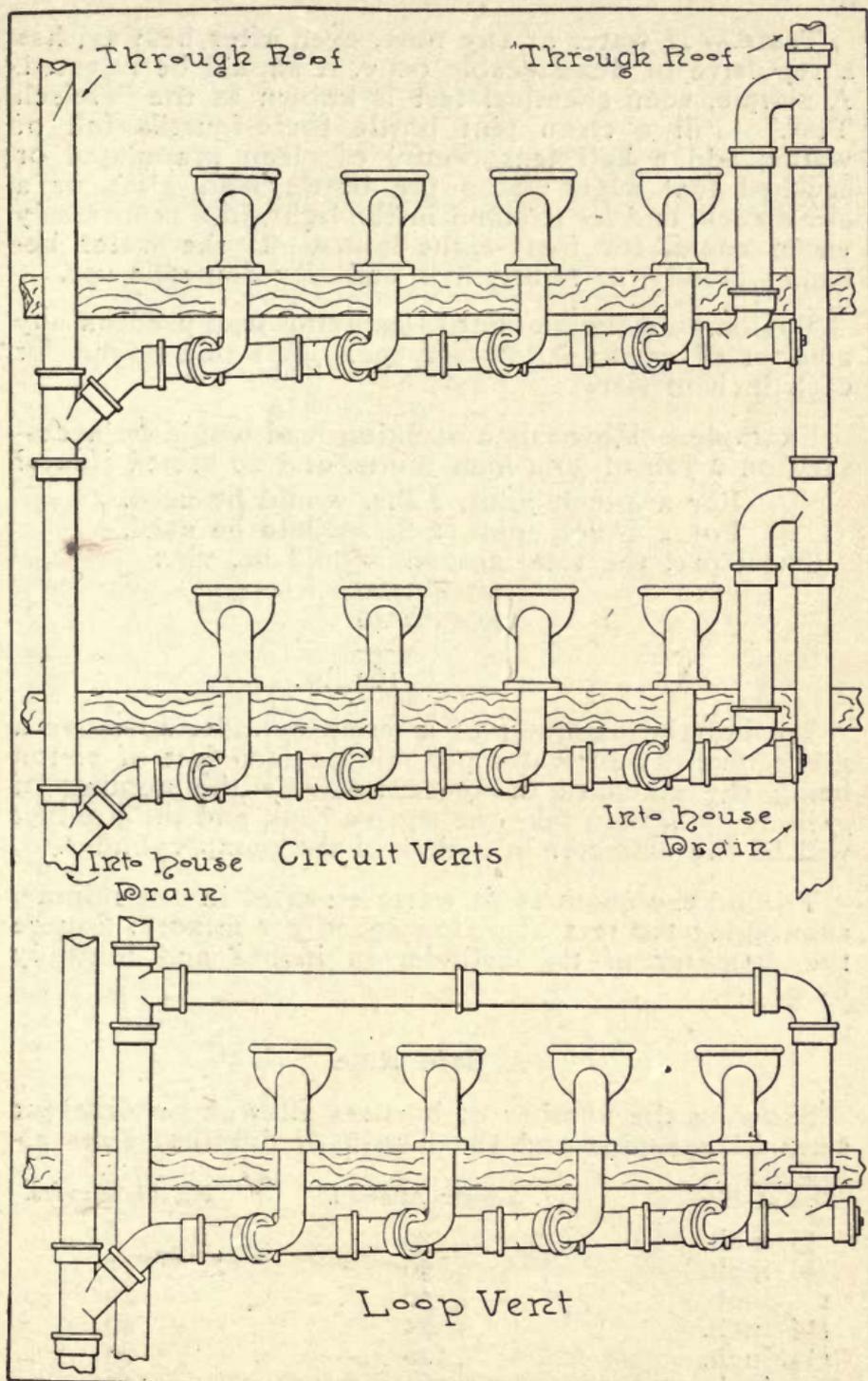
$$\frac{9}{16} \times \frac{9}{16} = \frac{81}{256} = .316406.$$

$$.765625 - .316406 = .449219 \times 3.8697 \times 1,200 = 2,086 \text{ lbs.}$$

### Tests for Pure Water.

**Color.**—Fill a long clean bottle of colorless glass with the water. Look through it at some blank object. It should look colorless and free from suspended matter. A muddy or turbid appearance indicates soluble organic matter or solid matter in suspension.

**Odor.**—Fill the bottle half full, cork it and leave it in a warm place for a few hours. If, when uncorked, it has a smell the least repulsive, it should be rejected for domestic use.



**Taste.**— If water at any time, even after heating, has a repulsive or disagreeable taste, it should be rejected. A simple, semi-chemical test is known as the "Heisch Test." Fill a clean pint bottle three-fourths full of water; add a half teaspoonful of clean granulated or crushed loaf sugar; stop the bottle with glass or a clean cork, and let it stand in the light, in a moderately warm room, for forty-eight hours. If the water becomes cloudy, or milky, it is unfit for domestic use.

To compute the amount of caulking lead used on any amount of work: Allow for each joint one pound for each inch in size.

**Example.**— How much caulking lead would be necessary on a job of 30 4-inch joints, and 20 2-inch joints?

For a 4-inch joint, 4 lbs. would be used.

For a 2-inch joint, 2 lbs. would be used.

Therefore, the total amount would be, viz.:

$$30 \times 4 = 120$$

$$20 \times 2 = 40$$

---

160 lbs.

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the standard of speed): Divide the number of gallons by 4, then take the square root, and the product will be the diameter in inches of the pump cylinder.

To find the quantity of water elevated in one minute, running at 100 feet of piston speed per minute: Square the diameter of the cylinder in inches and multiply by 4.

### A Safe Rule

Showing the number of burners allowed on different sizes of gas pipe and the length of different sizes allowed:

Size of Pipe.	Length Allowed.	No. of Burners.
½ inch.	20	6
¾ inch.	30	15
1 inch.	50	20
1¼ inch.	75	40
1½ inch.	120	60
2 inch.	160	100

## TABLES.

### Contents of Marble Slabs in Square Feet and Inches.

Length Inches.	WIDTH IN INCHES.										
	6	7	8	9	10	11	12	13	14	15	16
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
12	6	7	8	9	10	11	I				
13	7	8	9	10	11	I	I	I	2		
14	7	9	10	11	I	I	I	2	I	4	
15	8	9	10	I	I	I	I	3	I	4	I
16	8	10	11	I	I	I	I	3	I	4	I
17	9	10	I	I	I	I	I	4	I	5	I
18	9	11	I	I	I	I	I	4	I	5	I
19	10	11	I	I	I	I	I	5	I	6	I
20	10	I	I	I	I	I	I	5	I	6	I
21	11	I	I	I	I	I	I	6	I	7	I
22	11	I	I	I	I	I	I	6	I	7	I
23	I	I	I	I	I	I	I	7	I	8	I
24	I	I	I	I	I	I	I	7	I	8	I
25	I	I	I	I	I	I	I	8	I	9	I
26	I	I	I	I	I	I	I	8	I	9	I
27	I	I	I	I	I	I	I	9	I	10	I
28	I	I	I	I	I	I	I	9	I	10	I
29	I	I	I	I	I	I	I	10	I	11	I
30	I	I	I	I	I	I	I	10	I	11	I
31	I	I	I	I	I	I	I	11	I	12	I
32	I	I	I	I	I	I	I	11	I	12	I
33	I	I	I	I	I	I	I	12	I	13	I
34	I	I	I	I	I	I	I	12	I	13	I
35	I	I	I	I	I	I	I	13	I	14	I
36	I	I	I	I	I	I	I	13	I	14	I
37	I	I	I	I	I	I	I	14	I	15	I
38	I	I	I	I	I	I	I	14	I	15	I
39	I	I	I	I	I	I	I	15	I	16	I
40	I	I	I	I	I	I	I	15	I	16	I
41	I	I	I	I	I	I	I	16	I	17	I
42	I	I	I	I	I	I	I	16	I	17	I
43	I	I	I	I	I	I	I	17	I	18	I
44	I	I	I	I	I	I	I	17	I	18	I
45	I	I	I	I	I	I	I	18	I	19	I
46	I	I	I	I	I	I	I	18	I	19	I
47	2	2	2	2	2	2	2	19	I	20	I

Add one inch for each finished edge.

(Concluded on next page.)

Length Inches.	WIDTH IN INCHES.										
	17	18	19	20	21	22	23	24	25	26	27
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
17	2 2										
18	2 2	2 3									
19	2 3	2 5	2 6								
20	2 4	2 6	2 8	2 9							
21	2 6	2 8	2 9	2 II	3 I						
22	2 7	2 9	2 II	3 I	3 3	3 4					
23	2 9	2 II	3	3 2	3 4	3 6	3 8				
24	2 10	3	3 2	3 4	3 6	3 8	3 10	4			
25	2 II	3 2	3 4	3 6	3 8	3 10	4 2	4 4	4 6		
26	3 I	3 3	3 5	3 7	3 10	4	4 2	4 4	4 6	4 8	
27	3 2	3 5	3 7	3 9	3 II	4 2	4 4	4 6	4 8	4 II	5 I
28	3 4	3 6	3 8	3 II	4 I	4 3	4 6	4 8	4 10	5 5	5 3
29	3 5	3 8	3 10	4	4 3	4 5	4 8	4 10	5	5 I	5 5
30	3 7	3 9	4	4 2	4 5	4 7	4 10	5	5 3	5 5	5 8
31	3 8	3 II	4 I	4 4	4 6	4 9	4 II	5 2	5 5	5 7	5 10
32	3 9	4	4 3	4 5	4 8	4 II	5 5	5 4	5 7	5 9	6 5
33	3 II	4 2	4 4	4 7	4 10	5 I	5 3	5 6	5 9	6 6	6 2
34	4	4 3	4 6	4 9	5	5 2	5 5	5 8	5 II	6 2	6 5
35	4 2	4 5	4 7	4 10	5 I	5 4	5 7	5 10	6 I	6 4	6 7
36	4 3	4 6	4 9	5	5 3	5 6	5 9	6	6 3	6 6	6 9
37	4 5	4 8	4 II	5 2	5 5	5 8	5 II	6 2	6 5	6 8	6 II
38	4 6	4 9	5	5 3	5 7	5 10	6 I	6 4	6 7	6 10	7 2
39	4 7	4 II	5 2	5 5	5 8	6	6 3	6 6	6 9	7 I	7 4
40	4 9	5	5 3	5 7	5 10	6 I	6 5	6 8	6 II	7 3	7 6
41	4 10	5 2	5 5	5 8	6	6 3	6 7	6 10	7 I	7 5	7 8
42	5	5 3	5 7	5 10	6 2	6 5	6 9	7	7 4	7 7	7 II
43	5 I	5 5	5 8	6	6 3	6 7					
44	5 2	5 6	5 10	6 I	6 5	6 9					
45	5 4	5 8	5 II	6 3	6 7	6 II					
46	5 5	5 9	6 I	6 5	6 9	7					
47	5 7	5 II	6 2	6 6	6 10	7 2					

