PLUMBING

PART I

Plumbing occupies an important position among the trades as an application of Sanitary Science.

Sanitary science is defined by an eminent authority* as "that body of hygienic knowledge, which, having been sufficiently and critically examined, has been found so far as tested to be invariably true. Its phenomena are natural phenomena; its laws are natural laws; its principles are scientific principles."

The same authority defines the sanitary arts as "those methods and processes by which the applications of the principles of sanitary science are effected," and would include plumbing with other practical arts of construction involved in sanitary engineering and architecture.

Having thus noted the position occupied in this broad field by the matters under consideration, we may define plumbing as the art of placing in buildings the pipes and other apparatus used for introducing the water supply and removing the foul wastes.

Historically, the plumber is primarily one who works in lead; but this definition would be a misnomer applied to the handicraftsman of to-day. While in time past, and even within the memory and practice of men now working at the trade, it suited the occupation designated as plumbing, the term "plumber" survives the transition from lead to iron more by reason of established usage than from its fitness to indicate the workman of the present.

Two score of years ago, traps and soil, waste, and supply pipes were in many localities almost wholly of lead; and much of the larger pipe was hand-made. Lead was then everywhere more frequently used for all these purposes than it is anywhere in the country now. To-day, first-class plumbing is possible in any type of building without employing a vestige of lead, and that, too, with fixtures and fittings regularly on the market. Lead, however, is still used to a marked extent in plumbing, principally for traps, pipe connections, caulked joints, water-service pipes, tank linings, flashings, etc. Its retention for these secondary purposes is due generally to superior fitness; yet


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in some instances it is because of the style of connection provided on certain fixtures, or for other reasons independent of the merits of the metal. On the whole, its loss of prestige has been slow and impartial. Indeed, those manually skilled in the manipulation of lead have often opposed the adoption of other materials sufficiently to retard substitution of the better.

Lead has unequaled merit for plumbers' use in specific instances; and if the trade has suffered by injudicious substitution of other material during its rapid evolution in recent years, time will adjust the error as the fitness of lead becomes apparent. For service lines in the ground, no other material lasts longer or gives more satisfaction than lead, provided the use of lead is safe with the particular water which flows through it. For cold-water lines inside buildings, it answers well. Wood tanks properly lined with lead are, in many cases, the best for indoor storage.

Lead pipe is not self-supporting in any position, in the sense that iron or brass may be considered so; and the providing of reasonably permanent support for lead work is an expensive item. Lead pipe costs more than iron or brass, in every case; and the cost increases proportionally with the extra weight necessary for all but very light pressures; while ordinary merchant's iron pipe, or seamless brass pipe of iron-pipe size, will withstand the pressure of any municipal or private supply in America.

Lead does not serve well for hot water. The contraction while cooling appears not to equal the expansion from heating; hence the pipe deteriorates at the hottest points, usually showing weakness first near the reservoir in the kitchen, especially at bends, and finally crystallizing beyond repair at those points. So much trouble has been experienced with stove and range connections of lead, that lead pipe for this purpose has been entirely abandoned. The wish to install something better suited than lead for hot-water service, is in large measure responsible for the general adoption of other material. Hot and cold supply lines that are dissimilar in material, in diameter, in joints, and in fastenings, are so unsymmetrical and out of harmony in every way that no mechanic is willing to install them for a slight real or fancied betterment.

With reference to the action of frost, lead pipe has an advantage in that the diametrical expansion of the water when freezing does not
burst the pipe at the point frozen, unless it has been repeatedly swelled from the same cause. Lateral extension of the core of ice in the portion frozen, crowds the water which it cannot compress; and, as the ice is frozen to the wall of the pipe, the weakest place ruptures. Sometimes a faucet ball will be driven in, and occasionally a coupling collar will be stripped of its threads; but usually room is made for the extra volume of the water by the pipe swelling to an egg-shape and bursting at one point. Such a break can be repaired by wiping a single patch or joint on the original pipe.

Frost breaks in lead pipe nearly always occur on the house side of the point frozen, because the water in the street end is easily driven toward the main. Air-chambers on the house service would often obviate the bursting of lead pipe; but where the type of faucets or a limited pressure does not require their use in order to prevent reaction, plumbers frequently omit them, under the impression that air-chambers can serve no other good purpose.

With iron pipe, frost breaks are more serious. Diametrical expansion splits the pipe at the point frozen every time freezing occurs; and lateral extension of the ice staves in the faucet stems, etc., quite as frequently as would happen with lead pipe under the same conditions. Of late years, the improvement in types of buildings, more careful provision against frost on the part of plumbers, and the vigilance of the Weather Bureau in giving warning of approaching cold snaps, have made insignificant the amount of damage by frost in both kinds of pipe.

Lead pipe, as a rule, requires less trench work on ground lines than iron pipe, because drilling, even if very poorly aligned, will often suffice to get the pipe in place. There are numerous instances, however, where longer stretches of iron pipe have been placed in drilled holes than would be practicable with lead at the same excavating cost. It is well to remember that any small line of house service in the ground should be placed deeper, so far as immunity from frost alone is concerned, than is necessary for the protection of large pipes in the same locality, because the volume of contents in house pipes is small, the wall surface of the pipe relatively large, and the flow of the water not so regularly maintained.

The action of natural waters on lead has been a matter of wide discussion by able men. The subject of possible contamination of
water supply through the agency of lead conduits, is too broad, how-
ever, for full consideration here, and will therefore be but briefly
touched upon. This trait of lead has been voiced against its use,
with more or less effect; but known cases of poisoning from this
source have been exceedingly rare. Galvanized-iron pipe charges
the water with salts of zinc when the water contains certain impurities;
and most other kinds of pipe are also more or less open to objection
at times by reason of their injurious effect on the water, the staining
of fixtures, etc. Some of the salts of lead formed by the agency of
water conveyed through lead supply pipe, are protective. Others,
without doubt—fortunately of rare occurrence is actual practice—are
corrosive. Sulphate or phosphate of lime, in solution, will part with
its acid in passing through lead pipe, the acid combining with a new
base (lead) and forming sulphate or phosphate of lead as the case
may be. Chloride, sulphate, nitrate, borate, and other compounds of
lead, may be similarly formed. These incrust the pipe; and such of
them as are practically insoluble in water protect the lead from further
attack, thus preserving the quality of the water. Carbonate, sulphate,
and phosphate of lead, which doubtless form most frequently in lead
water pipes, belong to the protective class. Of course, not all the
compounds mentioned are encountered in any one source of supply.
Chemical compounds designed to produce an insoluble incrustation
have sometimes been purposely placed in solution, and allowed to
stand in systems of lead supply pipe where it was known that the
water to be commonly used would otherwise be dangerously corrosive.
In view of the possibility of such precautionary measures, the dele-
terious effect of lead on many water supplies, and the consequent
menace to health if lead were used indiscriminately, could hardly alone
to any appreciable extent result in the substitution of pipe of other
material.

Lead has been thus dwelt upon at the outset, because the industry
of plumbing itself derived its name from this metal (Plumbum, Latin
for "lead"). A discussion sufficient to define broadly the present and
past status of the metal in the plumbing business, is certainly apropos
in this connection. To many persons, the term "Plumbing" sugges-
tslants lead and lead work generally, without regard to its distinctive
forms, some of which are quite foreign to the ordinary trade meaning.
To those acquainted with the building practices of Europe, visions of
lead-covered roofs and spires, rainwater heads, etc., in addition to manifold other uses of the metal not common in America, may come to view in the mind’s eye when “plumbing” is mentioned. To American plumbers of the past generation, “plumbing” suggested stacks of hand-made lead soil and waste pipe; hand-made lead traps; lead “safe” pans cumbersomely boxed-in under fixtures; ridiculously small lead ventilation pipes; lead drip-trays; lead supply pipes (sometimes also hand-made); all “wiped” joints and seams; and blocks, flanges, braces, boards, and boxes galore, jutting out in profusion, for supports, covering, etc.

In reality, we in America have now but little of what the name “plumbing” would lead the uninitiated to expect. Stacks of plain or galvanized wrought-iron pipe, or of plain, tarred, or galvanized cast-iron pipe, of weight to suit the height of building and to serve as main soil, waste, and ventilation pipes, with sundry lead bends and ends for fixture connections—these, with galvanized wrought-iron or brass pipes for supply, constitute the “roughing-in” stage of a job of plumbing; while painted or bronzed main lines exposed to view, galvanized-iron and nickel-plated brass pipe, with fixtures, partitions, etc., make up a view of the finished work, conveying little idea of the functions and importance of the unseen portions. Finished work in an unpretentious dwelling or storehouse, when properly charted, is fairly easy for even the house-man to understand. In large apartment and office buildings, department stores, etc., however, the plumbing, ventilating, gasfitting, heating, and automatic sprinkler pipes and electric conduits, make, in any but the finished state, a maze of pipe beyond the understanding of any except engineers well versed in those lines of work. In the completed work, the details are concealed. The toilet rooms present an orderly perspective of closets, lavatories, or other fixtures, as the case may be, with simple connections according with the customary finish, kind, or purpose of the pipe.

This apparent harmony, proportion, and simplicity in the result, coupled with a memory of sundry glimpses of a confusion of pipes in the rough state, has, it is to be regretted, propagated in many minds, a sense of false security regarding plumbing, based on the assumption of the plumber’s evident ability to produce order and perfect service out of what in the “roughing-in” stage looked chaotic to a hopeless degree. The bulk of plumbing work, however, is not of the “sky-
scraper" class, nor is it handled by the same type of skill and superintendence. Any feeling of confidence or sense of security on the part of the public, is treacherous if based on the assumption that only by a degree of skill in direct proportion to the size of the job can satisfactory plumbing service be provided in residential and other small buildings. There is evidence of a somewhat indifferent state of the public mind regarding the plumber and his work, induced by the reasons stated and also by lack of due consideration and appreciation of conditions wrought by progress in other trades.

Plumbing, in its advancement, is merely keeping pace with the allied lines on which it is dependent. Their progress has created new conditions to be met, and as the future plumber will hail from the ranks of the populace, the light in which the public regards the plumber and the importance of his trade will have no uncertain bearing on the character and earnestness of those who take up the calling. The rank and file of apprentices have already too long been attracted merely on the score of a promising means of livelihood. There is ample reason to begin a plumbing career with all the pride felt by followers of any other vocation. It is altogether improbable that any individual will be found with so much education or such promising ability as to give rise to just grounds of fear that plumbing will not offer him sufficient scope to acquit himself with dignity.

The advent of tall buildings, the general increase in the height and other proportions of buildings in cities, and the changes in material and in design of fixtures, together with the abnormal demand resulting from the decreased cost, natural growth, and gradual awakening through education to the value of sanitary conveniences, have brought about a condition of affairs which the old-line plumbers were incapable of coping with, and which the old apprenticeship system was inadequate to provide men capable of dealing with in a creditable manner. The plumbing of one large building involves as much work as hundreds of the average small jobs put together. The handling of such work under the conditions that have prevailed, has developed a deplorable state of so-called "specialism." Men engaged in "roughing-in" a large job are likely to tell you with entire truthfulness that they have no idea what types of closets or other fixtures are to be used; that they know nothing of the principles or merits of plumbing fixtures, and do not need to; that they never connected a fixture in their
whole career; that the finishers do that kind of work. By further inquiry one would find the “finishers” utterly at sea in the work of “roughing-in,” and accordingly ignorant of the whys and wherefores that govern the success of a job as a unit. These men, called “plumbers,” are exceedingly skilful and rapid within their limitations; but it is easy to infer the fate of a job intrusted to such hands alone, and in practice it has been proven that others of metropolitan practice, and merely lacking in variety of experience, were not capable of creditable results on general residence work of the ordinary class.

