ON THE EFFICIENCY OF FREDERICK BREYER'S "MICRO-MEMBRANE FILTER."

By James H. Stebbins, Jr.

The essential part of the micro-membrane filter is a membrane composed of minute asbestus fibres, supported by a hollow metal grate. The filter is now so arranged that the membranes can be renewed at pleasure, whereas formerly they could only be produced upon the metal grate itself.

The best kind of asbestus to use for the manufacture of these membranes, is that which when split up and disintegrated, yields a wooly, silky and loose material. For the purpose of constructing these membranes the asbestus wool is ground in a mill, until the length of its fibers is reduced to such an extent that the longest ones are not more than 5–7 m. m., while the shortest ones measure far less than 1 m. m. in length.

This short asbestus wool is soaked in water for several days, and then mixed in about equal parts by weight with crystalline calcium carbonate, and put into a mill of peculiar construction, where the wet pulp is ground together with the crystalline calcium carbonate, the grains of which are about the size of peas. The grinding is kept up until the material has been reduced to the required degree of fineness. By observing the ground product, greatly diluted with water, in a test tube, the requisite degree of fineness may be determined. The ground product is now treated with sufficient dilute hydrochloric acid to dissolve the calcium carbonate, and, after being well stirred, it is allowed to stand for a day or two in this state, after which the calcium chloride is washed out in a common rag mill. After the washing there remains a loose, exceedingly fine, almost chemically pure asbestus emulsion.

The asbestus fibers on being ground up with the calcium carbonate are acted upon by the sharp edges of the latter, which, penetrating between the asbestus fibers wedge fashion, splits them up into innumerable individual fibers, just as wood is split with the ax. The minute crystals of the carbonate on the other hand, remaining after the splitting process is completed, would be prejudicial to a dense and uniform filtering tissue if not removed, but on being subsequently brought in contact with the dilute hydrochloric acid

CO_2 is given off, which disintegrates and resolves the chaos of filaments into infinitesimal particles.

The extreme minuteness of these asbestus fibers is such, that with Reichert's best lenses the inventor was unable to measure them, but estimates the larger ones to be about $\frac{1}{10000}$ millimeter in diameter, and the smaller ones to be invisible.

Now, if we imagine three such layers, one above the other, we shall obtain (if the membrane is $\frac{5}{10000}$ m. m. in thickness) about 2,500,000 pores per square m. m. It may then be assumed that one square millimeter of "micro-membrane" contains $2\frac{1}{4}$ millions pores. It is therefore not likely that a fibrous asbestus material, equal to the one described, could be produced as advantageously in any other manner. The crystalline calcium carbonate is just hard enough to effect the separation of the asbestus fibers without diminishing their length. The finely divided asbestus, prepared as just described, is called by the inventor for the sake of brevity "microfibrin."

With it he produces a membrane obtained by depositing the microfibrin, suspended in water, upon mosquito netting in a manner similar to that employed in paper making. When dry the membrane is so strong that it can be handled like paper. Asbestus membranes cannot of course be produced in exactly the same way as that adopted in the manufacture of paper, because by that means it would be impossible to obtain that perfect uniformity in the stratification of the fine fibers, which is actually the case and which is absolutely necessary for the separation of micro-organisms.

The membranes are made in the following manner:

Into a large wooden box is inserted a double wooden frame, called the "stretching frame." The inner frame is permanently covered with wire gauze, which serves to support the mosquito netting, and is firmly stretched by the outer frame, which presses it down by means of a rubber packing. After the frame has been placed in position, the box is filled two-thirds full with water, in which the microfibrin has been suspended. All the suspended asbestus is now precipitated upon the mosquito netting, in consequence of the water flowing off through a pipe at the bottom of the box.

The coarser and heavier fibers are deposited first, on account of their weight, and subsequently the finer ones. The uniformity in

the distribution of the fibers is due to the fact, that in the places where the fibers have been deposited more densely, the speed of the percolating water is diminished, so that less of the asbestus is able to accumulate in such places. In those places, however, where the layer of asbestus is very thin, the speed of the percolating water is greater, consequently a corresponding quantity of asbestus will be precipitated upon these spots. Thus with mathematical regularity, the speed of the flowing water equalizes the deposit of asbestus fibers over the entire surface. After the desired thickness of asbestus has thus been deposited, the frames are removed from the box, and the membrane dried in an oven at 150° C., after which it is peeled off, along with the netting from the wire gauze and cut into pieces of the desired size.

Without going into any great detail, I would state that the micromembranes are mounted with shellac, or a solution of sealing wax in alcohol, on nickel plated hollow brass frames of peculiar construction (usually two micromembranes per frame being employed), and placed vertically in nickel plated brass cylinders, or vessels, where they are held in position by suitable means.

If, after the filter is set up and in working order, it be charged with water, the latter should not, if the filter is in good order, begin to percolate through the micromembranes for at least 5–8 minutes after charging. If, on the other hand, the micromembrane is imperfect the water will come through much sooner than this. If such be the case the frame holding the micromembrane must be removed from the filtering vessel and carefully examined. If the leak is found to be caused by an imperfect cementing of the micromembrane to the brass frame, this can be easily remedied by applying another coat of sealing wax cement to the edges of the micromembrane; but if, on the contrary, it should be found that the micromembrane itself is imperfect, then the simplest thing to do is to remove the imperfect or injured membrane and replace it by a fresh one.

