The problem of getting water for domestic use has been a question from the earliest times. The first source was probably a spring or creek and no great system was needed. Each person used his own reservoir to carry it. But when the population centres are in large numbers, as in cities, the friction experienced in obtaining wholesome water is very great and some provision must be made.

Among the first systems of supplying water to a large community was that in Jerusalem. This task was undertaken by Solomon. It was the supplying of Jerusalem with water taken from Bethlehem, conducted in stone conduits three feet square and fifteen inches thick.

But the Roman aqueducts are the ones now most studied, and taken as a type of ancient water works. There were twenty of these systems in the city of Rome before the seat of government was moved to Constantinople. The channels were closed to keep out foreign substances. The slope was rather deep

and kept the rate of motion at a great speed. They were always kept at the same grade; this necessitated placing them under hills and on arches in crossing ravines. The greater part was underground. The conduits were usually four by six feet. Knowing the effect of air in the pipes, openings were made at short intervals to let it out. The main line usually emptied into settling basins. These were covered to prevent the action of light and air. From these the water went to distributing basins and from these to public baths and fountains and private service.

When a city becomes thickly populated surface wells necessarily become contaminated from sewage sinking into the underground streams. In such cases the only natural supply left is by what can be caught from the roofs and stored in cisterns. But these are not sufficient for all domestic purposes and fire service. This condition will necessitate the building of some larger artificial supply.

If a large body of fresh water is close by, the first attention will be turned to it. If very large such as the Great Lakes it will act as a settling basin and all substances held in suspension will be dropped. But if the sewage is dumped close to the shore, as in Milwaukee and Chicago, the supply must be taken from far enough out into the lake to guarantee its purity. This difficulty is overcome by building a crib at the required distance and from this a tunnel to lead the water to a well on the shore, from which the water is pumped. This method gives an unlimited and if far enough out a wholesome supply.

If a river flows near the place of consumption, it may or may not furnish the kind of water needed if pumped direct from it. The efficiency of such a supply depends upon the nearness and number of cities, slaughter houses, and manufactories that dump their sewage and refuse into it. It depends upon the kind of river to insure the water purifying itself before reaching the place of use.

For instance, at Albany the water of the Hudson is declared to be amply pure for domestic use, although the city of Troy empties its sewage into the same river only eight miles up the stream. While in other places it might take a far greater distance before the water is fit for use.

If the river is very muddy the water may be freed from this by first conveying it to large settling basins and after a required length of time drawing it off. This method is illustrated by the St. Louis system, which receives mostly Missouri River water, which is noted for its turbidity.

When the river supply is doubtful wells may be put under the river bed and the water received from these. It is preferable if under a stratum of clay. But this stratum may be so situated above a second that it holds contaminated water from cities, cemeteries, and slaughter houses. Or the first layer may be so situated that the contamination will remain above it. Therefore if such places of sewage exist within close distances a careful geological

survey of this stratum should be made.

In some places where a large water supply is needed, a whole river may be dammed and converted into a lake. This necessitates that the water shed of this river be entirely free from offensive agents. In the Croton Valley which supplies New York, the whole is entirely freed from habitation and cemeteries. This system needs a strong dam usually in a narrow gorge, and large enough to hold enough water to last through a dry season.

This method is adopted by nearly all cities favorably enough located. The stream is usually stopped high enough on hill or mountain to afford enough pressure to guarantee a good strong flow to place of distribution. If the dam is very high and the conduit not strong enough the pressure must be reduced by means of a gate house.

A method similar to the latter is getting the supply from small mountain streams. Many of these are dammed up and the water led to a common reservoir. This water is very pure and free from micro-organisms. Denver has a system similar

to this and the supply is so abundant that the water is very much wasted. Vienna reduced sickness and the death rate very appreciably by getting its supply from the mountains sixty miles distant.

Another good method is by taking water directly from springs and artesian wells. This water is practically pure, being free from organic decay and micro-organisms. It cannot be said to be absolutely pure but in the great majority of cases it is the best obtainable. The Paris water system is an example of this kind.

Taking from underground streams is sometimes resorted to. Wells are sunk down to water, these connected, and pumped out directly. The supply is usually steady and the water of the very best quality if taken quite away from a large city.