Length Inches.	WIDTH IN INCHES.										
	28	29	30	31	32	33	34	35	36	37	38
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
28	5 5										
29	5 8	5 10									
30	5 10	6 I	6 3								
31	6 6	6 3	6 6	6 8							
32	6 3	6 5	6 8	6 II	7 I						
33	6 5	6 8	6 II	7 I	7 4	7 7					
34	6 7	6 10	7 I	7 4	7 7	7 10					
35	6 10	7 I	7 4	7 6	7 9	8	8 3	8 6			
36	7	7 3	7 6	7 9	8	8 3	8 6	8 9	9		
37	7 2	7 5	7 9	8	8 3	8 6	8 9	9	9 3	9 6	
38	7 5	7 8	7 II	8 2	8 5	8 9	9	9 3	9 6	9 9	10
39	7 7	7 10	8 2	8 5	8 8	8 II	9 3	9 6	9 9	10	10 4
40	7 9	8 I	8 4	8 7	8 II	9 2	9 5	9 9	10	10 3	10 7
41	8	8 3	8 7	8 10	9 I	9 5	9 8	10	10 3	10 6	10 10
42	8 2	8 6	8 9	9 I	9 4	9 8	9 II	10 2	10 6	10 10	11 I

Add one inch for each finished edge.

**Capacity of Drain Pipe Under Different Amounts  
of Fall.**

GALLONS PER MINUTE.								
Size of Pipe.	½ in. fall per 100 ft.	3 in. fall per 100 ft.	6 in. fall per 100 ft.	9 in. fall per 100 ft.	12 in. fall per 100 ft.	18 in. fall per 100 ft.	24 in. fall per 100 ft.	36 in. fall per 100 ft.
3 in.	21	30	42	52	60	74	85	104
4 "	36	52	76	92	108	132	148	184
6 "	84	120	169	206	240	294	338	414
9 "	232	330	470	570	660	810	930	1140
12 "	470	680	960	1160	1360	1670	1920	2350
15 "	830	1180	1680	2040	2370	2920	3340	4100
18 "	1300	1850	2630	3200	3740	4600	5270	6470
20 "	1760	2450	3450	4180	4860	5980	6850	8410



Table of Quantity of Water Delivered by Service Pipes  
of Various Sizes Under Various Pressures.  
Proportion of Head of Water (H)  
to Length of Pipe (L).

Results in Gallons Per Minute.

Diameter of Pipe.	H=10 L.	H=9 L.	H=8 L.	H=7 L.	H=6 L.	H=5 L.	H=4 L.	H=3 L.
Inches.								
1/2	19.8	18.7	17.7	16.5	15.3	14.0	12.5	10.8
5/8	34.5	32.7	30.1	28.9	26.5	24.4	21.5	18.9
3/4	54.4	51.7	48.7	45.6	42.2	38.5	34.4	29.8
1	111.8	106.0	100.0	93.5	86.6	79.0	70.7	61.2
1 1/4	195.2	185.2	174.6	163.3	151.2	138.0	123.4	106.9
1 1/2	308.0	292.1	275.4	257.6	238.5	217.7	194.8	168.7
2	632.2	599.7	566.4	538.9	488.1	447.0	399.8	346.3
2 1/2	1104.0	1048.0	987.8	924.0	855.4	780.9	698.5	604.9
3	1745.0	1651.0	1560.0	1460.0	1351.0	1234.0	1103.0	955.5
4	3581.0	3397.0	3203.0	2996.0	2774.0	2532.0	2265.0	1962.0
5	6247.0	5928.0	5588.0	5227.0	4839.0	4417.0	3951.0	3406.0
6	9855.0	9349.0	8814.0	8245.0	7633.0	6968.0	6233.0	5391.0

Diameter of Pipe.	H=2 L.	H=1 3/4 L.	H=1 1/2 L.	H=1 1/4 L.	H=1 L.	H=3/4 L.	H=1/2 L.	H=1/4 L.
Inches.								
1/2	8.8	8.3	7.7	7.0	6.3	5.4	4.4	3.1
5/8	15.4	14.4	13.4	12.2	10.9	9.5	7.7	5.5
3/4	24.3	22.8	21.1	19.3	17.2	14.9	12.2	8.6
1	50.0	46.8	43.2	39.5	35.3	30.6	25.0	17.7
1 1/4	87.3	81.6	75.6	69.0	61.7	53.5	43.7	30.9
1 1/2	137.7	128.8	119.3	108.9	97.4	84.3	68.7	48.7
2	282.7	264.4	248.8	223.5	199.9	173.1	141.4	100.0
2 1/2	493.9	482.0	427.7	390.4	349.2	302.4	246.9	174.6
3	780.2	728.8	674.8	615.9	555.5	477.1	390.1	275.8
4	1602.0	1496.0	1385.0	1264.0	1133.0	979.3	800.8	566.2
5	2791.0	2613.0	2420.0	2209.0	1976.0	1711.0	1394.0	987.7
6	4407.0	4122.0	3817.0	3484.0	3116.0	2693.0	2204.0	1558.0

Table Showing Pressure of Water at Different Elevations.

Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.
I	.43	195	84.47
5	2.16	200	86.63
10	4.33	205	88.80
15	6.49	210	90.96
20	8.66	215	93.14
25	10.82	220	95.30
30	12.99	225	97.49
35	15.16	230	99.63
40	17.32	235	101.79
45	19.49	240	103.96
50	21.65	245	106.13
55	23.82	250	108.29
60	25.99	255	110.46
65	28.15	260	112.62
70	30.32	265	114.79
75	32.48	270	116.96
80	34.65	275	119.12
85	36.82	280	121.29
90	38.98	285	123.45
95	41.15	290	125.62
100	43.31	295	127.78
105	45.48	300	129.95
110	47.64	310	134.28
115	49.81	320	138.62
120	51.98	330	142.95
125	54.15	340	147.28
130	56.31	350	151.61
135	58.48	360	155.94
140	60.64	370	160.27
145	62.81	380	164.61
150	64.97	390	168.94
155	67.14	400	173.27
160	69.31	500	216.58
165	71.47	600	259.90
170	73.64	700	303.22
175	75.80	800	346.54
180	77.97	900	389.86
185	80.14	1000	433.18
190	82.30		

Table Showing the Weight of Pipe Required for a Given Head (or Fall) of Water.

Head, or No. of Ft. Fall.	Pressure per Sq. Inch.	Calibre and Weight per Foot of Lead Pipe Required.												
		⅜ Inch.	½ Inch.	⅝ Inch.	¾ Inch.	1 Inch.	1¼ Inch.	1½ Inch.	1¾ Inch.	2 Inch.	2½ Inch.			
Fountain.		lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.
30	15 lbs.	0 6	0 8	0 10 13	0 12	0 14 14	0 12	0 12	0 12	1 8	2 0	2 8	3 0	3 0
40	20 "	0 10 12	0 12	0 14 8	0 14	1 0 8	1 12	1 12	1 12	2 8	3 0	3 8	4 0	4 0
50	25 "	0 12	1 4	1 12 0	1 4	2 0 8	2 0	2 0	2 8	3 0	4 0	4 0	4 8	5 0
75	38 "	1 0	1 8 12	2 4 8	2 8	3 0 8	3 0	3 8	4 0	4 8	5 0	6 0	6 0	6 0
100	50 "	1 4	2 0	2 12 0	2 4	3 0 0	3 0	3 0	4 0	5 0	7 0	7 0	10 0	10 0
150	75 "	1 4 8	2 8	3 4 8	3 8	4 8	4 8	4 8	6 0	6 0	9 0	9 0	12 0	12 0
200	100 "	1 8	3 0	4 0	4 0	5 0	5 0	5 0	7 0	7 0	12 0	12 0	15 0	15 0

The above weights of pipe are of sufficient strength to permit the water to be shut off (or stopped.) When the water is permitted to run continually, lighter weight can be used, say ⅔ above weights.

## EXAMINATION QUESTIONS.

1. Why is a trap placed under each fixture?
2. What is a trap?
3. Name some of the principal traps in use.
4. What is meant by the trap seal?
5. What is the ordinary depth of a trap seal?
6. What advantage does the main or intercepting trap possess?
7. What are the objections to the use of the main or intercepting trap?
8. What are the comparative merits of the S and drum traps?
9. What precautions should be taken with traps in unoccupied houses during cold weather?
10. What effect might the pressure of sewer gas on the trap seal have?
11. How may the pressure of sewer gas on the trap seal be relieved?
12. With a sink properly trapped below, what should be done with the bell on the sink strainer?
13. How should the cellar drainage trap be protected from evaporation?
14. What qualities should a trap possess?
15. Name different ways in which the seal of a trap may be broken?
16. Why are internal partitions in traps dangerous?
17. Why should traps with mechanical seals be prohibited?
18. Where may back vent pipes be connected together?
19. What is the difference between local venting and back venting?

