WATER FILTRATION FOR INDUSTRIAL PURPOSES.

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It is frequently a matter of surprise to otherwise well informed persons that the ordinary standards of purity required in drinking water are sometimes not nearly as severe as those required in water used for industrial purposes. Nevertheless, this is true in many instances, because the water contains certain substances which are perfectly harmless to the human system but possess chemical affinities for other substances used in the arts and industries that create very annoying disturbances indeed. On the other hand, many waters that have been so highly contaminated by sewage and industrial wastes that no form of purification would make them suitable for drinking purposes, can be made eminently satisfactory for industrial purposes. It is a by no means uncommon condition to find a manufactory unable to use the city supply, which may be justly considered especially fine from a potable stand-point, yet by means of an efficient purification plant be able to get perfect satisfaction from a polluted stream which receives the sewage and industrial waste of the town itself.

Disregarding the hardness of the water, the reduction of which is not properly a function of filtration, there are a number of apparently harmless forms of pollution that are very troublesome in many instances.

The writer has in mind a rather remarkable case in a New York village of a manufactory wherein very gorgeously printed lap robes are made. This concern has been in business a great many years and the designs, which are quite ornate and many colored, are hand printed by large wooden blocks with certain colors imported from England supposed to be secret mixtures. These colors are all mordanted with alum. In fact, the robes themselves are passed through quite a strong solution of alum at one period of their manufacture, and are then dried. They are

finally washed, and at this point the trouble manifests itself in a rather singular manner. As soon as the water commences to get warm, or during the latter part of May, the light colors commence to get flat and as the season progresses and hot weather comes on, much of the detail is altogether lost and the whites and light shades commence to assume a yellowish cast. The wise men of the block printers shake their heads and say their secret colors are effected by the warm water and as a result robes of a dark shade only can be made during the warm weather.

An investigation of the water supply elicited the information that the major part of it is derived from a shallow lake about seven miles back in the country. The elevation of the water in this lake had been raised four or five feet a number of years ago and overflows a peat-bog over a square mile in extent. During the winter it is customary to close the outlet of this lake and allow it to fill up. About the latter part of May, when the water in the stream begins to get low the gates are opened and the highly colored water from the lake takes the place of the comparatively clear flow. When this colored water reaches the mill and the alum saturated lap robes are washed in it, the coloring matter derived from the peat is precipitated by the alum upon the fibre, and the more color there is to the water the greater the discoloration of the goods. Moreover, the drainage area of the lake being comparatively small and the drain upon the lake heavy the water keeps getting lower and lower until part of the peat-bog is exposed and the water percolating from this causes the lake supply to grow continually darker until the fall rains refill the lake. It can be seen by this that the color of the water and not the temperature is entirely responsible for the apparently bad behavior of the dyes. The above is a harmless but not too attractive city supply.

Another instance is in a city of some 60,000 inhabitants supplied from a fairly large stream. The water from this stream possesses considerable color and is filtered by means of a mechanical filter plant. This mechanical filter plant is very well operated indeed, shows a very high bacterial efficiency and is ideal in every particular save one, and that is that for some reason or other a small amount of hydrate of alumina, formed

during the chemical treatment of the water with alum, finds its way through the filters. This has no hygienic significance whatever and the inhabitants of the town are enthusiastic over the many virtues of their filter plant insofar as the potability and appearance of the water is concerned. However, there are a number of large silk dye-works in this town and this trace of hydrate of alumina present in the water prohibits its use in silk dyeing. Most of the dye houses are located along the banks of the same stream from which the city supply is drawn but at a point below town. The stream at this point is not only badly contaminated with sewage but the discharge from the silk dye houses themselves enters into it making the general color of the water blue-black. Nevertheless, the silk dyers have solved the problem of water supply by filtering this badly contaminated water with a filter which will not permit hydrate of alumina to pass through it. The filtered water is, of course, crystal clear and entirely free from dye.

Still again the anæmic person who spends some weeks at a high-priced sanitarium drinking chalybeate waters with the hope of bringing the iron content of his system up to the normal 26 or 27 grammes which it should contain would probably be quite indignant if told that the water he is drinking in such quantities is not even fit for laundry purposes.