Everything being now in order, the flow of water through the filter will depend of course greatly upon the size of the filter, and the nature of the water being filtered. Water containing much matter in suspension will naturally clog up the filter much sooner than one containing less matter in suspension; but, owing to the

peculiar construction of these filters they will be found to render service long after an ordinary filter has become clogged and useless, for, whereas in most of the ordinary filters the water passes vertically through them, in the micromembrane filters it is caused to pass laterally through them so that a large part of the matter in suspension will settle to the bottom of the filtering vessel and only a part of it will adhere to the micromembranes, thereby greatly prolonging their efficiency. After the micromembranes have become thoroughly clogged, through long use, they may easily be removed and replaced by fresh ones.

The filters used in these experiments consisted of a pocket filter and a stationary filter for household use. The former one was used to determine the quantity of water it was capable of filtering in a given time and the length of time it would run without clogging. The latter was used for biological purposes to determine whether (as claimed by the inventor) it was capable of freeing water of microbes by retaining them upon the micromembranes. I was at first rather undecided whether in the first case I should use water in which a very fine precipitate had been suspended, or, in the second case, a sterilized water which had been planted with microbes either from sewage or an aqueous extract of garden soil. I finally decided to use nothing but Croton water, as it would be a good test of the efficiency of the filters, inasmuch as it is a water in everyday use.

FILTERING EFFICIENCY OF THE POCKET FILTER.

The micromembranes in this filter were square, size $4''\frac{5}{8}$ x $4''\frac{5}{8}$. About eight minutes after immersing this filter in water, it was supplying water at the rate of 96 c.c. per minute or 5760 c.c. per hour, equivalent to $1\frac{1}{2}$ galls. per hour or 36 galls. per 24 hours.

From April 28th to May 18th it had worked 20 days of the average length of 7 hours, and at the end of that time it was still working pretty well, supplying water at the rate of 4.9 galls. per 24 hours. I consider these results remarkably good, and think it safe to say that if the filter will work 20 days without clogging, being in nearly constant use, it ought to run at least two months when only used occasionally. In such a case the water in the filter can be poured out and the membranes allowed to dry. The micro-

membranes, after these 20 days' usage, were found covered with a brown slimy mass, which was probably the cause of their decrease in filtering power.

BIOLOGICAL EXPERIMENTS.

The object of these experiments I have already stated. Tests of this kind are really the severest that can be made, as it is hard to imagine anything much smaller than some (especially the pathogenic forms) of microbes. My experiments were conducted in the following manner:

1 c.c. of unfiltered Croton water was added to 7 c.c. of sterilized gelatine-culture medium contained in a test tube, thoroughly mixed, and then poured rapidly upon a sterilized glass plate, covered over with a glass shade, and in order to prevent the internal atmosphere of the shade from being contaminated from without, it was protected by a seal consisting of a 2 % solution of corrosive sublimate.

The plates thus prepared were placed in the incubator, heated to 25° C. and allowed to incubate for two days. At the end of this time the plates were removed and the microbes counted. In the same manner plates planted with 1 c.c. of filtered Croton water were prepared and examined. By subtracting the number of organisms found in the filtered water from those found in the unfiltered water we obtain the reduction, *i. e.*, the number of organisms that were retained on the micromembranes, or in other words, the efficiency of the filter.

Initial efficiency or first day:

Unfiltered water	Organisms too numerous to count.
Filtered water	0
Reduction	100 %

Efficiency after three days' filtration:

Unfiltered water	3840 organisms per c.c.
Filtered	7
Reduction	3833
Eq. to	99.8 %

Efficiency after ten days' filtration:

Unfiltered water	4032 organisms per c.c.
Filtered water	8
Reduction	4024
Eq. to	99.8 %

SUMMARY.

From the foregoing experiments it will be seen, first, that these filters are capable of yielding a good supply of water and will run for a long while without clogging, and second, that the water filtered through them is practically free from micro-organisms, which is a point of great importance.

ABSTRACTS.

GENERAL AND INORGANIC CHEMISTRY.

Heat of the Alloys of Lead and Tin. W. SPRING.

The author thought that by studying the specific heat of these alloys within limits of temperature, and comparing the results with the heat of their constituents some light would be thrown upon the constitution of the alloys. Eleven alloys were examined, viz.:

$Pb\,Sn$; $Pb_2\,Sn$; $Pb_3\,Sn$; $Pb_4\,Sn$; $Pb_5\,Sn$; $Pb_6\,Sn$;
$Pb\,Sn_2$; $Pb\,Sn_3$; $Pb\,Sn_4$; $Pb\,Sn_5$; $Pb\,Sn_6$.

The specific heat was measured from 360° to 100°., and from 10° to 10°

The mean specific heat of lead was found from 16° to 292°$_2$ to be $C_{Pb}=0.02761+0.00002086\,t+0.00000001746_{t_2}$. For tin from 20° to 197° it was found to be $C_{Sn}=0.05032+0.00003646_t+0.00000006343_{t_2}$.

The author finds that the heat observed is considerably above the heat calculated, and that the specific heat of the alloys is equal to the mean specific heat of their constituents. This shows