20. What are the two principal traps on which nearly all other traps are based?
21. What style of trap should be used under a hotel or restaurant sink?
22. What is the result of double trapping?
23. Describe some grease trap.
24. What style of trap do you consider best for a bath tub, and why?
25. Why should traps be back vented?
26. Is it the amount of water or depth of seal that offers most resistance to sewer gas?
27. What are the advantages of a ventilated system of plumbing?
28. From which side of the trap should the back vent be taken?
29. What would be the result if the back vent were taken from the wrong side of the trap?
30. Is it the amount of water or depth of seal that offers the most resistance to syphonage?
31. Where should the back vent from a trap be carried?
32. Why should a back vent pipe enter the main vent above its fixture?
33. What should be the relative size of waste and back air pipes?
34. What material may be used for back venting?
35. What objection is there to black wrought iron pipe for back venting?
36. What fixture does not use the same size of pipe for both waste and back vent?
37. In what ways may water closets be back vented?
38. What is the distinction between soil and waste pipes?
39. What are the proper weights of soil pipe, standard and extra heavy?
40. How does back venting effect evaporation of trap seal?

41. Why should rubber vent couplings be prohibited?
42. Why is it wrong to vent from the water closet bowl?
43. How should the top and bottom connections of main vent with main stack be made?
44. What is the advantage of returning the main vent into the stack?
45. Where should the main vent be carried?
46. Why should the main vent enter the stack above the highest fixture?
47. Why should a stack be carried through the roof?
48. Why is it wrong to run a back air pipe into a chimney?
49. Why is a water closet at a long distance from the stack liable to syphonage?
50. What is understood by back pressure?
51. What causes sewer pressure?
52. How should a fixture eight or more feet from the stack be vented?
53. With long runs of vent pipe, what should be the increase in size?
54. What sizes of waste pipes should be used on the several fixtures?
55. What materials should waste pipes be made of?
56. What is the least fall allowed for waste and soil pipes?
57. Why should fixture wastes enter the stack independently?
58. What causes the gurgling sounds often heard in waste pipes?
59. Where should the drip pipe from a safe be run?
60. What is a safe, and what is its use?
61. What are the proper weights for lead pipe of the several sizes?

62. How should connections be made between waste pipes and stack?

63. How should connections be made between lead and wrought iron pipes?

64. How should horizontal and vertical soil pipes be supported?

65. What sizes of rod should be used for hangers?

66. How far apart should hangers be placed on horizontal soil pipe?

67. Why is it wrong to use a T on soil pipe?

68. How should a branch enter horizontal soil pipe?

69. How should a right angle turn in soil pipe be made?

70. Where should cleanouts be placed?

71. How deep should the lead be poured in a soil pipe hub?

72. What is the result if too much lead is used on a caulked joint?

73. Describe the process of making a caulked joint.

74. How is a horizontal caulked joint made?

75. How is a rust joint made?

76. How far should cast iron soil pipe be carried outside the foundation wall?

✓ 77. Why is it necessary to run the soil pipe beyond the foundation before entering drain tile?

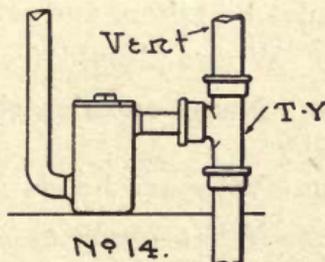
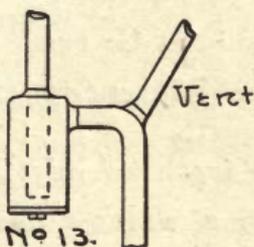
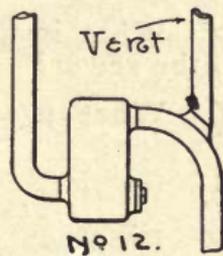
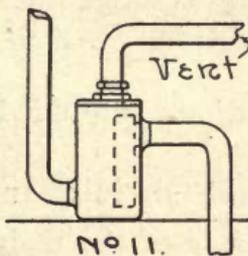
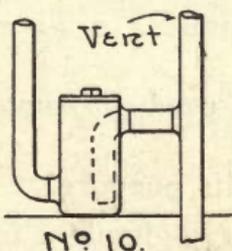
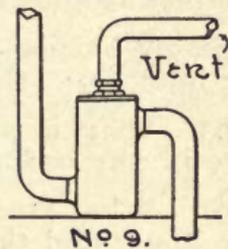
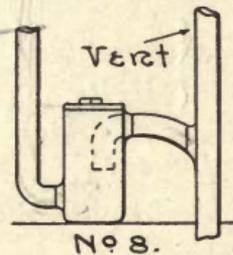
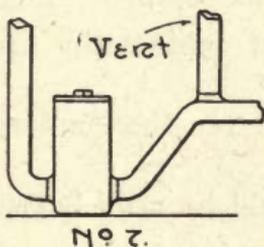
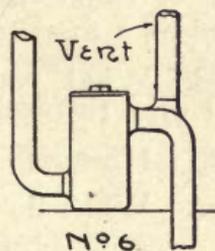
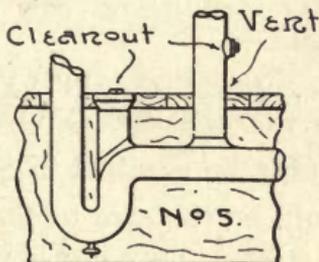
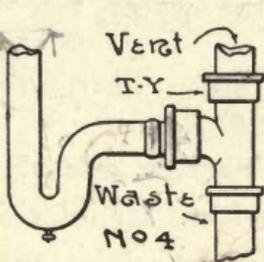
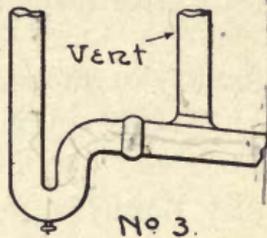
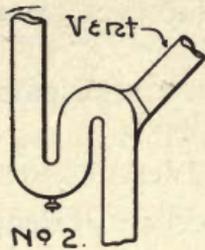
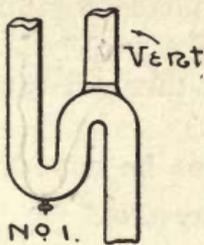
78. What should be done when the stack passes through the roof near a window?

79. Why should caps or screens be prohibited at the top of a stack?

80. What benefit is derived from carrying the stack through the roof?

81. How and where would you connect rain leaders into a main drain?

82. In what way does climate enter into the question of increasing the stack through the roof?



83. Describe the different tests applied to plumbing work.

84. Why should all stacks passing through the roof be increased to 4 inches?

85. Why should all lead connections be wiped?

86. Describe the cellar drainage system.

87. Under what conditions can the water test be used as a final test?

88. What precautions should be taken in running soil pipe through the cellar wall?

89. How can pipe be caulked in a narrow recess?

90. What should be the size of the fresh air inlet?

91. How and where should the fresh air inlet enter the main drain?

92. What is the disadvantage of taking the fresh air inlet from the main trap?

93. Why is a 4-inch soil pipe better than a larger size in any ordinary house?

94. What kind of drain pipe should be used between the house and the sewer?

95. What is the proper way of entering drain pipe into the sewer?

96. What precautions should be used in running drain pipe?

97. What is a fresh air inlet and its purpose?

98. From which side of the main trap should a fresh air inlet be taken, and why?

99. Where should fresh air inlet be run?

100. Name and describe the different types of water closets.

101. Why are bends in the fresh air inlet beneficial?

102. What qualities should a water closet have to be sanitary?

103. Under what conditions is a fresh air inlet in-operative when taken through the roof?

104. With the main trap not fresh aired, what might be the effect on a syphon water closet?
105. Why should cistern or tank closets be used?
106. Name advantages of modern water closets over the old styles.
107. Why is it wrong to salt an earthen water closet?
108. Explain the local vent.
109. Of what material should local vents be made?
110. Where should a local vent be carried?
111. Where should a local vent be connected to a water closet?
112. At what height should a flush tank be set?
113. Describe the setting of a modern water closet.
114. Why are rubber ells used on the flush pipe?
115. Why is a syphon water closet comparatively noiseless?
116. What is the objection to placing plumbing fixtures in dark places?
117. Why would an unvented water closet be liable to syphonage if located at a long distance from the stack?
118. What sizes of flush tanks are used?
119. What two methods of local venting are in use?
120. What advantages does the independent system of local venting have?
121. How can the draught for a local vent be increased?
122. What should be the size of local vents?
123. Name some general requirements of local venting.
124. Why should not the local vent be carried into a soil pipe stack?
125. How should chimney connections for local vents be made?

126. What are the melting points of wiping and bright solder?
127. Why is the top part of a joint wiped first?
128. How is the syphon applied advantageously to plumbing work?
129. Explain the syphon tank.
130. Why does overheating spoil solder?
131. Explain the construction of a cesspool.
132. How is the syphonage of traps prevented?
133. How may a boiler be syphoned?
134. Can the cistern boiler be syphoned or not, and why?
135. How is solder made?
136. Why should wiping solder be stirred when being used?
137. In what way is syphonage a detriment to the plumbing system?
138. What precautions should be taken in locating a cesspool?
139. How high can water be raised by atmospheric pressure?
140. What causes solder to stick to the cloth?
141. How should a bursted pipe be wiped?
142. Explain the preparation of a joint for wiping.
143. Explain the syphon and its action.
144. Describe different ways in which a trap may be syphoned.
145. How far should a horizontal branch waste be carried from the main soil pipe without extending it through the roof?
146. What is the result if there is too much lead in wiping solder?
147. If the wiping cloth is rough how would you remedy it?
148. How may the action of a syphon be destroyed?