Originally filtration for industrial purposes meant the removal of clay, silt, and vegetable stains from the water. The problem at that time was a simple one as it merely meant that enough alum or sulphate of alumina or similar coagulant was employed as a preliminary treatment, after which the water could be passed through the filters and would be suitable for industrial purposes.

However, as the country became more populated, its manufacturing larger and more numerous, the streams commenced to show considerable quantities of various forms of industrial wastes and sewage. The industrial wastes consisted very largely of dyestuffs, waste liquors from paper and pulp mills, chemical wastes from wire-drawing plants, gas-house liquors, tannery wastes, etc. Some streams contained only one or two different varieties of contamination while others contained several. This condition has increased with the population until most of the

streams in the East are greatly discolored and are badly polluted with sewage. Moreover, most of the available sources of pure water have been preempted by municipalities for their water supplies.

Cheap water is imperative in the present day to the manufacturer. He cannot afford to pay from four to thirty-five cents per thousand gallons to the municipality for several million gallons of water per day and he is perforce driven to the polluted streams, his only alternative being to place his establishment at so remote a point that it becomes difficult of access and almost impossible to procure labor. Naturally he chooses the situation of his plant with reference to the availability of labor and the propinquity of the market. The vital question that then comes before him is, can the highly polluted water supply which is available be made suitable for his purposes? The answer to this question, in ninety-nine cases out of one hundred, is in the affirmative. It can be done and done well. Moreover, in large plants the average cost of treatment can be kept well below \$3.50 per million gallons, or say one-third of one cent per thousand gallons as against the four to thirty-five cents per thousand the manufacturer would be compelled to pay to the municipality.

Such conditions as the last represent perhaps seventy-five per cent. of the problems of industrial filtration at the present day and the percentage is continually increasing.

The problems involved in such waters, especially when contaminated by many different substances, become complex in their nature. True, the old stand-by sulphate of alumina, still figures very extensively in all such plants, but there are many conditions wherein the use of sulphate of alumina alone as a preliminary treatment leads to a downright failure of the filter plant to accomplish the desired aims. To reach perfect results an intimate knowledge of the nature of the contamination must be reached. Chemical analysis, of course, tells us much and a bacteriological analysis is also necessary in some cases but an actual survey of the conditions to be met must be made before an intelligent purification plant can be constructed.

In making this survey it is necessary, particularly on a comparatively small stream, to notice the particular hours at which

certain industries discharge the most waste; to note the particular character of the most important of these wastes and to further note very particularly the influence that one set of industrial wastes will have upon another. For instance, the waste dye from a woolen mill mingling with the waste soap from the fulling and finishing department eventually come into contact with the lime existing in the water with the result that not only the soap is precipitated but a very considerable portion of the coloring matter is also carried down. Further down stream we may strike the waste from a wire drawing works or similar industry wherein sulphate of iron enters the water. This combines very actively with the coloring matter and forms a heavy precipitation. At the same time large quantities of domestic sewage are being discharged into the stream. This commences to ferment very rapidly. Portions of it are liquified and other portions precipitated. Bacteria become very active in the stream unless some poisonous or antiseptic substance is being discharged in it. By the time the water has reached the consumer possibly as high as seventy-five per cent. of the dissolved matter that had been discharged into the stream is delivered in a precipitated form, thereby lessening the load on the purification plant by that amount.

Now after having considered all of these points we come to the operation of the plant itself. In the first place we wish to get rid of the already precipitated matter as economically and as efficiently as possible. In the next place we must precipitate as cheaply as possible the remaining deleterious substances. As above stated the most economical and effective substance for doing the major part of this work is sulphate of alumina. The writer realizes that there will be considerable protest made in favor of sulphate of iron and lime. Nevertheless so far as his own experience goes, and, in fact, the experience of some others, sulphate of alumina is cheaper, safer, more satisfactory and far easier to apply than sulphate of iron and lime.