When the largest jobs were completed in a comparatively short time, and when much of the training which went to make up the plumber’s accomplishments was credited to the manual practice necessary to master the working of lead and solder, a period of service in shop and job practice, coupled with oral instructions from the journeyman, served fairly well to make a plumber out of raw material within the period allotted by the American abridgment of the apprenticeship term. On the work of to-day, however, there would be great chances of an apprentice serving such a term without seeing anything of more than from two to five jobs. He would be lucky if it fell to his lot to get even a little experience in each of the natural divisions of those jobs; and again fortunate if those jobs happened not to have the same general layout or to employ identically the same make of fixtures, for there are many shops which seem to have the faculty of securing work from certain particular sources, and which are equally likely for one reason or another to be recommending and using, where possible, one particular make of goods to the exclusion of other kinds just as good or better. These and kindred features now met with on every hand in practice, are stumbling-blocks—prohibitive, in fact, of anyone learning the plumbing trade within any period of time that can sensibly be prescribed for the acquiring of a trade or profession.

For more than a decade, the often-avowed reluctance of journeymen to teach apprentices has been held responsible for the trend of these affairs affecting the practice of the industry; but in the light of what has been said, it is easy to determine what it was that really introduced the Plumbing Correspondence School and Plumbing Trade Classes. It was necessity. Trade journals have done and are still doing good work in this line; but their best efforts, added to the opportunities of practice, were insufficient. There was no other satisfactory
solution than the Correspondence School—no other route to the
acquisition of principles and acquaintanceship with the accumulated
information as to the relative merit or fitness of certain materials,
designs, systems, etc., and as to the conditions under which this or
that would serve well, while it might act just the reverse under other
circumstances.

Under the present régime, it is not only apprentices and those
who intend becoming such, but journeymen as well, that need to seek
aid in the schools. The citizen at large, also, serves his own interest
in informing himself in a general way at the same fountain, so as to
be able to discriminate for himself in matters pertaining to plumbing.
Furthermore, any real plumber would prefer that his customer should
be familiar with the work in hand. Fewer misunderstandings occur
when such is the case, and there is a keener appreciation of good
work on one hand and a corresponding effort to merit approval on the
other. There is, too, in favor of the plumber, when the customer is
informed, an absence of those niggardly tactics of trying to secure
much for little, of sacrificing quality and future satisfaction by reducing
first cost below the safe limit. The well-informed customer never
makes you feel that all plumbing is alike to him and a necessary evil
to be paid for at rates far in excess of its value.

With the foregoing introduction in mind let us look further into
the subject and see what "Plumbing" really is. Whether we are
actual or self-nominated apprentices, journeymen, masters, or the
prospective customer himself, a view of the matter will be beneficial,
if only in the sense of refreshing memory.

There was a time when sanitary conveniences, crude in com-
parison with the present, were considered mere luxuries. Under
the present views of life and the conditions of living, we may with
greater propriety consider these erstwhile luxuries as actual neces-
sities, though they are often luxurious to a degree that dwarfs into
insignificance other appointments which even then were granted to
be essentials. Plumbing is, therefore, neither in fact nor in opinion,
a matter of simple luxury for the rich and delicate, but is, rather, an
important subject of deep salutary interest on the one hand and of
business acumen on the other—a matter of essentials deeply affecting
the best interests of our own health and that of our neighbors, with
which mere sentiment has no ground for association. The time
when it was thought sufficient to fan out the mosquitoes in summer and break the ice in winter at the family rain barrel in order to wash our faces and hands, has passed. A dwelling job may now embrace almost the entire range of plumbing fixtures. There is therefore no better example from which to build a word-picture of Plumbing.

PLUMBING FIXTURES

Bathtubs. Bathtubs are a prime factor in plumbing. They are of various types:—(1) Wooden cases, with sheet-metal lining, usually copper, on the order shown in Fig. 1; (2) all copper, and steel-clad, suitably mounted, as shown in Fig. 2; (3) cast iron, enameled, with a vitreous glaze fused on the iron, as in Figs. 4 and 5; (4) solid porcelain, potter’s clay properly fired, with vitreous glaze fired on, as in Fig. 3; and (5) marble, variegated or otherwise, cut from the solid block. Their cost ranges in the order mentioned.

The relative merit of the different materials and types is not so easily designated. Porcelain and marble baths are large, very heavy, and imposing-looking; and therefore are often selected on the score of massiveness, with a view to harmonizing with the dimensions and finish of the house. One would suppose the mass of material in such baths would have the effect of cooling the water to an annoying extent; but careful tests have revealed no appreciable difference in the effect of thin as compared with thick bathtubs on the warmth of water, and but little in their pleasantness of touch to the person. The bath of most pleasant touch was that of indurated wood fiber, which, however, had but little commercial success, on account of its lack of stability.

Most baths are made in from two to five regular sizes, ranging from 4 to 6 feet in extreme length. The general shapes are the French (Fig. 3); the Modified French (Fig. 4); and the Roman (Fig. 5). The various French patterns have the waste and supply fittings at the foot, which is modified in form to accommodate them. The waste water travels the length of the tub to reach the outlet, and generally leaves scum and sediment on the interior while emptying. Baths of the French type are suited to corner positions, or to positions in which one side runs along the wall; but the ideal position for a bathtub, in the interest of cleanliness, is with the foot end to the wall,
Fig. 1. Wooden Case Bathtub, with Sheet-Metal Lining.

Fig. 2. All-Copper, Steel-Clad Bathtub.

Fig. 3. Solid Porcelain Bathtub, French Type.
thus permitting entrance from either side. A medium size is best suited to the usual provision for supplying hot water for bath purposes; and is also preferred by many because the feet reach the foot, enabling a person, when submerging the body, to keep his head out of water, with his shoulder resting on the slant at the head of the tub. Where the house supply is pumped by hand, the medium size of any kind of bath is advisable.

The rims of baths vary from 1\(\frac{1}{2}\) to 5 inches in width. The larger rims are easy on the person in getting in and out of the bath, and are often used in lieu of a bath seat. In iron baths with rims large enough, the fittings are generally passed through the rim, as illustrated in Fig. 6, thus giving them additional stability and making the stated fixture length include the whole space necessary for its installation. This style of bath fitting is shown in Fig. 7.

Nominal sizes of baths now include the whole length of the fixture proper. Formerly many awkward mistakes resulted from lack
of uniformity, one not always knowing whether to consider the nominal size as inside measurement only or including twice the rim width. In cast tubs, actual measures vary slightly from the nominal, because of the furnace effect when heating to enamel. The variation, however, is not sufficient to be considered in noting the space required, or to require any advance in roughing-in measurements.

Roman baths have ends alike, with the fittings at the center of one side, as illustrated in Fig. 8, and the waste outlet at the center of width and length. In general, they empty with better effect, and may be placed in either right or left corner or free of all the walls;

Fig. 6. Fittings Passed through Rim of Enamelled-Iron Bathtub, to Give Additional Stability.

but the best position, everything considered, is with the fitting side near the wall, and not against either end of the room.

Any finish for iron bathtubs, other than plain paint, should be put on at the factory; iron surfaces cannot be ground and the successive coats of paint dried on in place, properly or cheaply.

Waste fittings and the outlets of baths have always been made too small. Slow emptying takes valuable time, and results in the adherence of scum, which necessitates careful cleansing of the bath before it is used again.

The fittings of baths are not interchangeable unless the obliqueness of the tub walls and the depth and drilling agree. The styles of fittings are universally applicable, except that double bath-cocks
(Fig. 9) are never placed on Roman baths. All double cocks are provided with detachable coupling and sprinkler, which, fitted to hose, provide a means of spraying the body. Independent spray, needle, shampoo, and overhead shower fixtures, simple and in combination, with or without curtains, are made for use with the various tubs, the tub serving as a receptor for the falling water.

The cheapest serviceable bath fittings are a Double Cock and Connected Waste and Overflow. These are shown in Fig. 10. Bell Supply and Waste fittings, a special type of which is shown in Fig. 11, are singularly popular, the water being retained by a ring valve attached at the bottom of the overflow pipe, and operated by means of a knob projecting above and through the top of the waste standpipe. This takes the place of the ordinary plug and chain used with the simple overflow. The supplies are made and fitted in combination with the waste arrangement, with the valve handles projecting above the rim of the bath, the two supplies being delivered into a common yoke-piece, where they mix and flow through a common passage to the bell-piece fitted through the vertical wall near the bottom of the bath. With the usual slotted-bell delivery, these fittings are a nuisance in one respect. Water cannot be drawn into a vessel through the bell for any ulterior purpose; and as no vessel of considerable capacity can be filled at the lavatory faucets, or at a sitz or a foot bath, the sink faucets are the only resort unless a
CONSTRUCTION OF "HAPPY HOLLOW" SEWER, LOUISVILLE, KENTUCKY

View showing arch and invert, with longitudinal and transverse reinforcing bars; also, in right background, one of the concrete manholes, the top of which is at the new grade that will be formed by filling in after completion of the sewer.
slop sink is available. Nozzle-delivery bells, which afford some relief in this respect, are made; and hand sprays used in conjunction with them avoid the expense of special shower fixtures, which would otherwise be essential if shower or spray were desired at all.

A modification of these fittings, termed "Top-Nozzle Supply and Waste" (Fig. 12), overcomes this objection to the strictly "Bell Supply" type. It has a high nozzle delivery projecting into the tub, and is fitted for spray attachment. The inward projection is much less than with a double cock, which, in a short bathtub, would occupy much needed space. The noise of falling water, obviated with the bell placed low, is the same as with the double cock; and the mixing space, intermediate between that of a cock and the regular bell delivery.

An element of danger is inherent in a bell-supply outlet placed so low down as to be submerged when the tub is in use. If the supply is opened when the tub contains dirty water, and the pressure of water is lowered by accident or by opening faucets elsewhere, it is quite possible that the fouled water will be drawn back through the bell or nozzle into the supply pipes, thus, perhaps, contaminating the water for domestic use. For this reason, cocks which discharge near the top edge of the fixture, above the level of the water, are increasingly used at present.

For private use, where both children and adults are to be regularly served, the bathtub is the only fixture answering the requirements. As the physical conditions of the members of the family are, or should be, mutually known, and the tub will be regularly cleansed between baths, any possible chance of communicating humors of the skin through the bath can be guarded against. For institutions and general public use, the tub bath is open to serious objections, some of
which apply as well to private use. The water for a tub bath is at its best when first drawn into the tub; and the person, before bathing, is certainly in condition to pollute it more or less. As the bathing process nears completion, these conditions are exactly reversed. Tubs used by the public may not be carefully cleansed between times of use, and the bather is ignorant of the condition both of the tub and of the person who used it previously. In institutions for the insane and feeble-minded, unscrupulous attendants have been known to bathe several persons in the same water. Large pools are better, but still not ideal; nor are they always suitable or practicable.

Shower Baths. Shower or rain baths are commonly installed in barracks, gymnasiums, and schools, and are no longer unusual in private dwellings. Some of the objections to the tub bath, which have been stated, are entirely avoided by the shower fixture with its supply of running water. Those who have studied the hygienic effects produced by the action of jets or streams on the surface of the body, urge very strongly that the impact results in stimulating the proper action of the skin. This is the opinion of most persons who have had experience with such apparatus.

The older forms of showers, which direct the water vertically upon the head of the bather, are not so desirable as those in which the outlet is inclined and placed at about the level of the shoulders, thus avoiding wetting the head unless desired. Indeed, all the essentials of a bath of this form are met by a water-supplied rubber tube discharging at about the level of the waist over a tight floor or pan provided with a drain.

Aside from the shower baths that may be provided in conjunction
with a bathtub, one type of which is shown in Fig. 13, many designs are fitted to floor-pans, called receptors, usually having a curtain, as in Fig. 14, thus providing for private installations a great variety of complete showering and spraying appointments. The receptors may be enameled iron, porcelain, or marble. A cement or asphalt floor, sloping to a drain, is simple and effective.

In lieu of the full curtain and regular receptor capable of providing six to eight inches' depth of water, and having tub-like supply and waste fittings in addition to the shower features, a shallow base of marble provided with a drain and having three marble sides, such as is shown in Fig. 15, can be provided with any preferred type of shower fittings. The overhead douche, already noted, set at an angle, with flexible joint for adjustment, as seen in Fig. 16, so that the body can be played on without wetting the hair, is not often fitted to private shower fixtures, as it requires considerable additional space. A rubber cap for the head enables one to use the vertical shower with a fair degree of satisfaction.