149. Explain how syphonage may be used in procuring water supply.

150. Why cannot a liquid be syphoned from a lower to a higher point?

151. Explain the intermittent syphon.

152. Should a cesspool be vented or not, and why?

153. Should the main trap be used in connection with a cesspool?

154. Describe methods of supplying the kitchen boiler with water.

155. How would you treat a joint to give it a mottled appearance?

156. What is the proper width for the different wiped joints?

157. How can a flaw on a wiped joint be remedied?

158. How do you test solder for the proper heat for wiping?

159. Describe cup and overcast joints.

160. How would you restore overheated solder?

161. How would you purify solder containing zinc?

162. Why is grease rubbed onto pipe before wiping?

163. Describe a vacuum valve.

164. Where there is no vacuum valve, what should be done?

165. What is an expansion pipe, and its use?

166. What causes noise in a hot water system?

167. Why does a boiler collapse?

168. Name different ways of securing a water supply in the country.

169. Why is the cold water pipe taken to the bottom of the range boiler?

170. Explain the double boiler and its use.

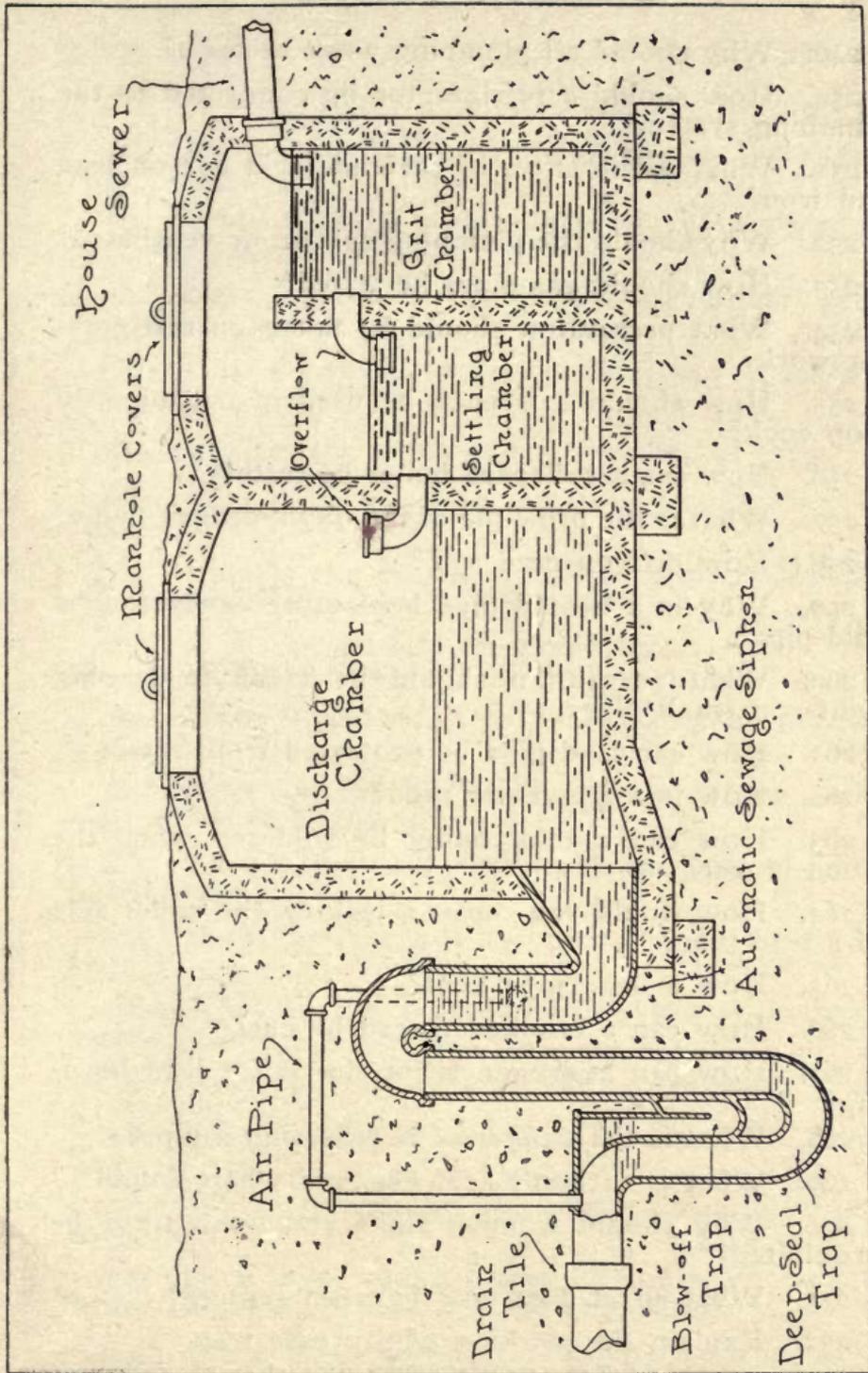
171. What is the advantage of a circulating system?

172. Where should the return pipe be connected to the pressure boiler?

173. How should lead pipes be supported?
174. At what intervals should lead pipe be clipped up?
175. If street pressure is not sufficient to raise water to the desired height, how can it be done?
176. How should circulation pipes be arranged?
177. What should be the relative difference in temperature to insure good circulation?
178. What is the object of the sediment cock, and where placed?
179. What may be done to protect pipes from frost?
180. What are the causes of chattering when the faucet is opened?
181. How can water be shut off on a main not supplied with a stop cock?
182. Why do flow pipes give out oftener than return pipes?
183. Practically, how high can water be raised by an ordinary pump?
184. Theoretically, how high can water be raised?
185. What makes the difference between the theoretical and practical height to which water can be raised?
186. What causes a water front to burst?
187. Why should the room in which a storage tank is located be ventilated?
188. What is a good size of supply tank for range boiler?
189. Explain the action of a pump.
190. Can water be drawn from so great a depth at a high elevation as at the sea level?
191. What is the purpose of an air chamber?
192. Explain the action of the hydraulic ram.
193. Explain the action of the lift-force pump.
194. How may an air chamber be destroyed?

195. Explain the deep well pump.
196. What is the least fall under which the hydraulic ram will work?
197. What is the relative size of the drive and delivery pipes of a ram?
198. How high will a ram raise water?
199. What is a vacuum?
200. How does friction affect water supply?
201. Explain distillation.
202. How should the bottom end of a suction pipe be arranged?
203. How would you proceed to repair a pump?
204. What is atmospheric pressure?
205. What is the pressure of the atmosphere per square inch at the sea level?
206. Why is atmospheric pressure less at the top of a mountain than at the foot?
207. How does atmospheric pressure apply to pump work?
208. Why does heated air rise?
209. In what way is the rising of heated air applied to local venting?
210. Explain evaporation and its causes.
211. What is fusion?
212. What is a flux?
213. What is an alloy?
214. Under what conditions will water absorb gases most readily?
215. Does water expand or contract in freezing?
216. Name some freezing mixture.
217. What is capillary attraction?
218. Why does oil in water prevent its freezing?
219. What force is exerted by frost?
220. What is a dead end?

221. What is a by-pass?
222. What is air lock?
223. Explain the bursting of pipes by frost.
224. At what temperature does water boil?
225. What is the melting point of lead and tin?
226. Explain gravitation.
227. Why does water that has been heated freeze more readily than other water?
228. What is a crown vent?
229. At what temperature does water freeze?
230. What is centrifugal force?
231. How is centrifugal force applied in plumbing?
232. Why is water called hard?
233. What characteristics are noticeable in pure water?
234. How may a vacuum be formed in a waste pipe?
235. When a vacuum forms in a waste pipe what is liable to occur?
236. Explain the value of filters.
237. Explain the value of circulation.
238. What is superheated steam?
239. Why is rain water soft?
240. What is specific gravity?
241. Of what is water composed?
242. At what temperature is water most dense?
243. Why does water take a spiral motion when running through a pipe?
244. Of what is air composed?
245. What is the effect of oxygen and hydrogen on animal life?
246. Why is there more nitrogen than oxygen in air?
247. Why do some pipes not burst when frozen?
248. What is a tell-tale pipe, and where should it run?



THE SEPTIC TANK AND AUTOMATIC SEWAGE SIPHON.

249. Why should all plumbing work be open?
250. How should a refrigerator be connected to the plumbing system?
251. What is the effect of carbonic acid gas on lead and iron?
252. Why should the plumbing system be ventilated?
253. How should gas pipes be tested?
254. What precaution should be taken on refrigerator work?
255. How should a wrench be used in putting in a stop cock?
256. How can a collapsed boiler be restored?
257. What is the principle of the oxyhydrogen flame?
258. How do you read a T?
259. Why is a heated pipe bent more easily than a cold pipe?
260. What precaution should be taken in leading joints on small pipe?
261. How can lead pipe be protected from rats?
262. How is a gas meter read?
263. How can a tank lining be soldered when the wood is wet?
264. How would you repair a leak on the under side of a lead pipe?
265. How is lead pipe bent?
266. How can a crooked thread be cut?
267. How can hydrogen be produced for lead burning?
268. What is the danger of overheating a pipe?
269. What is carbonic acid gas, and where found?
270. Why should wooden sinks and wash trays be prohibited?
271. What effect does cold have on sewage?
272. Explain the working of a grease trap.
273. How should a putty joint be made?