If water is not good a filtering process is gone through. The filters are of very varying styles and working on several different principles. The simplest is that of passing the water through large tanks of sand, this will catch from ninety five to ninety nine per cent of the

impurities which are again washed out and the same sand used. Another system used mostly in this country for removing organic matters is by coagulating them by the use of alum.

If the supply of water is from a low source it may be pumped into stand pipes or reservoir. These give a uniform pressure at all times if kept full, and also a place to store in case of sudden demand. Or the water may be forced directly into the pipes by the Holly system. This causes some breakage of pipes and necessitates pumping at all times. The pumps are so regulated that the pressure remains uniform. In places where elevated land cannot be had and stand pipes are impracticable, this system is the only satisfactory one, unless an artisian well can be driven. But in most cases such wells are out of the question.

When water can be found upon an elevation, a large reservoir of some kind should be built to store up water in case of drouth and yet this reservoir should be high enough to give good pressure at the

place of consumption. When such conditions exist, they can furnish, with a little manipulation, the best kind of water system in existence.

When water is kept stored a problem presents itself how to keep the water free from foreign substances and stagnation. If water is kept from the sun and other climatic changes it will keep pure for an almost indefinite period. When the sun is present all sorts of algae will grow, these live upon substances in themselves not injurious, but when these plants decay they cause a disagreable taste and odor. Without the sun but very little will grow and so most of the small reservoirs are covered; but with large systems it becomes a great undertaking. Still we hear of the subterranean chambers of Constantinople with the thousand and one pillars. Paris also has covered the water stored up for her use. The roof is supported by two tiers of arches and covered with soil and sown to grass.

Large bodies of water thus held give but few such bad effects, because of the amount

and the large surface which gives room for evaporation of stagnant gas and the solution of large quantities of air which purify the water to a large extent. In this country but few large reservoirs are covered.

As before said New York provides for the purity of her water supply before it is collected. She has bought the whole of the Croton river valley and to keep from pollution has entirely divested it of human habitation. The lake itself is of such large extent as to be self purifying.

When the reservoir is thus in the midst of habitation, it can be kept pure by building a public park around it. to which the lake will add attractiveness. Brooklyn has thus built the finest park of its size around its reservoir and is now open to the public. New York will soon put one around Croton Lake. In view of these the state of New York has passed a law which gives the Board of Health the power to maintain the purity of stored water by the removal of habitation from the neighborhood after giving just compensation for property.

One of the finest systems of water supply is that of Elmira, New York. By damming up a mountain stream a large lake is formed which holds enough water to last over the dry seasons when the source entirely stops. This body of water keeps very pure of itself. A distributing reservoir 250 feet square is built a mile further down the valley. It is from 110 to 144 feet below the large one, and receives its water from the other through a fountain whose central jet is four inches in diameter with 132 side jets.

A similar system is the one in Rochester. It is similarly situated and the system built on the same plan. Here a three inch jet with side jets will pass from 3,500,000 to 6,500,000 gallons daily with a hight of 30 to 45 feet into the air.

Such a fountain in a park will give a very fine appearance, and besides this, it will aerate the water. The large amount of water thrown to such a hight will bring very large quantities of air down again to be held suspended or dissolved. This will give excellent results in making the water fresh,

preventing the growth of algae, and removing impurities before going to the consumer.

To get the water to the consumer is now done through cast iron pipes. In New York the water is taken from the Croton dam to the Central Park distributing reservoir through two large conduits, the larger one being 15 to 13 feet in diameter, built of several circumferences of brick. It is 100 feet below ground to insure coolness and safety in case of war. Other examples of such large works, connecting the supply with the distributing reservoir is in Baltimore, Brooklyn, Chicago, and Philadelphia.

In the Holly system a contingency should be guarded against by having something to use instead of the large pumps. In the Gravity system when the supply is naturally high here also the pipe line should be duplicated if possible, especially in large cities, when putting down the plants.

New York and Brooklyn both have two supply pipes. The latter city was just putting down a cast iron pipe beside the old masonry aqueduct when a break in the latter occured which put the city in a critical con-

dition in case of fire and compelled the discontinuation of all steam street railways and manufactories for want of water for engines.

The service pipes should be so distributed as to give good fire pressure. This may be accomplished by laying the larger pipes at equal distances apart and these evenly distributed throughout the city. These should be connected by smaller pipes so that the hydrants receive pressure from at least two sides, and the gates so arranged that very small portions of the line may be shut off without effecting a large part of the system.

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