A point concerning shower fixtures and relating to the safety of the user, to which special attention should always be given, is that of the valve arrangement. If the design renders it at all possible, as sometimes is the case, one is apt inadvertently to scald himself by at first
turning on hot water alone. The chances of injury in this way increase with elaborate combinations, if not carefully guarded against by the designers; and we should not take it for granted that they have provided such safeguards. As a rule, reliable makers do embody ample mixing chambers, thermometers, etc., in such apparatus, where necessary, and they regulate the control of hot-service valves, or in some other way render the improper use of them unlikely.

Sitz Baths. These are primarily for bathing the hips and loins in a sitting posture, but may be fitted with special features as ordered. Porcelain and enameled iron are the usual materials. The fixtures
approximate in dimensions 15 inches in height at front and 26 inches at back, and are 26 to 30 inches wide. In the back, at a proper height, in a complete fixture, like that shown in Fig. 17, is a horizontal slit accommodating fittings for a "Liver Spray"—a wide wave-like spray of water, either hot, cold, or of intermediate temperature, as suits the person. In the bottom, in conjunction with the outlet, is a hot or cold douche, equally under control of the user. In the center of the douche, and operated independently, is a bidet jet. These provisions are entirely separate from and independent of the regular supply fittings, but one waste fitting is used in common for all. The simple sitz bath has the regular Bell Supply and Waste, like those used on the bath, the dimensions being diminished to suit. For the extraordinary features, these fittings are merely adapted in a way to give the user convenient control. For all but the simplest fixtures, the control appliances are invariably fitted through the rims, the valve handles being provided with proper indices to guide the user. Bidet jets in combination with sitz-bath fittings, have to a great extent curtailed the use of separate bidet fixtures. Bidet jets have often been added to a water-closet, but a satisfactory application cannot be made to a closet. Separate Bidet fixtures are now rare, but are furnished by
fixture makers; and in isolated cases, where frequent or regular use is necessary, are preferable to any combination with a fixture used for other purposes.

The sitz bath is conveniently used for a foot-bath, thus making this fixture doubly useful. Indeed, the sitz bath is a more comfortable means of bathing the feet than is the foot-bath itself. Children’s bath-tubs, small, and elevated by legs to the height of a lavatory, are made, but no well-defined demand exists for them. Greater convenience to the nurse, the use of less water, and quicker filling and emptying, are the only points in their favor.

Foot-Baths. The foot-bath is a small rectangular tub with proper feet and rim, furnished with supply and waste of the regular bath pattern, diminished to suit. The sizes average say 12 inches deep, with 20-inch sides. The feet make the total height about 18 inches. Fig. 18 gives a good idea of the usual enameled-iron foot-bath fixture. Enameled iron and porcelain are the usual materials. They require even less water than the sitz bath, but, as before said, are not so convenient for the purpose as the sitz fixture, and are not installed except in the most spacious and elaborate bathrooms. The foot-bath would serve admirably as a child’s bath, except that it is too near the floor.

Bidet Fixtures. The majority of leading fixture makers do not now catalogue these. They consist essentially of a pedestal like a closet pedestal, with bowl and rim contracted in the center, giving an outline something like the figure 8. Proper fittings to operate the jet and waste are provided. Porcelain is the material. As mentioned before, Bidet jets are furnished in combination with receptor shower fixtures, as well as with sitz baths.
Drinking Fountains. Drinking fountains are now frequently used in stores, schools, and residences, the various fixtures adapted to such installations being readily obtainable. The basins or drip-slabs for public indoor fountains, are often cut to order by the manufacturer; and the cooling and faucet arrangements are provided by the plumber. Porcelain, enameled-iron, and marble fountains of stock designs are made. For schools, trough-like basins, either with open spouts for continuous streams, or with self-closing faucets, as shown in Fig. 19, are frequent. The fixture shown in Fig. 20, consisting of solid porcelain, in which the recessed drain-slab and the high back constitute a single piece, is of recent design, presents an excellent appearance, and has the advantage of being easily kept in immaculate condition. The three deep waste outlets, above each of which is a faucet, afford facilities to many users in a short space of time.

One device which serves well for common use, is the ordinary lavatory, provided with a stiff perforated bottom fitting extending well up toward the top of the bowl. This, with a proper faucet on the slab, and a cup-chain fitted to the extra faucet-hole, makes a useful but not attractive fixture.

Recessed porcelain and enameled fountains designed to be placed in wall niches, and having concealed connections, as suggested by Fig. 21, are neat, and require very little room outside the finished wall line. Countersunk slabs with strainer waste, with back either integral or separate, as design or material dictates, are made in marble and porcelain. Marble fountains are adaptable to any location, because the slab and back can be cut to any shape or dimensions preferred. The fountain proper, faucet, cup, and pipe waste connection, with strainer, are all that is supplied by the makers.

A type of fountain shown in Fig. 22, is provided with a flowing jet of water from which one can drink without placing the lips in contact with any metal surface. The small central bowl or cup is constantly submerged and cleansed in the stream of water which
passes outwardly over it, thus avoiding the danger incident to the common use of the same drinking cup by many persons. The surface does not afford lodgment to possible germs of disease, which are most liable to transmit contagion when allowed to become dry and adhere to a surface.

**Lavatories.** Lavatories are made from porcelain, enameled iron, marble, and onyx, in numerous patterns. The number of designs is so large that they are best understood if considered in the classes into which they may be divided. In marble and onyx fixtures, the slab, back, and bowl are necessarily separate pieces. In any but very accurate fitting and erecting, the unavoidable joints soon, if not from the beginning, invite the accumulation of dirt. Poor workmanship, settling, abortive countersinks, and
faucet bosses not cut free within the countersink, have in many cases brought slab types of basins into unjust repute, or, at least, have given basis for strong talking points against them, which have been effectively so used. If made and installed in the most approved manner, these styles, properly cared for, offer little reason for severe criticism. One fact, however, must be borne in mind when comparing marble with other materials used for plumbing fixtures—namely, that marble is not an impermeable stone. Nearly all marbles (excepting only the very hardest and most dense) are quite absorbent, and depend upon the surface finish given to the
slab to resist the entrance of liquids into the body of the stone. As soon as the surface becomes roughened by wear, the greasy and acid wastes penetrate into the pores, and the marble becomes permanently discolored. Only a limited observation of the bad condition of marble floors or urinal slabs which have been subjected to use for a few years, is necessary to confirm this statement.

Ordinary Tennessee, Veined Italian, Hawkins County Tennessee, and Statuary Italian marble, range in cost in the order mentioned. Fancy imported marbles and onyx are much more expensive. Tennessee marble varies in color from grayish brown to very dark reddish brown, uniformly intermixed with light specks. The Hawkins County marble is bright reddish and white-mottled. All the ordinary materials are cut in stock sizes, and may also be had to order, like the more costly, in any size and shape desired.

The type with apron or skirting, shown in Fig. 23, has legs, and the slab is supported continuously by the skirting. In those supported by brackets or leg-brackets, the strength of the slab is depended upon for support between the bearings. Legs, brackets, and all other metal trimmings should be in keeping with the character and cost of the stone slab. If brackets are properly spaced, the weight is so balanced as to leave very little sagging strain on the center of the slab. A shelf of marble, or a mirror with marble frame, or both, may be fitted above the back as a part of the fixture.

Porcelain and enameled-iron lavatories have bowl, back apron, and soap-cup in one piece. The pedestal of the lavatory illustrated in Fig. 24 is separate, of course, and no back is required, but the general features of integral construction are shown. There are no joints to open. The only injury possible to them is the marring or fracture of the glaze or enamel. Porcelain and iron lavatories, unlike those of marble, are adapted to pedestal support; and some very desirable patterns are therefore made in these materials only. Neither pedestal nor wall lavatories are suitable for use, except where the wall or wainscoting is of marble, tile, or some other waterproof material.
Fig. 23. Brazilian Agate Slab Lavatory, with Apron and Legs.
To provide for leaving the floor clear and free of obstruction, lavatories supported on brackets or hangers, as indicated in Fig. 25, with supply, waste, and ventilating pipes fitted on or into the wall, are best. If found practicable, a neater job results if all pipes leading to and from pedestal lavatories are carried through the pedestal. A supply and waste run to the floor is generally far easier and cheaper to secure than the fitting of all pipes to the wall.

The purchaser seeking iron or porcelain fixtures, has no choice of styles beyond that which the market regularly affords. If he prefers the workable materials, he should insist upon certain features of design which are essential to the best service. Abrupt edges and sharp corners should be avoided; the slab ought to be at least 1½ inches thick, and the back not less than 12 inches high; the general dimensions must be as liberal as space will allow or the service demands (not less than 22 by 32 inches for a 14 by 17-inch bowl); the countersinking must be deep, \( \frac{3}{9} \) to \( \frac{1}{2} \) inch; the faucet bosses must not join the general border level at all; the faucets must not be less than 12 inches apart, nor so near the bowl that it will be difficult to secure them to the slab; nor may they be placed so close to the back as to make repairing troublesome with any type of Fuller faucets; the joint surface of the bowl must be ground to fit the slab, and provided with not less than four well-drilled anchor-holes for clamps to secure it.

Round bowls were formerly quite generally in use, but are now almost relegated to memory. The width of slab needed for a roomy, round bowl is too great; and at best the arms of the user must be cramped in a somewhat vertical and awkward position, while the smaller sizes are very uncomfortable in this respect. The sudden opening of the faucet when the bowl is empty, is likely to ricochet water with annoying results. This is caused by the water striking the curved bowl surface at a tangent, and is not peculiar to the circular bowl; the oval or crescent, or, indeed, any shape of bowl that presents
a curved surface to which the faucet stream is tangent, favors the same result; the ovals in integral fixtures are the most annoying. Marble and onyx have an advantage over porcelain and enameled lavatories so far as ricocheting is concerned. The opening in the slab is not so large as the bowl, and thus a horizontal overhanging ledge is formed all around, above the bowl, which generally intercepts the water in a way to keep it off the floor and person. Porcelain and enameled fixtures have not this virtue. The bowl surface, being integral with the slab, is uninterrupted and continuous; hence ricocheting is more violent with them than is possible with the separate bowl.

Oval bowls are now in general use on all types of lavatories. They employ slab space to the best advantage, and are the most convenient for use. The crescent or kidney shape, illustrated in Fig. 26, is, however, as far superior to the simple oval bowl as the oval is to the round. It permits the forearms to lie in a natural and most convenient position when dipping water to lave the face. This form of bowl should be accompanied with a scalloped or recessed front. The D-shaped bowl, and other bowls embracing the prime feature of the D-shape, while not so graceful in appearance, are, without exception, to be preferred, on the score of utter absence of ricocheting when the faucets are properly placed. The D-shape, a transverse section of which is shown in Fig. 27, has a semi-oval front, with the end lines continued parallel some distance past the major axis, and with a straight-line back nearly vertical. This form gives a nearly flat surface in the bottom between the back wall and major axis, on
which surface the stream strikes and breaks when the bowl is empty. A depth of water is quickly formed under the stream, which checks any spraying or spattering.

The traps used for lavatories are lead or brass (either cast or tubes), or combinations of these materials, plain or vented or of anti-siphon design. One trouble with lavatory trap ventilation, is the difficulty of obtaining a vertical rise directly above the trap. These vent connections should be carried as nearly vertical as possible, as high at least as the bottom of the lavatory slab, before any horizontal run is made; otherwise the choking of the waste pipe would float solid matters into places from which gravity would not dislodge them. In the absence of water-wash in the vent pipe, these solids would obstruct the vent and defeat its purpose. This danger is not given due attention by many plumbers. The patent and horn overflow bowls, with plug and chain, are the cheapest effective means of controlling the overflow and waste from the bowl. The standing waste, of essentially the same design as the waste fitting for a bathtub, with the body fitting projecting through the slab at the rear of the bowl, is perhaps the most satisfactory waste and overflow arrangement. Various schemes for operating basin stoppers by means of levers and swivels, are employed; but none of them has come into more than limited use.