274. How many cubic inches are there in a gallon?
275. What is the weight of a gallon of water?
276. How many gallons of water are there in a cubic foot?
277. What are the proper heights for setting the different fixtures?
278. How do you find the contents of a square tank? Give example.
279. How do you find the contents of a cylindrical tank? Give example.
280. Explain the cause of the sweating of pipes.
281. Why should a flow pipe be larger than the return?
282. How is the circumference of a circle found if the diameter is known?
283. How do you find the pressure per square inch, the head being known?
284. How do you find the head when the pressure is known?
285. How can the lateral pressure of water on the side of a tank be found?
286. Why is the supply taken to the bottom of the range boiler?
287. Why does the hot water rise to the top of the boiler?
288. What is the objection to bowls with patent overflow?
289. What is a check valve, and where used?
290. What weight of lead should be used for a tank lining?
291. Where should the overflow from an attic tank be taken?
292. How long would it take to empty a 100-gallon boiler through a 1-inch pipe, 10 feet long?
293. What is the diameter of a pipe equal in capacity to a 2-inch, 1½-inch and 1-inch pipe combined?

294. What would be the size of a tank 5 feet deep that holds 500 gallons?
295. What is the weight of water in a tank holding 200 gallons?
296. Why are submerged ball-cocks objectionable?
297. If more than two water closets are to be back aired, what size of pipe should be used?
298. If the back air pipes from a lavatory and from a bath tub are run together, what size must be used beyond?
299. How far from a window may a vent pipe terminate?
300. How far should soil pipe extend above the roof?
301. How far should the fresh air inlet terminate from doors and windows?
302. Where should the back air pipe connect onto a trap?
303. Why should a room be ventilated near the floor?
304. Why should a room be ventilated near the ceiling?
305. If sent to a house on complaint of escape of sewer gas, how would you proceed to find the leak?
306. Why is a boiler tube carried to the bottom of a boiler?
307. How would you protect a water closet from freezing?
308. How would you apply the final test to a plumbing system?
309. What causes hammering in the range boiler?
310. Describe a circulation hot water supply job.
311. Name the causes of poor circulation between the range boiler and the water front.
312. How should the range boiler be connected to the water front when located on the floor below it?
313. What is the result of a sag in the flow pipe between range and boiler?

314. What is a septic sewage tank, and where used?
315. What is a stop-and-waste cock and where used?
316. What is friction?
317. What is a flap valve?
318. Name essential points in connecting the house drain with the sewer.
319. Describe a syphon.
320. What is the objection to too great depth of trap seal?
321. In what ways may a trap lose its seal?
322. What kinds of wood are best for tanks?
323. What is a tell-tale pipe?
324. What is the continuous vent?
325. What are the advantages of the continuous vent?
326. In what way is the local vent applied to urinals?
327. Name different styles of urinals used in public buildings.
328. Show different methods of connecting inlet and outlet pipes to the drum trap.
329. What are the relative advantages of these different methods?
330. Show different methods of venting S traps.
331. What are the relative advantages of these different methods?
332. How may a cleanout be attached to a bath S trap so that it may be accessible from above?
333. Is a cleanout on the trap vent of value?
334. Describe the proper plumbing of a horse-stall.
335. How may a water closet be properly vented other than from the lead bend?

336. How may a cesspool be so constructed as to have the advantages of both the leeching and the water-tight cesspool?
337. Describe a system of subsoil disposal of sewage.
338. What is the Durham system of plumbing?
339. What are the advantages and disadvantages of the Durham system?
340. How may the water closet or any other fixture be installed without the use of lead work?
341. Describe the plumbing for a line of refrigerators.
342. Describe the operation of an automatic sewage lift.
343. How is sewage disposed of, which collects at points below the sewer level?
344. What is meant by the "roughing-in" of a plumbing system?
345. How is the plumbing system prepared for the water test?
346. Name the different methods and requirements for supporting soil-piping.
347. Compare the siphon-jet and washout water closets.
348. Should the use of non-syphonable traps without vents be allowed?
349. What is the chief cause of trap vents becoming useless?
350. What style of venting is attended by the least amount of trap vent stoppage?
351. Why does water freeze at the surface first?
352. Why does salt prevent water from freezing?
353. What is ventilation?
354. What is the best way to protect the ends of soil pipe from the entrance of refuse?
355. Name different ways of protecting pipes from frost.

356. Explain why a mixture of salt freezes water pipes.
357. How can it be proven that the air of a room is in constant motion?
358. Why does smoke rise in a chimney?
359. Why is a short chimney liable to have poor draft, and why is a very large chimney also liable to the same trouble?
360. What substances are the best conductors of heat?
361. What substances are the poorest conductors of heat?
362. Why are liquids poor conductors of heat?
363. Why will oil on the surface of water prevent freezing?
364. To what temperature can water be heated if exposed to the air?
365. When is steam visible?
366. What is the effect of carbonic acid gas on life?
367. What is a splash stick, and what is its use?
368. How should very high stacks be tested?
369. How is air-lock caused on the drainage system?
370. How is air-lock caused on hot water supply pipes?
371. Explain the action of the automatic cellar drainer.
372. What is the purpose of the automatic cellar drainer?
373. Explain the action of an automatic flush tank.
374. Explain the action of an automatic sewage siphon.
375. What is a blind vent, and what may be said against it?
376. Name various points on the drainage system where cleanouts should be located.
377. What is a circuit vent?

378. What is a loop vent?
379. On what particular classes of work are circuit and loop vents of value?
380. Describe the harmful action of electrolysis on underground piping.
381. What is a soil vent?
382. What is a waste vent?
383. What is a house drain?
384. What is a house sewer?
385. Is it proper to serve a line of lavatories or sinks with one trap?
386. Explain the pneumatic water supply system.
387. Give some of the requirements in running rain leaders.
388. Give some of the requirements in installing floor and yard drains.
389. What is a surface sewer?
390. What is a standing overflow?
391. What are the advantages of a submerged trap cleanout?
392. What is the action and purpose of an automatic sump tank?
393. What may be said concerning the lighting and ventilation of toilet rooms?
394. Why is the continuous vent preferable to the crown vent?
395. Why are individual water closets preferable to range water closets?
396. Why are recessed drainage fittings used on drainage systems?
397. Why should a leeching cesspool be located as close to the surface of the ground as possible?
398. Why should metal not be exposed in the construction of a urinal?
399. Why should not wrought iron drainage pipe be used underground?
400. What is the principal argument against the use of the main trap?

## APPENDIX.

### What is continuous venting?

Several examples of continuous venting are shown in illustration on page 123. It consists, as shown in No. 1, of connecting the outlet from the trap directly into a vertical fitting, the bottom of the fitting serving as a waste, and the top serving for the vent connection. Nos. 2, 3 and 4 show other examples of this method. In the case of the water closet, continuous venting is obtained by continuing the branch soil pipe, full size, beyond the line of water closets and upward through the roof or into a line of vent. Through this line the water closet traps are supplied with air, and it is claimed that the results are as satisfactory as when each water closet is separately vented.

### What is the advantage of continuous venting?

There is far less danger of such a vent connection becoming fouled with grease, etc., and finally closing up. The supply of air is brought in less directly upon the trap seal, and consequently the rate of evaporation is lessened. In many instances continuous venting results in a saving of expense both in material and labor.

What kind of fittings are generally used on the connection for a continuous vent for other fixtures than water closets?

Fittings of the T—Y style are generally used for this purpose.

Why may not Y branches be used for this purpose?

On most work the Y branch would bring the vent connection too low to properly guard the trap against syphonage.

In what special way may the continuous vent principle be applied to a stack which serves fixtures on two floors only?

When the fixtures are conveniently located, as on opposite sides of a partition, the plan shown in illustration No. 3, on page 123 may be followed with a considerable saving in expense.

Why could not this plan be followed if waste from more than two floors entered the stack?

For the reason that the waste from the third floor would necessarily have to enter a pipe which served as a vent for one of the other floors.

What are the relative advantages of different methods of venting S traps?

Referring to illustration on page 105 we give four methods of venting.

That which is most acceptable is No. 4, which illustrates the continuous vent, of which we have just spoken, naming its advantages.

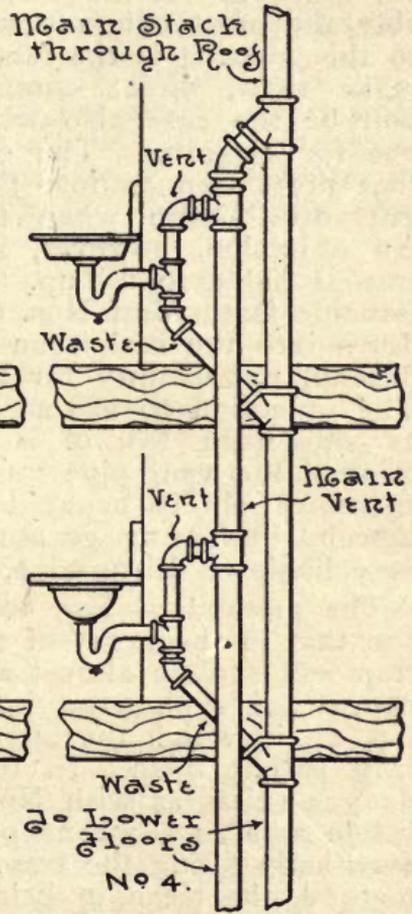
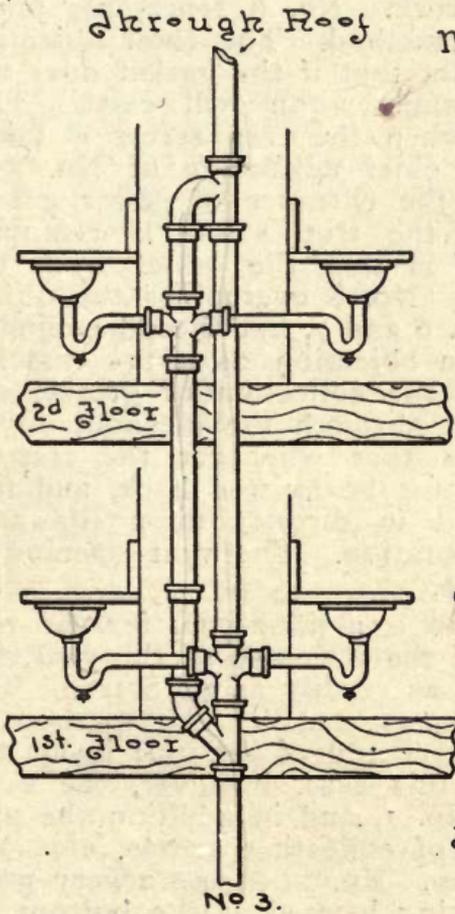
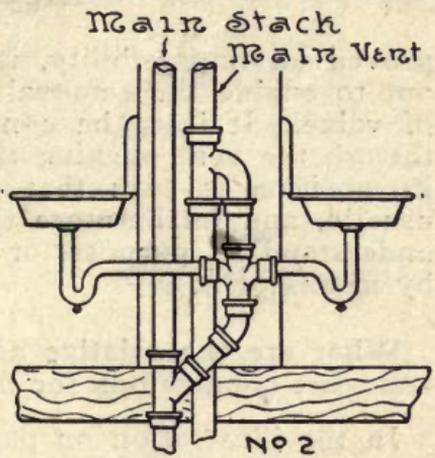
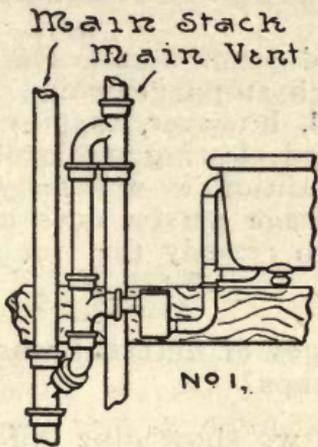
No. 1 shows the vent taken off the crown of the trap. This method causes direct contact of the air supply with the seal, causing evaporation at its highest rate. The vent connection is almost certain to fill up eventually as is that of No. 2 also. No. 2 has the advantage of bringing the air in less direct contact with the seal however. In the case of half-S and  $\frac{3}{4}$ -S traps, the vent may often be placed at a considerable distance from the seal and still protect the trap, and with less danger of stoppage of the vent opening. In order to ensure a good supply of air, however, it should not be placed at a level lower than that of the trap seal.