Having applied the sulphate of alumina with a due regard for the alkalinity of the water as evinced by the chemical analysis, the treated water is allowed to flow slowly through a settling tank. The period of time occupied in sedimentation varies greatly with different waters. In some cases one and one-

half hours may be sufficient. In others three hours. Occasionally twelve hours are required, and we know of one instance in which six days' sedimentation is employed. In the latter instance chemicals are not used, the biological conversion of the organic matter being aimed at. Generally speaking, however, three hours' sedimentation with aluminum sulphate for a coagulant is sufficient.

We occasionally find, however, upon operating a plant that complete decoloration of the water is not effected and that there is a very offensive odor. Moreover, strange things are taking place in the settling basin. As we look at it we see large masses of sediment rise from the depths, come to the surface, spread out and disappear. One point in the sedimentation basin will show a fairly good degree of sedimentation while further along where sedimentation ought to be further advanced we find the water far more turbid than when first introduced into the basin. The sewage in the water is simply fermenting and this fermentation is not only interfering with sedimentation by reason of the gases evolved but is producing resolution of the impurities entrapped by the hydrate of alumina. In other words we are undoing the good work we have done. Moreover, the volume of impurities going to the filter is far greater than it should be and the filters are requiring altogether too frequent washing.

Shortly afterwards a very singular manifestation takes place. The filters, which have been delivering a gradually deteriorating effluent finally refuse to deliver any water at all. An examination of the sand after washing shows it to be perfectly clean and there is no apparent reason why the water should not pass through. Nevertheless the filters are nearly impervious. A more thorough examination develops the fact that the pipes in the underdrains of the filters have become completely filled with a fungus growth, usually *beggiatoa* or sewage fungus. We clean it out and in a few days the same condition occurs again, the water that does come through is unusable.

The above conditions might take place in a filter plant provided we were confined to sulphate of alumina. However, with a knowledge of troubles about to occur we can guard against them by taking the proper precautions. The Imhoff tank which has been recently so successful in the removal of sludge from sewage might be applicable in this case, but there is a consider-

able doubt in the writer's mind whether complete decolorization of the water could be effected by filtration after the water had passed through such an apparatus without a subsequent chemical treatment. It is necessary to stop the fermentation of the precipitated matter. We can often do this by the addition of copper sulphate in fairly large proportions, say for instance, two or three parts to the million. This in certain cases is sufficient. The fermentation stops, sedimentation is good, the growths in the pipes gradually disappear, the effluent of the filter becomes clear, sparkling and odorless and everything is satisfactory. However, there are many cases where copper sulphate cannot be used in sufficient quantities, or where it is not useful at all. Where the percentage of sewage is very high we find that there is much undecomposed and unprecipitated organic matter in the water and to get really satisfactory results it must be consumed in some manner. Some powerful oxidizing agent is required. In such instances calcium hypochlorite recommends itself. This is to be used very judiciously as a very faint excess indeed would produce the most disastrous results in dyeing, but when accurately applied it consumes the dissolved organic matter as thoroughly and as effectually as if it were dried and burned in a fire. Moreover, it is a tremendously powerful bactericide and a bacterial analysis of the treated water shows it to be almost sterile even before filtration.

At Passaic, N. J., using Passaic River water, which runs about one million bacteria per cubic centimetre, or equal to ordinary sewage, it was found that with two parts per million of calcium hypochlorite, and five hours' sedimentation the bacteria ranged from twenty-seven to one hundred per cubic centimetre, and that so long as the hypochlorite was used there was no tendency whatever of the sludge at the bottom of the basin to ferment.

In most plants the amount of calcium hypochlorite employed ranges from one to three parts per million. Where fermentation is interfering with sedimentation it must be applied as the water enters the sedimentation basin but if sedimentation is reasonably good an economy can be effected by applying the calcium hypochlorite after sedimentation is completed. By following this procedure much of the oxidizable matter that would be precipitated by the alum has settled to the bottom and the

principal oxidizing activity of the hypochlorite is directed against the dissolved matter and the bacteria.