Basin faucets, aside from special designs, are made on three general operating principles—(1) screw-compression; (2) eccentric action without springs; and (3) self-closing. They are also made in two types—with regular and low-down nozzles. All of these are represented in Fig. 28. The regular type has the nozzle some distance above the base flange, and screws into, or is cast on, the body. The low-down type has its nozzle with a flat bottom, hugging the slab as
closely as practicable. The objection to the low-down is the inaccessible narrow space between the nozzle and slab, which becomes filthy and is difficult to clean. High, projecting nozzles obstruct the space over the bowl, especially when washing the hair, but are otherwise most satisfactory. The high nozzle gives trouble with patterns of faucets that separate in the body for repairs, such as the Fuller type, which closes rapidly with pressure. The fault, however, is often that the slab is so shallow as to necessitate the faucets being placed too close to the back to turn without removing the nozzles. If these are cast on, removal of the whole faucet is required before it can be separated. Some faucets are made with union joint in the body, thus avoiding such trouble; but these are not widely used.

The false economy which often dictates the purchase of a small slab, generally also prevails in the selection of its trimmings. Compression faucets close against the pressure, and are slow in action, causing practically no reaction. They are generally responsible for the omission of air-chambers on supplies of medium pressure. On account of their slow action, they are suitable for high pressures although but little weight is given this fact by the trade. The features essential to good, lasting service in the compression faucet, are: a cross-handle, a stuffing box, a raised seat, and a swivel disc. Self-closing faucets of various patterns are made with a view to preventing waste of water, the intention being to compel the user to hold the faucet open only as long as water is needed, and to insure automatic closing when it is released. There are none such except the crown-handled, that an ingenious person cannot find means to hold open at will; yet, withal, self-closing faucets are of great value in reducing wastage. A rabbit-eared faucet can be kept open by placing a ring over the handles while squeezed together; the telegraph bibb, by weighting down or tying up the lever; and the T-handled, while not so easily controlled, can be tied open by a lever secured to the handle. The crown-handled design can be operated with ease by the hand of the user, but does not readily lend itself to unauthorized control by means of a mechanical stop. Self-closing faucets require strong and well-designed springs to close them against the force of the water. They have sometimes come into disrepute through leakage for lack of adequacy in this feature of their construction.
HEADINGS CONTROLLING SUPPLY OF WATER FOR THE SMALLER LATERALS FROM THE MAIN IMPERIAL CANAL

View five miles northwest of Calexico, California.
Lavatory supports should have positive means of leveling the slab, such as set screws, screw-dowels, or whatever adjustment the kind of lavatory and support may be best suited to. Lavatory brackets are generally at fault in having limited bearing at the bottom of the wall-face. This point of the bracket is where all the strain is thrown against the wall, and the effect is noticeable if the upper end springs away ever so little. Full-length brackets are not open to this criticism, but they interfere with the washboard or other finish next the floor.

**Sinks.** These are made in four general classes according to the purpose to be served—namely, Kitchen, Pantry, Slop, and Factory or Wash-Sinks. The materials used are:—Porcelain; enameled, galvanized, and painted cast iron; enameled, galvanized, and painted wrought iron; brown glazed ware; copper; slate; soapstone; various compositions; and occasionally wood. Porcelain and enameled cast iron are most used, galvanized and painted sinks being confined principally to factory use. Sinks of extreme length, in one piece, as shown in Fig. 29, or sectional, 6 to 8 inches deep, with supply and faucets over the center line or at the side, belong to the factory class. These are usually provided with a flat rim, rest on pedestals, and are not over 24 inches wide. There are also roll-rim patterns, with bracket support and iron back, and with faucets fitted through the back. These are generally 8 inches deep and about 20 inches wide.

Kitchen sinks vary in size according to general requirements. Common sizes are 18 by 30 inches and 20 by 30 inches. The depth
ranges from 6 to 7 inches. There are two types of iron sink—flat-rim, with outlet at end; and roll-rim, with outlet in center. Neither style of outlet is always desirable as to connection; but the center outlet drains more directly. The flat-rim type is not provided with legs. Cast legs were formerly furnished, being attached to the sink by slipping into dovetails. When legs are desired for this type, the plumber provides gas-pipe legs, with or without a top frame. Iron splash-backs are provided for flat-rim sinks, but not of the deep pattern in which air-chambers may be cast. Plumbers drill these sink rims to attach brackets or legs, and sometimes also to secure to them hardwood capping or drainboard. Hardwood drainboards are generally provided by the plumber's carpenter. Hardwood splash-backs, set free of the wall to permit circulation of air behind the fixture, are also provided. Sometimes marble splash-backs are provided. Marble is best, but is not in keeping with a flat-rim sink. The back may extend to the end of the drainboard, or merely cover the length of the sink. Omitting the back behind the drainboard, as represented in Fig. 30, is often thought desirable. The drainboard should be free of the wall when the back is not extended. Iron sinks, with roll rim on front and ends, are furnished with drainboards suited to attach to either or both ends. These may be added as an after-consideration, or changed from side to side at will, if there is but one drainboard, or removed entirely, without marring the looks or service of the sink. This interchangeability commends itself to both plumber and customer.

Roll-rim sinks, with the end recessed to receive a drainboard, are also made, which give good service, but in any subsequent change of location require setting in the original relative position.

Wooden drainboards, with an iron end to attach to sink, and enameled-iron drainboards, are furnished if ordered.
Open strainers are most frequently fitted to sinks, in which case the sink cannot be then used for washing dishes, but merely serves as a support for dishpans and other vessels and as a catch-all for drippings from the drainer. Hence the open-strainer sink must be large enough to accommodate suitable washpans, etc., while one fitted with a plug-strainer should be relatively small if it is designed to use the sink proper as a washrpan.

The use of wooden sinks in large installations, such as hotel kitchens and restaurants, is not unusual, the theory of their use being that less breakage of crockery occurs, by reason of the softness of the material. The argument against the use of wood is not given due weight in this connection. The well-recognized objection to any porous, absorptive material which retains moisture and is subject to decomposition, is especially to be considered in the use of wood for greasy wastes. For the reason mentioned, wood is never a suitable material for this use.

Rubber mats are essential for both sinks and drainboards having enameled or glazed surfaces, in order to avoid accidental injury to the articles cleansed. As a matter of fact, the average dwelling has but one sink, which serves both kitchen and pantry purposes. Dual service is not always satisfactory, however, as no sink can be well
adapted to both uses for a large family. A plug-strainer sink should also be provided with an overflow.

Porcelain and iron sinks have generally been supplied with loose backs; but sinks of one piece—that is, with sink and back integral—are now obtainable. Sinks with integral apron or skirting all around, to be placed free of the wall, are suitable for installation where the wall is waterproof.

Sinks are built from slabs of natural stone as desired, and may be with or without drainboard or skirting. They are generally provided with a high splash-back. These sinks are not limited to the patterns of a moulding room, and easily keep pace with the desires of the purchasers. Selection is confined to a choice of material, as every desirable type of fixture is easily supplied.

In the use of any natural stone, such as slate or soapstone, for plumbing fixtures, and especially for sinks, it should not be forgotten that angles and rectangular corners are with difficulty maintained entirely free from deposit. Although the flat surface can be readily scoured, it is always difficult to clean the sharp angles and corners satisfactorily. The difficulty is increased by the fact that some plastic jointing material, such as putty or cement, must be used in putting together the fixture; and small fragments of this material project into the angles and render the corners rough. Stone and porcelain sinks are heavy, and require careful packing for shipment.

Air-chambers may be cast in iron sink-backs. The ordinary sink-back is not well suited to the convenience of the plumber where supplies to any fixtures pass up behind the sink. The faucet-holes cannot be changed, and slots for pipe are not provided at the top edge. Sawing these gaps after the goods are enameled, leaves the fixture with an unfinished appearance. The proportion of shank to the handle of faucets of the Fuller pattern used on sink-backs, must be such that the handles will turn straight back.

A popular fixture of comparatively late design, adapted for small dwellings and now made in the cheaper materials, is the kitchen sink in combination with a single laundry tray, an example of which is shown in Fig. 31. In this, the drainboard serves as a cover for the tray when the sink is in use. Sinks have also been supplied in combination with lavatories, one sink being placed in the center or at the end of a battery of lavatories.
A pantry sink (Fig. 32) should always be provided with a drainboard. It is a smaller fixture than the kitchen sink, and is nearly always of the plug-strainer and overflow type. Its faucets are generally of the high-nozzle type, like those for shampoo purposes, but of smaller capacity and better adapted to rinsing than are kitchen-sink faucets. Indeed, the pantry sink proper need not necessarily differ at all from sinks used for other purposes. Every feature of its trimmings and setting is intended to best serve the butler's needs.

The waste matter from the butler's sink is not like that from the kitchen sink; hence the waste pipe is not necessarily so large, nor is a grease-trap so badly needed. Grease in considerable quantities finds its way into kitchen-sink waste pipes. It floats on the stream of waste water as it travels through the pipe, and, being always next the interior surface, either adheres thereto on contact, or by a reduction in temperature is chilled and congealed, thus clinging to the pipe walls. Successive layers of grease are in this way accumulated, and the bore of the pipe is finally reduced so much that solid matter easily completes the stoppage. Forcing out, and then filling the pipe with boiling lye water, and again flushing with hot water, will usually remove most of the obstruction. Sometimes the lye loosens the grease in chunks, which clog the pipe seriously at the first favoring point, and the pipe must then be cleaned manually.

When once choked with grease, the pipe must ultimately be opened and cleaned by hand, often at material expense when long lines are deep underground. To avoid this trouble, various traps (of which two examples are shown in Fig. 33) have been designed to
separate and collect the grease, either by flotation or by chilling—generally by the former. Traps to collect the grease by flotation were formerly improvised by the plumber, being placed in the drainpipe just outside the building. This location left too much pipe subject to choking between the grease-trap and the sink; and the trap itself often became a generator of bad odors in warm weather.

The grease-traps now commonly furnished are placed in the kitchen under the sink, and frequently serve as the regular trap for the fixture. The grease is easily removed by lifting out the container or by skimming from the top. Hinged bolts with thumb-nuts secure the covers so that they can be easily and quickly opened and securely closed.

Traps which chill the grease are not used so much as those acting by simple flotation, but they do the work perfectly. The chilling process is accomplished by means of a water jacket through which the cold-water supply passes. The water entering low, surrounds the wall of the pot trap within, and passes out high up on the opposite side (see fixture at left in Fig. 33). Circulation—or, rather, change of water—in the jacket, is dependent on the amount of water used at the fixtures.

The usual slop sink is 18 by 22 inches and about 12 inches deep. Generally it is furnished mounted on a trap standard, as in Fig. 34, which serves the double purpose of support and waste-trap.

Care should be taken before installing a fixture placed upon a trap standard, to examine carefully whether the seal of the trap is provided for by suitable interior partitions. It is not uncommon to find defects in the casting, if of iron or brass—or in the porcelain, if of that material—which would seriously affect the maintenance of the
water seal. In fact, it is desirable in connection with slop sinks, as with all other fixtures, that the trap be of such a form as to show clearly, even after being set in place, the position of the various portions which constitute the trap and maintain the water seal.

The waste pipe is never less in diameter than 2 inches, and is usually 3 or 4 inches. The outlet is invariably through an open strainer.

Slop sinks are made in all the materials common to other fixtures except natural stone. These sinks are to the chambermaid what the kitchen sink is to the cook. The shape and liberal-sized waste are well adapted to removing slop and scrub water. In the complete fixture, the sink is provided with an elevated tank and flushing rim,

Fig. 33. Types of Kitchen Sink Traps for Separating and Collecting Grease.

to cleanse the fixture walls; also with hot and cold supplies for drawing water, rinsing mops, etc. The supplies usually connect between the valves, and terminate with a long spout with pail-hook and brace. The spout supports the pail over the center of the sink while filling. The ordinary slop sink is provided with hot and cold faucets; and as the rims of the cheaper kinds are plain flanges, no tank flushing is possible.