How may a cleanout be attached to an S bath trap so that it will be accessible from the bath room without the removal of flooring?

Such a cleanout is shown in No. 5 in the illustration on page 105.

Is a cleanout on the trap vent of value?

It is needless to say that vents should be so constructed as to be free from stoppage, but as this has



CONTINUOUS VENTING.

proved an impossibility, it would seem that a clean-out to enable the removal of such stoppage would be of value. It is to be considered, however, that even though the vent opening may need clearing out badly, its position is such that its condition is not known usually, and furthermore the average person does not understand its purpose, or how to remedy the trouble by means of it.

**What are the relative advantages of different waste and vent connections for drum traps?**

In the illustration on page 105 we show nine different methods for this work. No. 6 represents probably the most common method. The chief objection to this method is the fact that if the gasket does not make tight, direct communication will exist. This will be the case also when the trap screw is taken out for cleaning. The chief advantage of No. 7 is that protection against the entrance of sewer gas is guaranteed even when the trap screw is removed. An objection, however, is that the outlet from the trap is liable to fill up. No. 8 overcomes the objectionable features of Nos. 6 and 7, but the pipe dipping down into the seal is an objection, as it presents additional opportunity for the collection of grease, etc. The objection to a vent through the cleanout cover, as shown in No. 9, is that whenever the trap is cleaned the vent pipe must be twisted back, and furthermore air is brought in directly upon the seal, thereby increasing evaporation. The vent opening is very liable to fill up also.

The method of Fig. 10 is a poor one, for the reason that in the event of the stoppage of the vent, the trap will syphon almost as readily as an S trap. The danger of syphonage is averted by the method of No. 11, in which the upper end of the pipe inside the trap is left open. In this case, however, the same danger exists as with No. 1, and in addition the pipe inside acts as a means of collecting grease, etc., and eventually filling the trap. No. 12 shows a very good method, the cleanout being located at the bottom, so that when the gasket is not tight the fact is made known by leakage. The cleanout in this position also enables the contents to be cleaned out very readily. No.

13 shows the same advantage as No. 12, although the presence of the pipe inside the trap is objectionable. No. 14 shows an example of continuous venting, the advantages of which have been previously explained. Continuous venting applied to No. 12, we believe will make a very satisfactory method.

**Is the local vent applied to other fixtures than water closets?**

It may be used to advantage on slop sinks, and on urinals, especially in the case of the latter fixture when used in public toilet rooms.

**How is the waste from a line of urinals disposed of?**

A common practice is the use of slate urinals, provided with perforated flush pipes which continually wash the surface of the slate, the flush entering a gutter at the back of the urinal stalls. The gutter is graded and delivers its contents into the drainage system through a trap properly vented.

Another common method is the trapping of each separate urinal, the waste from each generally entering a horizontal line of brass waste pipe running behind the back of the stalls. Continuous venting may be applied to advantage in this work.

A third method, but somewhat expensive, and particularly applicable for comfort stations, is the use of porcelain or earthenware stalls, the upper surface of the floor slab being counter-sunk so that all liquids drain to the center, where they enter the drainage system through separate traps. These traps may be supplied with a local vent leading to a heated flue.

**Describe the plumbing for a horse-stall.**

For this purpose there is made a special sink, the four sides of which pitch to the centre, which is provided with a guard to prevent the passage of heavy substances. This sink is set lengthwise of the stall, and toward its entrance, and above the sink is set a hinged trap door, made with sufficient spaces to allow liquids to pass freely into the sink. The connec-

tion to the sink is arranged so that it may be calked directly into the hub of cast iron pipe. The waste for the horse-stall is of cast iron pipe, and should be provided with a trap properly vented. Two inch pipe is generally used for a single stall.

**In what other way than from the lead bend, may a water closet be properly vented?**

It may be vented from the vent hub of a vented T—Y, or from the vent hub of a vented sanitary tee, of which there are several different forms.

**What is the flush valve and its use?**

The flush valve is a device in several different patented forms, used for the flushing of water closets, whereby the use of a flush tank is avoided. The valve is opened by means of a lever or push button, is of the slow closing type, and before automatically closing, will deliver sufficient water to thoroughly flush the fixture.

**In what ways is the flush valve operated?**

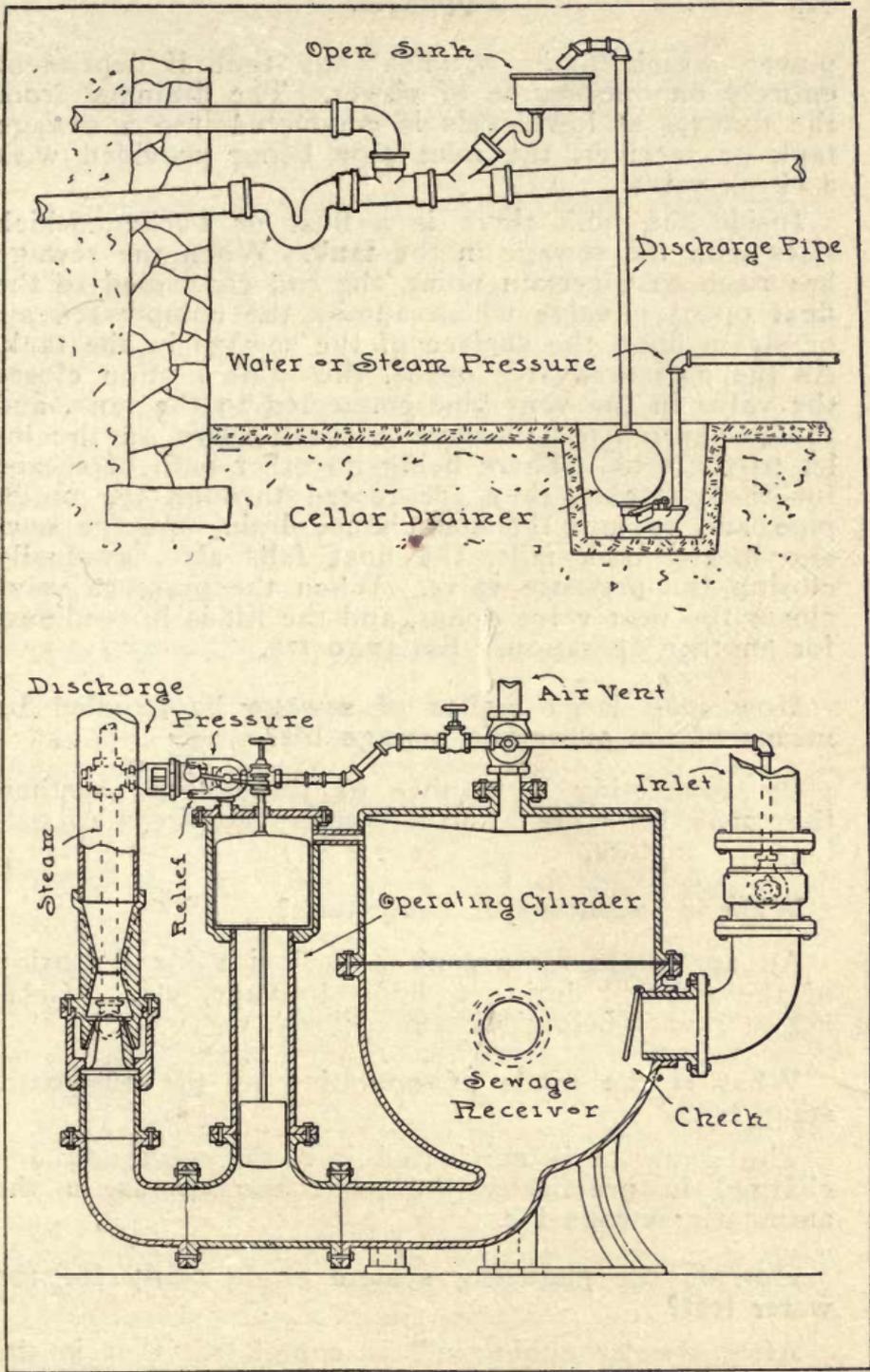
It may be operated either by direct pressure or by tank pressure.