Another action of the calcium hypochlorite is to decolorize the dyes that may have resisted action of the aluminum sulphate. This action, however, is not especially important as the strength required to produce this result is usually greater than is safe to use.

Needless to say the treated water must show no trace whatever of free calcium hypochlorite and the only logical way of attaining this result is to keep the quantity of chemical applied at such a point that its energy will be entirely expended upon the organic matter. An accurate chemical feed is of the utmost importance when using the calcium hypochlorite.

With certain waters it is found that although a suitable degree of precipitation is obtained by the use of the aluminum sulphate the precipitate is of a flocculent, buoyant nature and will not settle. In fact it has a tendency to come to the surface of the water. On examination it will be found that the buoyant tendency of the precipitate is due to small bubbles of carbonic acid gas given off in the reaction between the sulphate of alumina and the earthy carbonates. If the water is soft this tendency is corrected by adding either shortly before the application of the aluminum sulphate, or shortly after, a small quantity of calcium hydrate. This calcium hydrate absorbs the free carbonic acid gas with great avidity and the flocculent precipitate falls to the bottom of the settling basin at as rapid a rate as could be desired.

In the above examples we have mentioned the beneficial action that takes place in the tendency of one set of wastes to neutralize another; the treatment with sulphate of alumina to produce precipitation and sedimentation; the additional treatment by antiseptics to prevent further bacterial action and to inhibit the growth of other objectionable vegetable organisms and the oxidization of the excess of organic matter.

There is still another feature to be considered which is of especial importance on small streams to which at times extremely large quantities of defiling matters may be discharged for short periods of time, and that is the advisability of directly avoiding this extreme contamination, or producing such a degree of dilution that the problem involved is a very slight one.

The writer has in mind a small stream on which is located a paper mill. A few hundred feet below this paper mill is a felt mill drawing its supply from the same stream, the flow of which runs as low in dry weather as one and one-half million gallons per day. At certain irregular periods the digesters containing large quantities of free caustic soda together with the saponified grease, resin, pectin and various other substances extracted from the rags, etc. are discharged into the stream. This proportion of impurities at the time of discharge is so great that the alkalinity of the stream is raised from sixty parts per million to twelve hundred parts and the basin below the dam where the water falls over is frequently filled to a depth of six feet with what appears to be soap-suds.

The effect of alkali upon wool is disastrous and the felt mill experienced great trouble with the soda. They even went to the trouble of stationing a man at their head gate some eight or nine hundred feet above their mill with instructions to close it at such times as he saw the digester discharge coming down. As soon as this substance had passed by, usually a period of not more than twenty minutes, the gate was opened again, the head race holding enough water to supply the mill in the interim. This was manifestly a clumsy way of avoiding the trouble. The real solution of the problem was worked out in the following manner: At the lower end of the head race near the mill a settling reservoir holding a half million gallons of water was constructed at such an elevation that the water flowed by gravity into it. The water for the mill was drawn from the opposite side of the reservoir to the point at which it entered. The amount of strongly alkaline water entering this reservoir was so small in proportion to the entire body of water in it that it not only had no deleterious effect but the alkali actually tended to soften the main body of water in the reservoir.

The point I wish to make in this connection is, that only a small amount of the highly alkaline water enters the reservoir, the major portion of it passing the inlet and going on down stream, the quantity entering the reservoir being such a small portion of the whole body of water that even if it had no beneficial effect it would be so greatly diluted that its treatment would be a very small matter.

The quantity of water required in the various industries is

very great in comparison to the requirements of municipalities. For instance, a supply of two million gallons per day would furnish a town of 20,000 inhabitants, a small paper mill of say twenty tons daily output, a very small bleachery, or a small silk dye-works. The largest silk dye-works, in this country consumes 23,000,000 gallons of water per day and a contract has just been let for a bleachery in the New England States requiring a filter plant having a capacity of 36,000,000 gallons per day. This is approximately the amount of water used by the city of Philadelphia west of the Schuylkill. These figures seem stupendous to the person who has not studied industrial requirements.