Laundry Trays. These are made in all the materials used in other plumbing fixtures. Wood trays were formerly common but their unfitness because of absorption and odors, coupled with the increase in cost of lumber and the lessening in cost of the better materials, has effectually driven them out of the business.
The same inherent objection to the use of wooden covers may be urged as to the use of that material for the body of the fixture.

Trays are made singly and otherwise, but generally used in sets of two or three, except in the combination with sink already described. They are supported by a center standard or a metal frame, as best suits the material used.

Some means of attaching wringers are provided, if possible. The waste is usually 2-inch. One trap answers for a set of trays. The size approximates 26 by 30 inches at top, with 15 inches' depth. The walls are all vertical except the front, which inclines about 30 degrees, making the width at bottom considerably less than at top. Some makers furnish one tray with each set, designed to serve as a washboard, the interior of the front wall being corrugated like the surface of a portable washboard. The inclination of the front is about right for scrubbing, whether the tray or an ordinary board is used, and the supports place the top of trays convenient to the work.

All trays were formerly made with faucet-holes in the back; and the plumber furnished a hinged cover. Side-handle faucets were necessary to allow the cover to close, as holes for top-handle faucets would be so low as to make useless too much of the space above them. The faucet-holes were seldom fitted water-tight. Holes are not now made in trays unless ordered, and the side-handle wash-tray bibb is disappearing. They were always annoying. If placed with the handles
right and left as intended, the seat could not be examined, and no reaming or dressing of the faucet seat could be done without removing the faucet. When placed with the faucet handles facing each other, they were wrong-handed and too close together. It was awkward to supply air-chambers—especially so when all the faucet holes were equidistant from the top. When placed for one line of supply above the other, one line of holes was too low. These objections combined brought about the practice of omitting the covers, putting the supplies over the trays, and using regular sink faucets. Overflows are provided only when so ordered.

Enameded backs with air-chambers and faucets are supplied with roll-rim enameded-iron trays. A complete set of three trays, with all attachments and fittings, is shown in Fig. 35. Flat-rim trays are made with or without faucet-holes, and are intended to have a hardwood frame to secure them rigidly. The wood frame and cover can be had with the fixture, but the plumber often supplies them. Nickel-plated or plain brass wastes and traps are furnished for trays, but the plumber can provide lead or cast-iron waste, if wanted.

**Water-Closets.** Types of water-closets are innumerable, and are separable into classes according to principles of action. Porcelain and painted or enameded iron are the materials used. Porcelain is more fragile, but has the better finish and is susceptible of a greater variety of design and ornamentation. The all-vitreous body of water-closet china of to-day is far superior to the glazed clay ware

Fig. 35. Set of Three Laundry Trays, with complete attachments and Fittings.
of the past, which, depending only on surface impermeability, soon cracked badly, thus permitting of absorption, the forerunner of odors which no plumber's skill could prevent. Enameled iron has not so durable a surface, but will stand rough usage, and has the advantage of very seldom cracking from frost even though the water in the trap freezes.

The greater relative advantage and durability of the porcelain closet over the best qualities of enameled-iron fixtures, should not be overlooked. There is less adherence of the foul wastes to a porcelain surface than to the enameled surface. It is also a fact that enamel is subject more or less to abrasion by the use of harsh scouring materials, as well as to decomposition by uric acid and water-closet discharges, and is therefore not a very durable material. These statements can be confirmed by observation of closets which have been in use for a number of years.

Iron closets of the better forms are used most in public places, stores, warehouses, etc. The pan closet, of iron, with earthenware bowl, is not now installed. For these, a trap was placed under the floor. The pan, operated by the same lever as the flushing valve, retained water, partially sealing the body from the bowl. The flush was by the swirling of a stream which entered tangentially under the rim. The bowls were round, as is necessary in all hopper closets thus washed, for water will not swirl in an oval bowl.

The objection to the pan water-closet is principally due to the fact that the outer bowl or container is a receptacle of filth which can never be properly cleansed. When the pan deposits its contents in the lower portion of the fixture, a considerable amount of the filth is spattered upon the walls and is not subject to the cleansing effect of the stream of water which scour only the upper bowl. When the closet is operated, the odors from this concealed surface permeate the room in an objectionable manner.

Tall round hoppers with swirling supply are yet frequently used in outhouses and other exposed places. No other form of closet will stand such locations under like conditions. The waste-trap is not placed immediately under the hopper, as in other forms, but down below the freezing depth—five feet as a rule. The supply valve is also placed below freezing, and is operated by a pull or by seat-action. These closets are continuous or after-wash, according to the style of
valve used. Such an outfit is the simple frost-proof closet of the market. Tall oval hoppers with valve and slotted spud attached, swirl or rather direct the water sideways in both directions, but not effectively. The tank supply is also inefficient when delivered through a slotted spud under the common flanged rim. Short oval and round hoppers, with valve or tank supply operated by a pull or by seat-action, fitted to "S," "3/4 S," and "1/2 S" or "P" traps, for lead or iron pipe floor connection, make up several hundred closet combinations, each differing in some respect from the others. These are the poorest types of water-closet.

A sectional view of the Combined Hopper and Trap pedestal of to-day is shown in Fig. 36. It is made in one piece, in both porcelain and enameled iron. This form resulted from the separate hopper and trap fixtures before mentioned. The combined form has oval bowl and flushing rim for tank supply.

The Wash-out closet is a modification of the combined hopper and trap, being formed with a dipping bed under the mouth of the bowl, which retains enough water to keep soil from sticking to the surface. The water-bed makes it necessary to discharge the contents at either front or rear of bowl. The back-outlet wash-out is most repulsive to view; in them the drop-leg, which the flush never washes thoroughly, is always in view, so that its filthy condition suggests cleansing by hand. The front-outlet wash-out, shown in section in Fig. 37, is of more inviting appearance; but the drop-leg, although hidden, is there just the same.

Both the Wash-out and the Combined Hopper and Trap types have one fault in common. The trap almost always contains the soil from one usage. When the contents of the trap are flushed out after using, sometimes a similar mass refills it. Of course, two or three consecutive flushes would leave comparatively clean water in the trap, but this is not to be expected in regular usage.

On certain occasions the wash-out may serve a useful purpose on account of the water-bed. The stools of children or the sick may thus be easily observed at the will of the physician or at the discretion of those in charge, while such is impossible where the soil is submerged at once.

Pneumatic Siphon closets of various types have been put on the market. A good example of the type requiring two traps with an
air-space between, is shown in Fig. 38. A specially constructed flushing tank is connected with the air-space between the traps. The falling of the flush water creates a partial vacuum in the bottom compartment of the tank, which induces siphonage of the bowl contents.

To maintain a plenum in the flushing compartment of the tank while the flush water is flowing down and into the closet, the air between the traps is extracted, being drawn up through the air-pipe into the tank. Atmospheric pressure in the room simply presses the water out of the bowl and upper trap when the pressure below it is sufficiently reduced. This water, in motion, added to that of the lower trap which has been drawn above its normal level in response to the vacuum, is sufficient to form the long leg of an ordinary siphon; and thus both traps would be entirely emptied were it not for the vent in the crown of the lower trap breaking the siphonage in time to save a water seal for the lower trap.

The upper trap with water visible in the closet bowl in repose, is supplied by the after-fill, thus establishing conditions for the next action. The lower trap of such closets must be back-vented, and it is essential that the upper trap have no back vent.

The proper action of the tank is necessary to operate a pneumatic closet. A closet constructed on any other principle can be flushed with a bucket, by hand, if its tank is out of order. When a pneumatic closet, however, gets contrary, pouring water into the bowl simply fills or overflows it. The outlet is air-bound, and no passage of water to the soil pipe can take place until the barrier of air between the traps is removed.
The closets now accorded first place and generally used in the best work, are of the Jet-Siphon type, illustrated by the sectional view, Fig. 39. These use more water than is necessary to flush other kinds of closets, because a portion of the water is employed to produce the siphonage. A channel leading from the flush-water inlet to the bottom of the trap, conveys a stream of water to the trap leg, and injects it upward therein. The water in the channel has considerable velocity, and, being discharged into the water in the trap, imparts its energy to the whole mass, which, aided by the rise due to the incoming water from the flushing rim, moves upward at an increased speed depending on the ratio of mass and jet. When the water in the trap has been lifted in this way to an extent where sufficient of it can fall over the weir into the out-leg of the trap, a siphonic movement begins, and true siphonage finally takes place, the cessation of which depends upon the lack of sufficient water to continue it. Before the closet tank is emptied, siphonage often sweeps out the trap thoroughly; and what water falls back into the bowl when the siphon breaks, together with the incoming jet and flush, causes a second siphonage.

Accuracy in pointing the jet and in shaping the surfaces of its environment, are essential. If the surface above the jet-hole favors interference by the water flowing from the bowl, siphonage will be delayed and abortive, and may not take place at all. So, also, if the jet is not directed so as to maintain approximate concentricity in its travel through the mass of water, its energy is not expended to advantage, and failure is likely.

There is no excuse for iron closets not siphoning perfectly. The iron pattern can be altered until it gives the best effect in practice, after which all closets cast from it should do the same. With porec-
lain ware, however, every closet made requires the same skill in design; and notwithstanding how perfectly the closet may be formed and the jet-hole cut, shrinkage in the kiln during the drying and burning process is apt to warp the wall and change the product so that it will not act properly. Closets of both materials, apparently perfect, often fail when first tried after installation, owing to foreign matter or fragments of enamel, clay, or iron lodging in the jet and changing its action. Usually these obstructions are easily removed by the plumber.

The jet principle has been added to the Combined Hopper and Trap closet before mentioned, producing in it a siphonic action resulting in very much improved service over that of the simple form. With the jet-action, the Combined Hopper and Trap is generally termed a Wash-Down Siphon. The so-called "jet" is applied in two ways. In some makes, the flush rim has an extra large and specially formed fan-wash feature, which directs down the back wall of the bowl a sluice-like stream. This stream, in addition to wetting the paper and forcing it down into the water, where it will be promptly carried out, sweeps round the curve of the bowl outlet in such a way as to lend its force to the water in the trap to produce apparent and not infrequently true siphonage.

Another form of the wash-down siphon is provided with a channel from the flush inlet, down outside the back wall of the bowl, to near or even below the water-level in the bowl, where the jet enters through a slit. The action is much the same as with the special fan-wash mentioned, but is generally superior in siphonic effectiveness.

Jet-siphon closets are not provided with vent openings in the closet proper, except for the local bowl ventilation. Wash-out traps are, or should be, vented. The simple hopper and trap should be vented in the trap. Wash-down siphons, generally, are not vented, but it is permissible to vent them low down in the outlet leg of the trap.

All closets for indoor use should have flushing rims. In all earthenware closets and in some forms of iron closets, the rims are made integral; but the iron rims are, as a rule, separate pieces, forming a water channel around the bowl. The bottom, inner edge of the iron rim hugs the wall of the bowl as closely as practicable, and the bulk of the water falls through regularly spaced serrations. Various provisions in the shape of barriers opposite the flush inlet, per-
forated race-way shelves along the rim above the exit openings, etc., are made to insure the rim filling and flushing properly all around.

All kinds of closets were formerly made without regard to the kind of seat to be used. Boxed-in cabinet seats, self-supporting, were universal. These gave way to seat and frame, with wall and leg support. To-day closets are commonly made with base flanges designed to support the weight of the person, and are provided with lugs or seat-shelf for attaching the seat directly to the bowl, as seen in Fig. 40. Metal post hinges are best in every way, if well made and strong. The competition goods, however—made to sell rather than use—are so light as neither to keep the seat in place nor to aid in holding it together under the severe strain. The hinged wood-cleat seats bolted to the closet are strong, but are objectionable because they cannot be kept dry or clean under the cleat.

Closets are operated with pull or push-button tanks requiring the attention of the user; and are also made of the seat-action type. Children are likely to be forgetful, and visitors to public toilet rooms indifferent, to such an extent that automatic closets are desirable for public places and schools.