**How is the sewage from fixtures located below the sewer level disposed of?**

It is sometimes carried into a receiving tank or cesspool located at a lower level than that of the lowest fixture, and forced by pumps into the main house sewer. Generally however, especially in the case of large city buildings, it is disposed of by means of special apparatus known as automatic sewage lifts, of which there are several patented forms.

**Give a general description of the operation of the automatic sewage lift.**

This device is operated by various means, including water pressure, steam, electricity, and compressed air. They are usually provided with cross connections arranged so that either of two sources of power may be used. This is done to provide against the disabling of the entire system due to a breakdown in



THE AUTOMATIC CELLAR DRAINER.  
THE AUTOMATIC SEWAGE LIFT.

power, which might occur at any time if dependent entirely on one source of power. The drainage from the fixtures at low levels is conducted into a sewage tank or receiver, the inlet pipe being provided with a check valve.

Inside the tank there is a float or bucket, which rises with the sewage in the tank. When the sewage has risen to a certain point, the rod connected to the float opens a valve which admits the compressed air or steam upon the surface of the sewage in the tank. As the pressure valve opens, the same motion closes the valve in the vent pipe connected to the tank, and the pressure itself closes the check valve on the inlet to the tank. There being no other path of escape for the contents, they are forced through the outlet pipe, and up into the main house drain. As the sewage in the tank falls, the float falls also, gradually closing the pressure valve. When the pressure valve closes the vent valve opens, and the lift is in readiness for another operation. See page 127.

**How may large bodies of sewage be handled by means of the automatic sewage lift?**

By connecting a number of these lifts together, they may be made to handle many hundreds of gallons per minute.

**What is an automatic sump tank?**

An automatic sump tank is a device for disposing of the sub-soil drainage, floor drainage, etc., collecting at points below the sewer level.

**What is the mode of operation of the automatic sump tank?**

The drainage is conducted into the tank and discharged in practically the same manner as in the automatic sewage lift.

**How is the plumbing system made ready for the water test?**

After the "roughing-in" is completed, that is the soil-piping and venting, but before the fixtures and their traps are placed in position, all waste and vent

ends are closed by soldering or capping, and all soil pipe openings closed with the exception of the roof pipe. The system is then ready for the water to fill it.

**Describe a properly constructed refrigerator drip pan.**

The box used for this purpose should be so lined that the lining will pitch from all sides sharply to the outlet hole, in order to allow sediment to drain off as much as possible. To the under side of the pan the refrigerator pipe should be soldered. Just below the top of the pipe a strainer should be placed inside the pipe, to prevent the passage of foreign substances, and a screw cleanout should be placed in the outlet where it enters the pan, to allow the waste to be capped over during the part of the year when the refrigerator is not in use.

**What is the Durham system of plumbing?**

In operation and in all its principles, the Durham system does not differ from the ordinary system of plumbing. The only difference between the two systems is that the piping of the Durham system is of wrought iron or steel, and all joints are screw-joints.

**What style of fittings are used on the Durham system?**

Cast iron screw fittings of the recessed style.

**Why are recessed cast iron fittings better adapted to drainage work than fittings such as steam or water fittings?**

For the reason that in using recessed fittings, the inside of the fitting and the inside of the pipe line up, while in the use of other fittings the pipe projects inside the fitting, forming shoulders with sharp edges, at which points accumulations of lint, etc., may easily collect. The use of recessed fittings is not accompanied by this objectionable feature.

**What is the chief advantage claimed for the Durham system?**

It is claimed by advocates of the Durham system that owing to the fact that a screw joint is as strong and rigid as the pipe itself, the Durham system is stronger and more substantial than the common cast iron system.

**What great objection is there to the Durham system?**

Experience shows that for drainage purposes, pipe of wrought iron or steel is far shorter lived than cast iron pipe. The result is that while the cast iron system lasts indefinitely, the Durham system must be renewed or pulled out after a period of years.

**In installing the Durham system, what course is followed regarding underground piping?**

All underground piping must be of cast iron with calked joints, for the reason that the wrought iron or steel pipe rusts out so much more rapidly.

**Is the use of lead increasing in favor?**

Much of the best and largest work is now being installed without the use of any lead pipe whatever.

**How may the water closet be installed without the use of lead bend?**

By the use of a floor flange which either calks or screws into the soil pipe, and the use of cast iron fittings.

**Why is the use of the ordinary leeching cesspool often to be looked upon with disfavor?**

After a time the joints and crevices of the cesspool fill up with solid matter, and if there is no overflow to carry the liquid portion of the waste to a second cesspool, the cesspool overflows, saturates the surrounding soil, and in many ways becomes a nuisance.

**How may a cesspool be constructed so that it shall have the advantages of both the water-tight and the leeching cesspool?**

An excavation is first made of considerably greater dimensions than the cesspool itself. The bottom is filled in with a heavy foundation of broken stone, and upon this the brick cesspool with brick bottom is built. A considerable space should be left between the brick work and the excavated ground on all sides, this space being filled with broken stone. The brick cesspool is made water-tight by means of a coating of Portland cement inside. The top should be arched somewhat, and provided with a manhole cover. At a proper height overflow pipes should be cemented into the brick-work, all on the same level. The outer end of the overflows should terminate at the center of the broken stone filling. By means of the overflows, the liquid portion of the contents of the cesspool are carried off, and allowed to leech off through the surrounding soil, while the solid portion is retained in the cesspool, and may be emptied when desired. The solid matter should never be allowed to rise to such a point that it may pass out through the overflows or close them up.

**Why should a cesspool not be located too low in the ground?**

For the reason that the bacteria of the soil, which attack and disintegrate the impurities of the sewage, must have air to live upon, and the air does not reach them at levels far below the surface.

**When there is no system of sewers to handle the sewage from a residence, institution, or from a number of dwellings, how may this work usually be accomplished?**

By means of a septic sewage tank for receiving the waste, in connection with an automatic sewage siphon, by means of which the contents of the septic tank are siphoned off onto filter beds, into a system of underground filtration, or other means of final disposal.

**Give a general description of the construction and operation of the septic tank.**

As generally constructed it consists of three or more separate compartments, the plant being located

underground usually. The sewage is delivered directly into what is known as the grit chamber, which connects by overflow with one or more settling chambers. Most of the solid matter remains in the grit chamber, the liquid overflowing into the settling chamber or chambers, and becoming clearer in each successive compartment. From the last settling chamber it overflows into the discharge chamber, connected to which is an automatic sewage syphon. (See page 113.)

**Explain the action of the sewage syphon.**

This is a device made in several patented forms, all working somewhat on the same principle. The syphon is connected to the discharge chamber of the septic tank at its outlet. When the sewage in this chamber reaches a certain height it automatically starts the syphon which quickly syphons off the contents, delivering them into a pipe which conveys the sewage to the point of final disposal. (See page 113.)

**Explain the chemical or bacterial action that takes place in the septic tank and is essential to its proper operation.**

It will be seen that under ordinary conditions the heavy matter entering the tank, if carried off would foul the filter bed or sub-soil system very quickly, and if allowed to remain in its original state, would quickly fill the grit and settling chamber with disastrous results to the proper working of the plant.

Experiments of recent years have proved, however, that bacterial action, if allowed sufficient opportunity, will completely disintegrate and liquify almost all solid matter, even substances such as leather, bones, etc., provided it is of animal or vegetable matter. The bacteria which perform this work multiply rapidly, and live on the surface of the sewage and on the sides of the different compartments of the tank. It is essential, however, that they be left undisturbed. Consequently the entrance of waste and the overflow must be accomplished with as little commotion as possible. The solids rise to the top and form a sort of scum or crust, and upon the under side of this the bacteria make their strongest attack. In a very few hours bacterial action will disintegrate and liquify

most substances naturally entering the sewage. It is essential that the operation of the syphon be at sufficiently long intervals to allow this bacterial action to take place completely.

### **Why does water begin to freeze at the surface?**

For the reason that the surface is in contact with the air, and the air absorbs and carries away the heat of the water.

Water being a poor conductor, it is slow in freezing below the surface, only freezing as the water next to the ice becomes chilled and the heat contained passes out into the air through the pores of the ice.

### **Why does salt prevent the freezing of water?**

Salt water freezes much more slowly than fresh, a temperature 25 degrees below freezing point being required in the freezing of salt water. This explains why salt thrown upon ice causes it to melt. The salt dissolves the crystals of ice, thereby forming a fluid. Whenever a solid is converted into a fluid, heat is absorbed, and the cold thereby made more intense. This explains why a mixture of salt and ice is a freezing mixture.

### **What is ventilation?**

Ventilation is a continual change of air.

**How can it be proven that the air of a room is in constant motion?**

If a flame is held near the crevice at the top of a door, it will be noticed that the flame is blown outward, while if it is placed near the crevice at the floor, the flame will be blown inward.

### **Why does smoke rise in a chimney?**

Because the air in passing over the fire becomes heated and therefore lighter, consequently rising, and carrying the smoke with it up through the chimney.

### **Why is a short chimney liable to have poor draft?**

Because the smoke simply rolls out of the chimney before it has attained full velocity, and as the rarified

air passes very slowly up the chimney, fresh air flows equally as slowly toward the fire to supply it with oxygen.

**Why is a very large chimney liable to have poor draft?**

Because the flue is so large that much of the air which goes up the chimney does not become heated, and mixing with the cold air, ascends very slowly.

**What are soil and waste vents?**

A soil vent is that part of a soil stack which is above the waste entrance of the highest fixture on it, and a waste vent is the same part of a waste stack.