A pound of muslin, or similar cotton fabric requires in the bleaching process about twenty-seven gallons of water. A pound of paper requires about fifty gallons of water, and a pound of silk not less than one thousand gallons of water. Moreover, many of these processes in which water occupies such an important part include very delicate chemical reactions in which strong acids and alkalies play their part.

The dyeing of silk in the skein is an interesting example of the importance of a sufficiency of very good water. The dyer receives a quantity of silk and some sample colors. Say for instance, one hundred pounds of silk are delivered to him to be dyed a pale blue, and white. He receives instructions to return two hundred pounds of silk. The first operation through which the skein is put is to place it in a bath of soapy water and boil it for a period of time. This removes the natural gum or sericine from the fibre, and after drying it is found that the one hundred pounds of silk now weighs but seventy-five.

The next process is to make this seventy-five pounds of silk weigh two hundred pounds. This is effected by hanging the silk in a bath of bichloride of tin. After a certain period of time the dyer estimates the fibre of the silk has absorbed enough tin to weigh the necessary two hundred pounds. This is not a deposit of a metallic salt upon the fibre but is a chemical combination that has taken place between the fibre and the tin. It cannot be washed off nor out, and practically the only process by which the tin could be separated would be by burning the silk. This bichloride of tin is a very corrosive substance and the silk cannot be handled with the naked hand until after it has

been washed to remove the excess. Washing is effected by hanging the skeins over the revolving rolls of a washing machine against which thousands of needle-like jets of water are directed. After this washing the silk is treated with a dilute solution of sodium phosphate and is again run through the washing machine. If the silk has not taken up enough tin to reach the desired weight it is again placed in the tin bath and the same process is gone through, sometimes a half dozen treatments being required to gain the requisite weight.

The dyeing of the silk, either white or colored, is usually done in a hot soap bath to which the dye is added, and to give additional body to the bath a part of the seracine extracted from the silk in the early part of the process is put in it. It is not customary in this country to bleach silk, the white being produced by dyeing it purple and exhausting the color in an acid bath. This is done by dyeing the silk red and blue and the shade of white eventually evolved depends upon the proportions of red and blue used. This dyeing process is rather mysterious to the uninitiated. The dyes used are not faint reds and blues but when mingled produce an intense purple which, of course, is deposited on the silk. The immersing of these purple skeins in the acid bath and the rapid transition from purple to silvery white is a most interesting and attractive process.

After a period of time in the acid bath during which the scroop, the trade name for that property which gives to silk its rustle, is formed, the skeins are again washed and passed through the hydro-extractor after which they are placed in a steam-tight compartment, stretched under a pull of several thousand pounds and live steam turned in on them for a minute or so. They are then taken out, hung over a smooth stick, twisted, yanked and otherwise mauled by a strong determined man for two or three minutes. This terminates the dyeing process and the dull yellow, linen-like skein, not half as big round as one's wrist has been converted into a silvery fluffy mass of shining fibre at least four times its original bulk, for during the absorption of the weighting materials the silk has increased greatly in volume.

The owner of the silk then receives the two hundred pounds of silk for the one hundred delivered, which seems very much like getting something for nothing until you realize that the dyer

gets anywhere from \$1.50 to \$3.50 per pound on what he returns for his pay.

It is possible to weigh a pound of raw silk up to sixty ounces, so that little more than twenty per cent. of the fibre itself is silk, the rest being weighting substance. Needless to say the wearing value of such silk is almost nothing.

In the above process large quantities of water are used in the boiling off of the seracine. Soft water is desirable as it prevents the formation of lime soaps. In the washing, after the bi-chloride of tin bath the water must be absolutely bright and colorless and is preferably hard from earthy carbonates. Any trace of color in this water will be immediately precipitated by the acid upon the silk and produce a stain. Then again, after being placed in the sodium phosphate bath if there were any trace of color or vegetable matter in the water it would be precipitated upon the silk fibre in such a manner as to act as a resist in the subsequent dyeing process with the result that streaky skeins would be produced. This tendency is so strong that even jet black silk will show streaks in it if the water is not perfect.