Closets are fitted with two styles of tanks—one placed about 7 feet from the floor and serving with a flush pipe never more than 1½ inches in diameter; and the other placed low down, as close to the bowl as connections will permit. Examples of the high-tank and low tank arrangements are shown in Figs. 41 and 42, respectively. The low tanks are wider and deeper than the high style, but do not extend out from the wall so much. The low position delivers the water at much less velocity than the elevated style, and, to secure the utmost speed and the volume necessary, the flush connection is never less than 2-inch in a low-tank closet. The rim and jet channel are proportionately larger in bowls intended for use with low tanks. High tanks are about 17 by 9 by 10 inches. Sheet lead and sheet copper are used for closet-tank linings. Some kinds of water, through galvanic action, attack the soldering of the seams in copper-lined tanks with more
effect than where lead alone is used. Generally, however, copper-lined tanks give satisfaction if the copper is heavy enough (12 to 16 oz.) and properly put in. Some makers lock-seam the linings water-tight, and solder on the outside before placing the copper in the wood case.

On account of the greater depth of low tanks, swelling of the wood case has, doubtless, been the cause of most of the trouble experienced with this type. When put together in the factory, the wood is very dry, and after being used for a short time, increases in height as a result of swelling from dampness. If the lining be tacked to the wood at bottom and top, injury is sure to result. If tacked at the top only, the copper will soon be supporting the water without help except where

the connections are attached. It is now the practice to omit fastening the lining. Very great care has been found necessary with ball cocks for low tanks, in order to secure proper after-fill, the flush connection being too short to aid much in resealing the bowl with its drainings.
Low tanks flush with much less noise than high ones, and permit placing the closet under windows and low ceilings. Low ones require more width on account of the tank, and more depth from the wall to the front, as the seat and lid must be placed far enough forward to be thrown back and remain leaning against the front of the tank. Low tanks are provided with ventilated covers; while the high pattern, which is out of children's reach, is left open at the top. The fewer working parts in a tank, the less likely it is to get out of order.

A type of seat-action closet very seldom placed in private houses, is that with closed metal tank, as represented in Fig. 43. Depressing the seat opens a valve in the supply, and the water passes up through a flush pipe into a closed tank. The air in the tank is compressed until the air-pressure counterbalances that of the water. When the seat is released, the supply valve closes: and a valve is opened, establishing communication between the closet and the tank. The compressed air then expels the water in the tank, flushing the closet just as a large supply with corresponding pressure would do without a tank. Closed-tank closets depend on pressure. The space occupied by the air in the tank is inversely proportional to the pressure; hence, even in heavy pressure, considerable of the tank's capacity is yet occupied by air when equilibrium is established; and the less the pressure, the smaller the amount of water it is possible to get into the tank. They are therefore not fit for very light pressures, though they sometimes serve well in the basement of a building where failure would be certain on the upper floor.
CONCRETE HEADWORKS, GATES CLOSED, HUNTLEY PROJECT, MONTANA

This project calls for the irrigation of 26,000 acres of Crow Indian Reservation land by means of water diverted from the lower Yellowstone River.

Photo by Reclamation Service.
Condensation on metal tanks is annoying. Open tanks of porcelain and iron are used more or less, but sweating is hard to overcome. Zinc paint and ground cork finishes have been employed with some satisfaction; and drip-cup collars discharging into the flush just under the tank have served in this capacity, but nothing overcomes the sweating so well as a tight wood case, insulated metal cases not excepted. Some makes of the pressure-tank closet require too much weight on the seat for successful operation by a child, and children would as a rule leave the seat too soon to allow the tank to fill reasonably well. The flush pipe of pressure closets is from a few inches to four feet in length. The after-fill is accomplished by projecting the flush connection into the tank an inch or more, and drilling a $\frac{1}{4}$-inch hole or less through it near the bottom of tank. The rapid flow ceases when the water-level falls to the upper end of the inward-projecting flush connection, and the after-fill drains into and down the flush slowly.

The flush fittings of an open tank consist essentially of a valve to admit water to the flush pipe; an overflow always open to the flush pipe; and a lever and connection, with chain and pull or button, to open the flush valve. A simple example of these is the siphon goose-neck, with flush-valve disc on one end and lever connection at the other. Prongs extend below the disc to guide and keep it in place. The overflow is through the gooseneck. Lifting the gooseneck an instant permits enough water to flow down the flush to start the siphon through it when the pull is released. The tank then siphons to the lower end of the gooseneck arm.

Where shortness of flush pipe or form of closet requires a decided after-fill, this is secured by special provision in the flush fittings, or by leading some of the supply delivered by the ball cock into the overflow.

The supply fittings of a closet tank consist merely of a ball cock of suitable form. For light pressure, simple leverage suffices. For heavy pressure, the inlet in the valve would have to be too small, or the ball too large and stem too long, for a small tank, if simple leverage were employed. Therefore compound-leverage cocks are usually substituted where the pressure contended with is over 30 pounds. There are ball cocks made in which the buoyancy of the ball merely operates a small secondary valve in a way to establish the initial
pressure over a disc of larger upper surface than that of the under side which covers the main water inlet of the cock. The disc is thus effectually seated, regardless of the pressure; and a 4-inch ball may be arranged to close almost any size valve against any pressure.

When the cock is attached through the bottom of the tank, no precaution against sound is necessary. When the cock is fitted in high up, a pipe from the delivery is extended to near the bottom of tank for the purpose of muffling the sound of the water as it fills the tank. An unmuffled delivery and a high-tank flush make considerable noise when the closet is flushed, and are suggestive and very embarrassing to sensitive people. Silent action is therefore the goal for which many strive. Silence at the expense of thoroughly washing the closet surfaces and flushing out the contents, is not desirable; some noise is necessary to the rapidity of action essential to thorough scouring and evacuation.

Tanks requiring the flush valve to be held off the seat during the entire flush, are now no longer installed. Perfect silence in the flush pipe of a high-tank closet has been obtained by a type of flush fittings that permits the pipe to hang full of water. The flush valve being opened, water begins to flow into the closet immediately. When the valve closes, no air having access at the upper end of the flush, the pipe remains filled. The flush valve of such a closet must close absolutely water-tight to prevent continual dribbling into the bowl.

Of late years, direct-flushing valves of many forms have been a feature of water-closet design. These valves make the individual closet tank unnecessary. Direct-flushing closets, a type of which is shown in Fig. 44, have the same advantage as the low tank in the matter of being placed where high closets cannot conveniently be arranged. A check to their more general adoption has been the lack of large supplies in residences and other buildings.

The possibility that the house system of water supply may be contaminated from the water-closet if the water supply is directly connected to the water-closet fixture, should not be overlooked. Although this contamination is more likely to take place in the operation of the older types of closets, such as the pan closet and the plunger type, it is not of rare occurrence in connection with later types, especially the so-called frost-proof fixture. If the pressure is materially lowered in the street main by accident or otherwise, it sometimes
happens that water may be drawn back into the house system by siphonage from a water-closet or like fixture, thus of course incurring the possibility that germs of disease may be brought into the water supply used for domestic purposes. The use of a tank into which the water is first drawn, obviates this danger.

The ordinary dwelling or storehouse supply can be made to operate successfully by placing an accumulating chamber on the branch to the closet, and having a check-valve on the street side of it, so that the water cannot flow back when the pressure falls as a result of drawing at other points. In such cases the pipe between the accumulator and the closet must be the usual 1½-inch size. Closets thus fitted are really only pressure-tank closets with the flush controlled by a direct-flushing valve to be operated at will instead of automatically by seat-action.

In all tank installations, the direct method is easily employed by carrying the proper size flush main directly to the closets, independently of the supply for other fixtures. This is recommended in buildings having numerous closets. One tank, with large flushing main, will serve all the closets, and thus the individual tanks and equipment are not needed. Furthermore, no trouble is then experienced in providing suitable space for the small tanks. The flushing valves may, if desired, be placed out of sight, and only the operating lever brought to view in a convenient position. A flushing valve has been made which, like the secondary-valve ball cock, works on the old Jennings diaphragm principle, using a “time” filling cup to establish the initial pressure over the diaphragm. Releasing the pressure over the diaphragm by means of the operating lever, opens the main channel and causes the closet to flush while the time chamber fills again.

In this country and most others, the height of closets has always been uniformly 16 to 17 inches to top of seat. It is claimed that this height results in an unnatural position, and individual opinions against it have been voiced from time to time with little effect. Lately, however, more earnest attention has been given the subject of height, and there has been designed a closet considerably lower than usual, with the top sloping down toward the back. This form, it is said, induces the user to assume an upright position of body, relatively more closely conforming to that of the limbs, and favoring
unrestricted action of the intestines. It remains to be seen whether this form will result in any general departure from the old lines.

Closets often also serve as urinals, especially in private houses. For limited service, this is not to be considered an actual abuse of the fixture, though general use of distinct urinal fixtures is indispensable.

Range Closets. Batteries of individual closets are usual in office buildings and many other such structures; but in schools and in many public places open to all classes, ranges divided into stalls or compartments have been considered a satisfactory solution of the problem.
The objections to the range type of fixture are inherent in the design. The fouling surface of a trough fixture is much greater than that of the number of individual closets to which the fixture corresponds, and certain parts of this surface are not subject to an adequate flushing action. A certain portion of the surface, much larger relatively than that in individual fixtures, is exposed to spattering with the filth, and is alternately wet and dry. It is also true that the method of applying the water for scouring purposes is much less satisfactory than with single closets. A further objection to the range fixture is that in general its material is less desirable for the purpose than the earthenware or porcelain used for closets. On account of these deficiencies, for some ten years past, individual closets have been used in public schools in certain cities which have given the most attention to this branch of sanitation, and their use is being extended.

Range closets have automatic flushing tanks acting at any required interval between flushes. The tanks are, as a rule, without moving parts, and give good service without much attention after the supply is once set to flush at the interval desired. Whether the users of a closet are indifferent or irresponsible, does not change the result of abuse; and the range type of closet overcomes many annoyances attending the use of ordinary individual closets in unsuitable places—institutions for the insane and feeble-minded, for example. Ranges, like seat-action closets, are not dependent on the user, who may forget to pull a chain or push a button and thereby leave the closet foul.

Various forms of ranges are now operated on the siphon eduction principle. Siphonic eduction is accomplished in three ways—first, by the double trap and air-pipe to the tank indicated by the sectional view, Fig. 45, and operating exactly like the individual pneumatic closet already described; second, by a siphon outlet-end in which the water falls over a central weir that maintains the proper depth of water until the flush begins, and causes siphonage by breaking up and filling the channel as it passes through a constricted bend below. The latter method is shown in section in Fig. 46. Still another type of range is made to siphon by jet-action, just as the individual jet-siphon closet does, the trap providing a retaining weir which holds the water at the proper level in the range between flushes.
There are wash-out ranges with sloping weirs at the outlet to retain enough water to keep soil from sticking. These are open troughs, and the plumber provides the trap. Some siphon ranges are of the open-trough pattern, but the trap or the siphon outlet is a part of the fixture. All open-trough ranges can be supplied with a ventilating section from which a large vent pipe may be carried to a stack in which a draft is insured by a hot flue or some other means. Such ventilation changes the air in the room; and by having lids to all the seats, odors from the entire trough may be uniformly removed by leaving up one lid only, at the end opposite the vent pipe. Some forms, having individual flushing-rim bowls cast integral with the section, are supplied by one general flush pipe, as indicated by the plan and elevation shown in Fig. 47. In these, each bowl is separately water-sealed, as the normal water-level is above the general conduit into which the bowls discharge.

Other forms, which receive the entire flush at one end, are water-sealed between the seat holes. The seat-openings, instead of converging like flushing-rim bowls, diverge downward, so that, as the water-level recedes in the sections during flushing, soil falls away from the surface by gravity instead of grinding against it. Therefore, so far
as cleanliness is concerned, the type with diverging surfaces but without the scouring effect of flowing water in the openings is, in operation, the practical equivalent of the flushing-rim type with converging surfaces. The open-trough ranges, including the jet-siphon type, have perforated wash-down pipes along the sides and ends, which, however, have little value. The open troughs are made in cast sections as long as convenient, joined by flanges with rubber gaskets and bolts. Suitable feet or chairs for supports are furnished with these fixtures.