**How should batteries of lavatories and sinks be trapped?**

Long lines or batteries of fixtures such as lavatories and sinks should have each fixture individually trapped.

**Why is it unsanitary to use one trap only to serve a long line of fixtures?**

For the reason that there must necessarily be a long line of fouled waste pipe which will throw out foul odors into the room through the waste outlet of each fixture.

**What is meant by the conduction of heat?**

The transmission of heat from one body to another, when the two bodies are in contact.

**What materials convey heat most readily?**

Metals, such as gold, silver, platinum, iron, zinc, and tin.

**What materials are particularly poor conductors of heat?**

Light and porous bodies, such as fur, wool, charcoal, wood, etc.

**Are liquids good conductors of heat?**

They are not, for the reason that when they are heated, evaporation takes place, and the water passes off in the form of vapor.

**How does the presence of oil prevent freezing?**

When oil rests on the surface of a liquid, it prevents heat from leaving the liquid, as it is a poor conductor. In this way it prevents the freezing of the liquid.

**Can water in an open vessel be heated above 212 degrees?**

It can not, for the reason that at this temperature it is converted into steam, and passes off as a vapor.

**Is steam visible?**

It is not, but in coming in contact with the air it condenses into small drops which are visible.

**What are the effects of carbonic acid gas?**

It acts like a narcotic poison, and if in sufficient quantity is fatal.

**What is the chief source of carbonic acid gas?**

It is generated in the decomposition of vegetable and animal matter, and is thrown off in the breath of human beings and animals.

**What is the best method of testing stacks in very high buildings?**

Such stacks should be tested in sections of not more than 75 ft. in length. If the water test is applied to an entire stack of great length, the pressure of such a high column of water would be enormous, and far greater than the piping should be expected to stand.

**What is meant by a blind vent?**

It sometimes happens in the plumbing of houses in places that are not subject to plumbing ordinances and inspection, that unscrupulous workmen will carry the vents from fixtures back to the wall, ending them at this point without connecting them into a main line of vent. They are sometimes left open, and sometimes closed with a rubber packing. Such a vent is called a blind vent, and is of the most unsanitary nature, as through the vent, direct communication with the sewer exists.

**How close to the surface of the ground should a leeching cesspool be located?**

It should set as close to the surface as possible. The reason for this is that the bacteria which exist in the soil, and the action of which purifies the liquids leeching from the cesspool, exist only within a very few feet of the surface. They depend upon air for life, and as the air does not penetrate sufficiently to lower depths, they cannot live at such levels.

**What kind of pipe should be used for drainage underground?**

Inside the foundations of buildings nothing but cast iron pipe should be used underground, and outside either cast iron or earthenware pipe.

Wrought iron, even though galvanized, should not be used underground, as it is readily attacked by moisture and various substances contained in the earth, and its length of life is therefore very short.

**What is the cause of air-lock?**

Air-lock is a frequent trouble on both the drainage and the hot water supply system. On the drainage system it is caused principally by double trapping, under which circumstances the air standing between the two traps prevents the easy passage of waste with the consequent greater liability of stoppage. In the case of hot water supply systems, unless properly piped, air will collect at high points, and seriously effect the circulation.

**What section of the drainage system is called the house sewer?**

That section of the drainage system which extends through the cellar, into which all soil and waste stacks and branches deliver their waste. The house drain extends just outside the cellar wall, where it connects into the house sewer.

**What section of the drainage system is called the house drain?**

That section of the drainage piping, usually running from the point where the house drain ends, to the sewer in the street.

In what manner are underground drainage, water and gas pipes seriously effected by electric currents?

The action of electrolysis is essentially the action of the electric battery, which consists of two metallic plates in a saline solution.

As is well known, in the action of the battery, one of the plates constantly wears away. The same action takes place underground in many cases, due principally to the escape of the electric current from electric railway circuits, the pipes in this case representing that metal in the battery which is attacked and destroyed. Generally the electric current of the railway system is carried from the power station through heavy wires, and returns through the tracks. The latter are not insulated or protected in any way, and if the current finds an easier passage through some nearby pipe than through the rail, it will jump from the latter into the pipe, later on returning to the rail again.

Whenever there are two paths for the current, it will divide between them, the greater part of the current taking the path which presents the least resistance. The points where rails come together represent the points of greatest resistance in the rails, and are the points where the most trouble occurs. If the current passed into the pipe and did not have to leave it again, no damage would result to the pipe, but at those points where the current jumps from the pipes back to the track or to some other conductor, the pipe becomes corroded and finally eaten entirely through. No harm results however, at points where the current enters the pipe.

What provision is now made in many cities to handle rain water and other surface waters in such a way that they may not have to enter and overload the public sewage system?

This is accomplished by installing separate sewer systems, known as surface sewers, for the reception of all surface water, none of the latter being carried into the regular system of sewers.

How should trap cleanouts be located to give the best results?

They should be placed so that they are at all times under water.

The advantage of such submerged cleanouts is that there is no opportunity for the passage through defective gaskets, of sewer gases and odors, any defect being at once made apparent by the leakage through the cleanout cover. Generally traps provided with such cleanouts may be more easily cleaned.

**Why is the use of exposed metal surfaces to be avoided in the construction of urinals?**

For the reason that the acids of the waste entering the urinal attack metals and corrode them, thereby making the fixture more filthy than it need be.

**Describe the operation of the pneumatic water supply system.**

The operating force of this system is compressed air. An air-tight storage tank is used, which may be placed underground or in the basement or cellar, thus doing away with the objectionable attic tank. As water is pumped into the tank, the air already contained in the tank is compressed, the amount of compression increasing as the tank fills. By means of the pressure produced by this compressed air, water may be delivered by this system under as high pressure as 75 pounds, which is ample not only for house and stable purposes, but also for garden and fire use.

If sufficient pressure cannot be obtained by ordinary means, a special valve may be used on the suction pipe, which will draw in air with each stroke of the pump, in any desired quantity. On large work, such as the supplying of water under pressure to institutions, small towns, etc., several tanks may be used to provide the necessary storage, and if necessary, a special air pump to provide air pressure. This system is of great value in sections that are not provided with a public supply.

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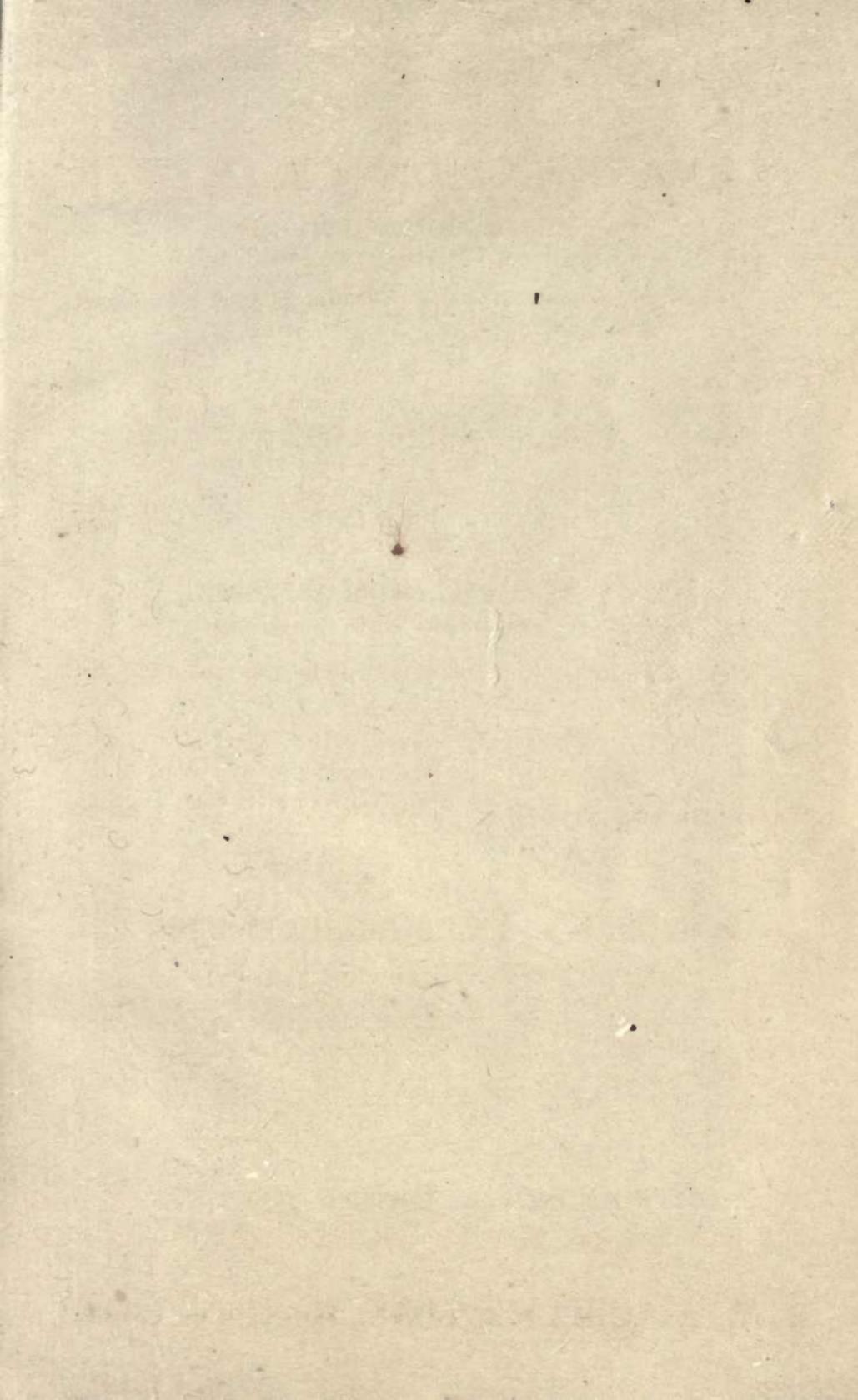
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