Perhaps the most important point of all is the acid bath in which most skein silk of every color is placed to produce the scroop. If there is any trace of color in this water to which a small amount of acetic acid has been added, when the skeins are placed in it this color will deposit itself upon the silk in the most incredible manner and a skein dipped a few times in this water will come out very much off color. This tendency of the color to deposit itself on the fibre is so strong that when the water does not appear right to the dyer, without any further instructions he takes a batch of silk which is to be dyed a dark color and runs it first through this acid bath so that all of the color will be precipitated upon it, after which he can place his light colors and whites in it with impunity.

Still another dangerous point is the final washing of the silk after removing it from the acid bath. This wash water must naturally be very pure as otherwise we would have a deposit upon the silk from it.

Until a comparatively recent time nothing but spring or well water was used for the whites and light colors. There is one silk dye-works in Paterson, N. J. that has seventy-five 8 inch

artesian wells, none of which are less than three hundred and fifty feet in depth, all of them drilled through the red sandstone.

So much has been said in this article about forms of contamination by industrial wastes and the benefits of filtered water that possibly a brief description of the two general types of filter plants would be interesting.

There are two kinds of filters, pressure and gravity. Really they are identical in operation, the only difference being in their application. The pressure filter is the same device as the gravity filter excepting that it is placed in an enclosed steel tank and operates under whatever pressure the service main may carry, delivering its water filtered and still under pressure with a loss of head ranging from two to ten pounds, depending upon the make of filter.

The gravity filter on the other hand relies upon the weight of water on it to drive the water through the bed and the water is discharged at the bottom under no pressure.

Taking the detailed parts of a gravity filter plant for an example, we find that they consist of a chemical feed, a settling basin with the necessary baffles, the filter proper and the machinery for washing the filter. As the consumption of every industry varies more or less from moment to moment there are fluctuations in the rate of flow of the raw water coming to the settling basin. The chemical feed must be an apparatus that will regulate whatever chemicals are being applied to meet this fluctuation. For instance, if the feed is set to apply two grains of sulphate of alumina and one-eighth of a grain of calcium hypochlorite per gallon of water it must do that and exactly that, whether the plant is running at full speed, one-quarter speed or a twenty-five per cent. overload. It is a small but vital part of the entire plant and might be compared in its way to the governor of a steam-engine. Of course, chemicals are applied in the form of solutions of a definite strength.

The water after receiving its dose of chemicals flows through the settling tank in a continuous process, in at one end and out at the other. To stop the tendency of the water to flow directly across the basin from inlet to outlet leaving a large eddy on either side, baffles are placed so as to compel the entire body of water to take a circuitous course through the basin. Much of

the solid substance in the water has already been coagulated by the action of one set of impurities upon another, and the applied chemicals have produced further precipitation and have, moreover, gathered together the finer particles of suspended matter into comparatively large masses so that all settle with considerable rapidity toward the bottom of the basin, where they remain until such time as it is convenient to remove them. The hypochlorite used is sufficient to prevent fermentation if the water is highly contaminated with sewage. Moreover, the alum applied has exhausted such remaining dyes as have not been precipitated prior to the time it was added.

Finally the water reaches the far end of the settling basin. It is much clearer, has much less color, the odor has practically disappeared and there seems to be a decided improvement in every way. It is far from being fit for use however. It is then conducted to the filters through the necessary pipes, passes down through them and every trace of suspended matter is removed with the result that a water that three hours before was very dark in color, had a strong odor of sewage and contained much suspended matter is as bright, sparkling and clear as the clearest spring water, and, so far as the senses can determine, is its equal in every way.

The three essential parts of a filter itself are the case, the filter bed proper and the strainer system. The case is of either steel, wood or concrete. The filter bed itself is of carefully selected sand and the strainer system, which consists of a series of pipes leading to all parts of the bed terminating at their outer ends in strainers or sand valves, devices which have slots or perforations of too small a size to permit the sand to pass through, but sufficient in number to allow a definite quantity of water to leave the sand bed. This strainer system is placed on the floor of the filter, and its object is not only to collect the filtered water from the bottom of the filter but also to distribute the wash water uniformly underneath the bed during the washing process.