Cast partitions, partitions and backs, and full compartment partitions, with slat doors and indicators, are furnished to order in any style or combination desired. For example, the range for a schoolroom may consist altogether of 24-inch sections or divisions, except one intended for the teachers' use made 30 inches and fitted with door and full-length partitions to give a thoroughly private compartment. Ranges are usually made of cast iron, and almost invariably finished with enameled interior and painted exterior. Bowl or section ventilation is provided for where possible. Wood seats and covers are generally used; but enameled-iron top frames with hinged seats and covers, and rigid enameled seats, are also made.

The lower trap of a double-trap range must be ventilated. All soil-pipe stacks into which ranges discharge, and fixtures connected
to them, must be well protected against siphonage, because the volume of water discharged at one time by a range is sufficient to siphon traps that would retain their seals under most other conditions.

**Urinals.** Sectional urinals are made of the same materials and finish, and with much the same types of design, as range closets. They are generally installed in the same classes of buildings as range closets; but such urinals will often be found in the same toilet-room with individual closets. Roll-rim enameled troughs, with back and with simple perforated wash-down flush pipes on the back, are available.

Single urinals are usually of porcelain, although some have been made of iron. The common types are plain or lipped, made in flat-back and corner designs. Flat-back types of both de-

![Fig. 47. Sectional Elevation and Plan of Range Closet Seat with Flushing-Rim Bowl Supplied from General Flush-Pipe.](image)

![Fig. 48. Flat-Back Types of Single Urinals.](image)

signs are shown in Fig. 48. All have flushing rims. Direct-flushing valves of the same type as used on closets, adapted to the purpose,
and cocks of various types, are the means of flushing generally provided for a single urinal. When two or more are placed in one toilet-room, an automatic tank with branched flush pipe is employed. These tanks are of greater variety than those used with range closets. The tilting bucket, pivoted within a tank case, which empties itself periodically by means of the flow of water changing the center of gravity to the unsupported side and tipping it just before it overflows, is a familiar type of automatic urinal-flushing tank. The standard tank with immovable parts, which siphons automatically, is also prevalent. Examples of these types are illustrated in section in Fig. 49.

Another design consists of a tank with common siphon, fitted with a ball cock which opens, instead of closing, as the water in the tank lifts the ball. The interval between flushes is governed by a small bibb cock, which may be turned on more or less so as to take greater or less length of time for the water in the tank to reach the ball. When water begins to lift the ball, the ball cock also admits water. From this point the tank fills
rapidly. The higher the ball is lifted, the faster the tank fills, so that by the time the water-level reaches a point where water begins to flow over the neck of the siphon, it is coming into the tank rapidly enough to more than keep pace with the overflow necessary to start the siphon. True siphonage, however, empties the tank much faster than the supply can fill it; and the tank is soon empty, leaving the small bibb cock to admit water again slowly to where this action can be repeated.

Individual urinals which siphon by admitting additional water to that which normally stands in the fixture, and various other types, will be best understood from a study of dealers’ catalogues. In good work, marble backs and partitions usually enclose the urinals on three sides. Marble and slate stalls of various construction, with channeled and guttered floor, as shown in Fig. 50, all washed by perforated pipes fixed along the surfaces, are frequently used in lieu of specific urinal fixtures. A thick base of slab material is sometimes used, the gutter and drain-hole being cut in it. Cast-iron gutters, galvanized or enameled, with an outlet-end adapted to a soil-pipe connection, are supplied by the makers.

In describing the fixtures and trimmings that have been noticed, only salient features of form and principles of design have been considered. Sufficient guidance to insure intelligent comparison of merits and skilful discrimination in selection, has been given. Catalogue detail and illustration, and a view of the actual goods described therein, should, with what has now been given, insure the fullest understanding of the fixture branch of Plumbing.

**HOUSE WATER SUPPLY**

While the plumber is apt to give more attention to supply pipe, and to methods of installing it in buildings to secure specific service, water supply embraces also, in its broadest sense, the source and quality of water and the means of conveying it to the building. Plumbers generally have little dealing with water supply outside of the house walls. Custom has fixed certain arbitrary sizes in ordinary work, to such a degree that the average plumber has generally ignored information on the flow of water through pipes. Indeed, he is so rarely in actual need of this knowledge, that it appears a burden to acquire and to fix permanently in his mind the simplest formula bearing on the subject. Enough information to determine approximate deliveries
and point the road to further research, will not be out of place in behalf of those who may need simple directions.

The laws of gravity are the basis for the science of hydraulics, of which a prime factor of every problem is *velocity*. There is no exception to the rule that all bodies falling freely, descend at the same rate—in round numbers, 16 feet for the first second, at the end of which the acquired velocity is one of 32 feet a second. This is the basis on which are formulated the laws of falling bodies, which, exhibiting what is known as *velocity of efflux*, together with loss by friction, must be considered when calculating the flow of water.

There are three kinds of velocity—*uniform, accelerated, and retarded*. It is the last, and its cause, friction, that plumbers should be most interested in, as velocities calculated merely from the laws of falling bodies do not take account of friction, change of course, etc., which must be allowed for as causes diminishing the delivery of water through pipes. Briefly stated, the mysterious-looking Torricellian formula \( v^2 = 2gh \), means only that velocity is found by extracting the square root of the product of the head multiplied by \( 2 \times 32 \), \( g \) standing for the force of gravity, and \( h \) for the height. For example, a stream filling a 1-inch pipe, with 25 feet head of water, would have a velocity calculated thus: \( 2 \times 32 \times 25 = 1,600 \); and the square root of 1,600 = 40 = Velocity, friction not considered.

The shape of the orifice through which water enters a pipe, has much to do with the amount of water that will enter it. Friction against the sides of the pipe, and change of direction due to bends and connections, occasion great variation from the theoretical flow. Not only is the character of the pipe surface and fittings to be considered as initial causes varying the delivery, but velocity, the all-important factor, must be reckoned with in every instance. With a velocity of 10 feet per second in a pipe of comparatively smooth interior surface, the friction loss in pounds on one square foot of surface will be about \( \frac{1}{2} \) pound. If this velocity is increased or diminished, the factor of friction will vary accordingly, always in proportion to the square of the velocity. Suppose the velocity to be 20 feet instead of 10 feet per second; we then have, 10 squared equals 100, and 20 squared equals 400. The square of these velocities is as 1 to 4, and as we assign a \( \frac{1}{2} \)-pound loss to ten feet velocity per second, on a stated amount of surface, the friction due to doubling the velocity should be four times.
a $\frac{1}{2}$ pound = 2 pounds, showing that doubling the velocity increases the friction four-fold; trebling it increases friction nine-fold, etc.

A column of water weighs .43 pound per square inch of base, per vertical foot. Therefore a vertical pipe 100 feet high, with 1-inch sectional area, filled with water, would contain 43 pounds, and a gauge at the bottom would show 43 pounds pressure. If the pipe were only $\frac{1}{4}$ inch, or were 40 inches in diameter, the gauge would show the same pressure for the same vertical height—namely, .43 pound per square inch per vertical foot. A head of water expressed in feet, may be changed to pounds by multiplying the feet of head by .43. Pressure is made to read in feet of head by multiplying pressure per square inch by 2.3. A head of water is the number of vertical feet from level of source of supply to center of outlet or point of delivery.

Diameter of the pipe has nothing to do with static head or pressure; but its relation to the size of the orifice from which the water is to be drawn has much to do with the amount of pressure lost by friction. If a faucet and supply pipe are of the same size, and we double the size of the pipe, the velocity of the water flowing through it is reduced three-fourths; and the friction is, under these conditions, but one-sixteenth what it was in the original size. Moreover, as in drawing similar amounts of water under the same head through a one-inch and a two-inch pipe, the amount of friction surface presented is twice as great in the one-inch as in the two-inch pipe, the friction in the one-inch can be shown to be 32 times as much as in the two-inch pipe.

With the formula given, one can roughly approximate by finding the theoretical delivery and deducting a liberal percentage for friction, according to size, length of pipe, and head or pressure. The subject, however, is vast and tedious, introducing intricate calculations in higher mathematics when considered in detail with a view to extreme accuracy of results, and is a branch properly belonging to hydrodynamics, rather than suited to presentation at length here. Two tables are given, however, which with the rules for use, will be of value to those who fail to make further research.

Table I shows the pressure of water in pounds per square inch for elevations varying in height from 1 to 135 feet.

Table II gives the drop in pressure due to friction in pipes of different diameters for varying rates of flow. The figures given
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are for pipes 100 feet in height. The frictional resistance in smooth pipes having a constant flow of water through them is proportional to the length of pipe. That is, if the friction causes a drop in pressure of 4.07 pounds per square inch in a 1\(\frac{1}{2}\)-inch pipe 100 feet long, which is discharging 20 gallons per minute, it will cause a drop of 4.07 \times 2 =

<table>
<thead>
<tr>
<th>Feet per pipe</th>
<th>Second</th>
<th>Velocity in Feet per second</th>
<th>Friction loss in pounds</th>
<th>Pressure loss in pounds</th>
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TABLE II.

8.14 pounds in a pipe 200 feet long; or 4.07 \div 2 = 2.03 pounds in a pipe 50 feet long, acting under the same conditions. The factors given in the table are for pipes of smooth interior, like lead, brass, or wrought iron.

**Examples.**—A 1\(\frac{1}{2}\)-inch pipe 100 feet long connected with a cistern is to discharge 35 gallons per minute. At what elevation above
the end of the pipe must the surface of the water in the cistern be to produce this flow?

In Table II we find the friction loss for a 1\(\frac{1}{2}\)-inch pipe discharging 35 gallons per minute to be 5.05 pounds. In Table I we find a pressure of 5.2 pounds corresponds to a head of 12 feet, which is approximately the elevation required.

How many gallons will be discharged through a 2-inch pipe 100 feet long where the inlet is 22 feet above the outlet? In Table I we find a head of 22 feet corresponds to a pressure of 9.53 pounds. Then, looking in Table II, we find in the column of Friction Loss for a 2-inch pipe that a pressure of 9.46 corresponds to a discharge of 100 gallons per minute.

Tables I and II are commonly used together in examples.

A house requiring a maximum of 10 gallons of water per minute is to be supplied from a spring which is located 600 feet distant, and at an elevation of 50 feet above the point of discharge. What size of pipe will be required? From Table I we find an elevation or head of 50 feet will produce a pressure of 21.65 pounds per square inch. Then if the length of the pipe were only 100 feet, we should have a pressure of 21.65 pounds available to overcome the friction in the pipe, and could follow along the line corresponding to 10 gallons in Table II until we came to the friction loss corresponding most nearly to 21.65, and take the size of pipe corresponding. But as the length of the pipe is 600 feet, the friction loss will be six times that given in Table II for given sizes of pipe and rates of flow; hence we must divide 21.65 by 6 to obtain the available head to overcome friction, and look for this quantity in the table, 21.65 \(\div\) 6 = 3.61, and Table II shows us that a 1-inch pipe will discharge 10 gallons per minute with a friction loss of 3.16 pounds, and this is the size we should use.

In calculating the contents of pipes, cylinders, and cisterns, where it is usual to correct the area found as a result of squaring the diameter by multiplying by .7854, before dividing by 231 for U. S. gallons, multiplication by the decimal may be omitted, and dividing by 294 instead of 231 will then give the same result.

**EXAMPLES FOR PRACTICE**

1. What size pipe will be required to discharge 40 gallons per minute, a distance of 50 feet, with a pressure head of 19 feet?

   Ans. 1\(\frac{1}{2}\)-inch.
2. What head will be required to discharge 100 gallons per minute through a 2\(\frac{1}{2}\)-inch pipe 700 feet long?  

**Ans. 52 feet.**

**TYPES OF WATER SUPPLY**

There are various ways in which it may be necessary to obtain the water supply for a building. The usual course in cities and towns is to employ the Municipal Water Works service. This, of course, settles the supply feature, and the plumber simply provides the house and yard pipe, \(\frac{1}{2}\)-inch or larger main, according to the character of the work. If of lead, the pipe must be of strength according with the pressure. Any of the light-weight grades of lead supply will stand 1,000 pounds per square inch for a short time; and the usual strength used on 50 to 80-pound pipe will not burst under 1,400 to 1,600 pounds when new and unstrained. Under constant pressure, the enormous strain possible from water-hammer, and general deterioration from use, make it advisable to employ pipe which, when new, is 20 times as strong as that necessary to contain the pressure. No attention is necessary as to the strength of zinc-coated or tin-coated iron pipe; it will stand any pressure ordinarily encountered.

The two general methods of supplying buildings with water are: (1) the **direct** system; and (2) the **indirect** or **tank** system. The direct method, generally employed in cities, places each fixture connected with the supply under the same pressure as the street main, unless a reducing valve is introduced, thus often subjecting the work to needless high pressure and always to the widely varying conditions and quality of service incidental to such use. In the direct system it is good practice, where at all practicable, to pipe and fit the work generally for pressure not exceeding 50 pounds per square inch, and then use a reducing valve to maintain such pressure as is required.

The indirect method is almost always necessarily employed in isolated work; and even where municipal service is available, it is generally better for ordinary domestic purposes. With the indirect system, the connection with the street main is carried directly to a tank placed in the attic, or at some point above the highest fixture, as shown in Fig. 51. The supply to tank is regulated by a ball-cock which automatically shuts off the water when the tank becomes full, and opens and refills it again when water is drawn out. All the plumbing fixtures are supplied directly from the tank, and are there-
fore under a constant minimum pressure depending on the distance the fixtures are situated below the tank. The tank storage is a matter of great convenience during repairs to street mains, aside from its ad-

![Diagram of indirect tank system]

Fig. 51. Indirect or Tank System of House Supply.

vantages of uniform pressure, reduced expense of fitting and maintaining low-pressure work, etc.

In municipalities where the pressure in the main is not sufficient to carry the water up to the house tank in the attic, and in elevated situations, an automatic, electrically-operated rotary or other suitable form of pump is often installed to lift the water. A screw pump like that shown in Fig. 52 is especially adapted to this use when
equipped with an electric motor to start and stop automatically by means of a float in the tank operating an electric switch as shown in the engraving.

Where steam pressure is available, steam-operated pumps are very frequently used, and are invariably arranged for automatic service whether there are engineers regularly in attendance or not. A device that may be attached to steam pumps for this purpose is shown in Fig. 53. When the high-water line in the tank is reached, the float closes a valve in the pump discharge pipe, thus promptly increasing the pressure in it so as to actuate a piston through a pipe connection from the pump discharge to the regulator beneath the piston head. The regulator is shown complete, in detail, partly in section, in Fig. 54. Raising the piston shuts off the steam supply to the pump at the governor valve. When the water line in the tank is lowered, the float falls and the ball valve opens, relieving the pressure in the pump discharge pipe and allowing the steam governor valve to open by the action of the coun-
Fig. 53. Steam Pump Equipped with Regulator Operated by Float in Tank, Securing Automatic Service.
terweights attached to the lever arm, as shown; and the pump then works regularly until the lifting of the float by the rising water again closes the valve in the pump discharge and repeats the action described.

Outside of corporations, the supply may be from an elevated spring or stream, or from wells, cisterns, or other sources below the level of use. If the natural supply is high enough, it may be conveyed into a tank of sufficient height without intermediate apparatus. Tanks inside the dwelling or house are best, ordinarily.

**Tanks** for cold-water storage are made of various materials and in different shapes and sizes, according to the special uses for which
they are required. For indoor use, copper-lined or lead-lined wood-case tanks without safe-pans, and wrought-iron or cast-iron tanks with safe-pans to catch the condensation, constitute the list generally favored by reason of superior fitness. Within limited dimensions, a durable and satisfactory tank-case can be made of heavy, well-fitted, and well-seasoned plank bolted together with iron rods and nuts, as shown in Fig. 55. For large sizes, heavy wood stays with tie-rods one-third of the way from each end, are added. With copper linings, but few nails should be used; and they should be so placed as to be covered by the copper, the joints being soldered by soaking the best quality of solder into the seams. The locking of the seams is shown greatly exaggerated in the engraving.

Cast-iron sectional tanks, like the form shown in Fig. 56, can be had in almost any size or shape. They are made up of plates planed and bolted together, the joints being made water-tight with cement. The sections are in convenient sizes, so that they can be handled.
easily, and conveyed without difficulty through small doorways or other openings to any part of the house. These tanks are easily set up, and are practically indestructible. Open and closed wrought-iron tanks, plain or galvanized, are often used, but are not so easily handled; and the larger sizes require to be riveted together and caulked in place.

Lead-lined tanks are most frequently used for ordinary house plumbing. The linings were formerly wiped-in without exception. Sweating the lead together with a torch flame is however, quite as durable, and is much cheaper. To sweat-in a lining, take the exact length and breadth of the tank, trying at different points to be sure of allowing for any variations. Then cut out the bottom lining just the shape of the tank bottom, one and one-half inches larger each way, less twice the thickness of the lead. This allows three-quarters of an inch to turn up all around; and the bottom will just fit when the side pieces are in place. Mark off the bottom all around, as shown by the dotted lines in Fig. 57; and turn up the edge. With the intersection of the lines A as a center, and the termination of one of them as a starting point, describe the line B, and cut off the corner outside of it. Then work the corner up square without a kink. If the lead is heavy, a little heat will make it work better. After working-up, the lead at the corners will be much thicker than along the sides; this may be needed in stretching out, at some of the corners.

When the edges and corners of the bottom are formed, clean the edges and about three-eighths of an inch down the outside all around, and rub the clean part with sperm candle. Next make a mark, say three feet from one end on each side, as at E and F, Fig 58. Then, on lines C and D, push the edges down inside, and fold the ends over as indicated by the dotted lines.
The bottom is now ready to be put in the tank, but it must wait until the sides and ends are in. If the sides and ends are light enough to be handled after joining like a ring, cut out a strip half an inch longer than will exactly go around the tank inside, equal to its depth plus the thickness of the tank wood for a flange at the top, as shown at J, Fig. 63. Then clean a half-inch of the under side and edge of the end that is to show in the seam, and three-quarters of an inch of the side that comes in contact with it, at the other end. The lead may then be propped up in the position shown in Fig. 59, by means of treestles and poles or in any other convenient manner; and the seam may be set, as shown, upon a board of hardwood, and the solder sweated into the lap by means of the torch and blowpipe. Solder for this kind of work should be three-fifths tin and two-fifths lead. A hardwood board is used because it will not smoke and burn like soft wood.

When the seam is made in this way, it shows inside the tank, and a good joint where the bottom seam crosses it can be made with ease, while one is never quite sure of the result if the seam crossed is on the other side.

Another method is to cut the lead the exact length that will go around the tank, clean the edges, butt them together over a hardwood board, as shown in Fig. 60, and burn them together instead of soldering. This can be done by using, instead of solder, a well-cleaned strip of lead about half an inch wide. Sperm candle will also answer as flux for burning. A piece of steel
or iron is best to place under the seam when burning, as more heat is required to do the work. An old crosscut saw blade, fastened to a board, serves well for such seams. The bottom edge of the side lining should be cleaned 1\(\frac{1}{2}\)-inches wide, as shown at \(H\), Fig. 61, which indicates how the cleanings on the bottom and the side and end lining come together in the tank. It is a good plan to run the soil brush around the bottom edge of the lining, as shown at \(O\) and \(P\), Fig. 61. The soil keeps the solder from sweating too deep, and enables the seam to fill quickly. Further than this, however, soiling, as in the preparation for wiping, is not necessary for sweated seams.

When the side lining “loop” is ready, lift it into the tank, square it out, flange over at the top, and secure the flange with brass, copper, or galvanized nails. Next, mark distances in the tank corresponding to those at \(E\) and \(F\) in Fig. 58. Then catch the bottom at the folded edges (Fig. 58), and lower it into the tank. As the ends are folded, there is room to stand inside the tank at the ends. Pull the folds upright so that marks \(E\) and \(F\) can be seen, and slide the bottom back or forward until \(E\) and \(F\) correspond with the marks made on the side lining. The ends may then be pushed down in place, and will be found to fit exactly if the measures have been properly taken.

After dressing down the bottom and pressing the turned-up edges against the sides and ends, sweat the bottom to the sides in the same way as the other seam was made, being sure that the solder “takes” well to both pieces of lead.

When a tank is large, handle the sides and ends in two or more pieces, always having the seams that are to be made in place come at the ends of the tank, as the ends are stiffest and best to brace against.
Fig. 62 shows the method of keeping the lead in place while making the upright seam in the tank, \( I \) being the tank wood, \( JJ \) the lining, \( K \) the straight edge, and \( M \) the brace. \( K \) is a piece of hardwood fastened to a strip of steel (a piece of an old framing square), as shown in the cut, the wood being about four inches wide by two feet long, and the steel \( L \) sticking half an inch out from the beveled edge of the wood. This steel edge keeps the lead from buckling under influence of the flame while blowing the seam, and is much better than a wood straight-edge, as it can be applied at the proper place with no fear of its burning or annoying the operator by smoking from the heat.

Fig 63 shows the lining in place, and the method of applying the brace and straight-edge to the seams that are to be blown upright in position. Letters and parts in Figs. 62 and 63 correspond, \( N \) in Fig. 63 being the bottom.

Unless the supply is regular and abundant, and the storage by gravity, outside tanks of ordinary capacity, if of wood, are expensive and troublesome from leakage due to shrinkage of staves above the water-line and from necessity of painting; if of iron, from change in character of water, freezing, cost of boxing, delivery to, and discharge from, in a frost-proof manner, etc.

A spring supply will answer if of sufficient elevation to store water by gravity; or a waterfall above or below the house level may be handled with a hydraulic ram if 5 to 15 per cent of the water regularly available will suffice.

Hydraulic Ram. A ram uses the energy of a fall to elevate part of the water passing through it—one-sixth or less, according to the
fall and the height to which the water is to be delivered. Four feet
of fall is about as little as can be utilized to advantage; and fifty feet
of liberal-size drive-pipe, even though it has to be coiled with uniform
fall, is necessary to give the water momentum enough to get the best
results.

Fig. 64 illustrates the elementary principles of a simple ram. A
represents the source or spring; B, the drive (supply) pipe; C, a
valve opening upward; D, an air-chamber; E, a valve tending to
close downward by gravity; and F, the discharge pipe. In action,
the water passes through the ram and out at a waste valve E, which
is open downward until sufficient velocity is attained to lift and close
the waste exit. There being then no other means of egress, the
check-valve C, opening upward to the discharge pipe, is forced open;
and the energy of acquired momentum delivers water into the air-
chamber D and discharge pipe F, until the pressure on the waste
valve falls too low to hold it up (closed). The check-valve C then
closes, and retains the water in the discharge; and the waste valve
E falls open by gravity, leaving a comparatively unrestricted exit
through which the water continues to waste with increasing force
until the velocity in the drive pipe is again sufficient to repeat the
impulsive delivery. Rams are made with large air-chambers, to
cushion the initial strain of impulse, and should have a delivery pipe
at least one size larger than the ram opening, especially if working
under light fall or high delivery.

Cisterns are seldom so deep or situated so low that ordinary
house force-pumps within doors cannot be used. The distance of the
cylinder above the lowest level from which water may need to be
pumped, is limited in all pumps alike—33 feet 9 inches atmospheric
lift under perfect conditions, and about 25 feet under the most perfect
practicable pump arrangement. Indeed, the velocity of flow into the
cylinder at any point above 20 feet is so slow that in practice the cylin-
der should be well within a twenty-foot limit in vertical distance from
the water; and the closer the better. A foot-valve strainer at the end
of a cistern suction pipe will keep the pipe filled and avoid frequent
exhausting of the air before water can be obtained. When a foot
valve is used, means of draining the suction to below frost line, when
necessary, must be provided.