Considerable quantities of sulphate of alumina and some hypochlorite of lime have been used. As any trace of either of these substances in the filtered water would utterly condemn it for almost every industrial purpose they must be removed or con-

verted into innocuous substances. This is effected in the following manner: Referring first to the sulphate of alumina, a previous analysis of the water has been made which shows the amount of its alkalinity. For every ten parts per million of alkalinity that the water contains one grain of sulphate of alumina per gallon can be used with safety, because this quantity of alkali will combine with the alum to convert it into an insoluble substance, hydrate of alumina, which is readily removed by the filters, and sulphate of lime. In other words, the carbonate of lime existing in the water renders the alum insoluble and converts it into a form in which the filter can hold it. Occasionally we find a water, particularly in the New England States, so soft that it does not possess sufficient alkalinity to permit the use of alum in sufficient quantities to produce the desired result. In such an event an artificial alkalinity is produced by the addition of a small amount of carbonate of soda or by the introduction of corresponding quantities of quick-lime.

Calcium hypochlorite, chloride of lime or bleaching powder, as it is variously known, on being mingled with the organic matter is decomposed into calcium chloride, and ozone is liberated in sufficient quantities to produce the necessary oxidization. Calcium chloride, being an inert salt and existing in such minute quantities has no significance from any industrial stand-point whatever. We thus see elimination of the applied chemicals or their metamorphosis into harmless and insignificant substances.

In addition to economy in the use of chemicals the other costs of operation such as attendance, power, etc. must be reduced to a minimum. One hour per day for each million gallons of water treated is sufficient to cover the attendance of a well designed industrial plant. The sedimentation basins are so arranged that the sludge drains into a channel passing down the middle connecting with a blow-off valve. Opening this valve at intervals of one to six months and permitting the entire chamber to drain takes care of most of the sludge.

The filters must be so designed that they can be washed very rapidly and very thoroughly. This is done by simply reversing the current in the case of the pressure filter and forcing the water up through it at a high rate of speed. This causes the

sand grains to dance up and down rapidly, each scouring the other so that after a few minutes the entire sand bed is cleansed.

In gravity plants an economy in washing can be effected by inducing additional agitation of the sand either by means of a revolving rake or by forcing compressed air under the entire filter bed. Either of these processes produce the same result, that is, very rapid motion of the sand grains and a consequent rapid loosening of the retained impurities.

All types of filters are connected directly with the drain so that wash water can flow to it. Moreover, the first water that comes from the filter after washing is of poor quality and it is customary to filter into the drain for a minute or two or until the filter bed gets thoroughly packed. Depending upon its design, an ordinary filter will wash in from five minutes to an hour's time, and will consume from two to fifty per cent. of the water filtered for washing. The general type of filter used for industrial purposes, however, is designed to be washed very quickly.

From the above it will be seen that the chemical treatment in many industrial problems is as essential as the apparatus itself. Given a properly designed plant employing the proper chemicals, there is no reason why the most polluted American rivers cannot be made satisfactory for all industrial purposes.

The Effect of Mercury Vapor. WERNER VON BOLTON. (*Zeit. Elektrochem.*, xvi, 667.)—A test-tube containing barium amalgam, closed with a vulcanized rubber stopper, was maintained at room temperature for three weeks. The part of the stopper exposed to the amalgam became carbonized, and carbon and microscopic diamonds were found. This carbonization proceeds very rapidly at 100° C. Sulphur hastens the reaction; selenium and tellurium retard it. Vulcanized rubber emits a hydrocarbon gas, which mercury vapor decomposes, as it also does illuminating gas. This decomposition is not perceptible with dried mercury vapor, a definite quantity of moisture seems essential. Mercury vapor also decomposes chloroform, tetrachloride of carbon, carbon disulphide, carbon dioxide and hydrogen sulphide. No reduction to carbon was noticeable when unvulcanized rubber stoppers were used. Probably graphite and diamond were formed in nature by the action of metal vapors, such as iron or magnesium, or carbon dioxide.