

ON THE RELATIVE EFFICACY OF THE DOULTON,  
BERKEFELD AND BROWNLOW FILTERS.

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(Two Figures in the text.)

IN a previous communication (1906) it was shown by Bulloch and Craw that the Doulton "white filter" prevented the direct transmission of micro-organisms, and that the filtrates from highly contaminated waters were germ free until sufficient time had been given for the bacteria to grow through the filter mass. It was demonstrated, in fact, that the Doulton filter was at least as efficient in the retention of micro-organisms as the best material on the market, viz. the Pasteur-Chamberland filter, and excelled the latter in its rate of filtration. It was pointed out that, with the possible exception of *Kieselguhr* filters, only porcelain bougies could be relied upon to prevent direct transmission of germs. During the past year we have tested the relative efficiency of porcelain and *Kieselguhr* filters, in particular the Doulton porcelain filter and the Berkefeld *Kieselguhr* filter. A few samples of the Slack and Brownlow filter (sand and porcelain mixture?) were also tested.

The Berkefeld filter has been repeatedly tested by bacteriologists in the last fifteen years, and for a time, at any rate, it was considered to be an efficient filter. Fourteen years ago, however, M. Kirchner (1893) had shown that it was not a trustworthy filter, a view more recently

held by E. Pfuhl (1903). In a series of experiments carried out by him 50% of the large Berkefeld candles were unable to keep back bacilli approximating the size of *B. typhosus* and *B. dysenteriae*. With the small Lilliput-*Kieselguhr*-filter the results were even more disappointing, as of four candles tested only one yielded a sterile filtrate of 100 c.c. Of the remaining three one yielded only 50 c.c. of sterile filtrate, the other two were even worse. The matter is of considerable importance in connection with filtration experiments as an indication of the ultra-microscopic size of the microbes of various diseases, for it has been frequently supposed that if the filtrate, from an infectious material which has traversed a Berkefeld filter, is infective, the infecting agent must be ultra-microscopic. Novy and Knapp (1906) have, however, shown that so large a microbe as *Spirochaeta obermeieri* (7 to 19  $\mu$  or more in length) easily traversed the small Berkefeld filters (35 mm. long  $\times$  15.5 mm. broad) under a pressure of 50 pounds within 10 minutes of the commencement of the experiment. Novy and MacNeal (1904) also found that even *Trypanosoma brucei* can pass through a Berkefeld filter.

On the other hand it will be remembered that in their exhaustive inquiry Woodhead and Cartwright Wood (1894, 1898) stated that Berkefeld filters "afford complete protection against the communication of water-borne disease."

With reference to the Slack and Brownlow filters the chief experiments are those of Woodhead and Cartwright Wood (1898), who also considered that this filter "protects against the transmission of water-borne disease." The Board of Trade (Marine Department) also states that "Slack and Brownlow's filters have undergone stringent tests, and may be passed as part of the medical stores required by the Board's medical scale for emigrant and merchant ships."

The following experiments were carried out to test the relative efficacy of the Doulton, the Berkefeld and the Brownlow germ filters.

In order to prevent any unfair comparison all the filters used were obtained in the public market.

A full account of the earlier investigations of water filters, with references, is given by Loeffler and Oesten in Weyl's *Handbuch der Hygiene* (1896), Bd. I. Abt. 2.

*Method*:—Figures 1 and 2 give a diagrammatic representation of the arrangement used in the comparison of the various filters. To the water main, *M*, a vertical branch pipe, *B*, was fitted carrying a horizontal pipe, *Hr*, to which a Bourdon pressure gauge, *G*, was affixed.

A T-piece was attached to the horizontal portion furnished with screw taps, *T, T'*, on its remaining limbs.

This arrangement permitted of the direct comparison of two different kinds of filters under identical conditions as regards degree of contamination and variation in pressure of the water supply, etc.

In the figures a Doulton filter, *D*, and a Berkefeld, *Bk*, in their metallic cases, *C, C'*, are shown attached to these taps by the rubber lined hoods or sockets, *H, H'*.

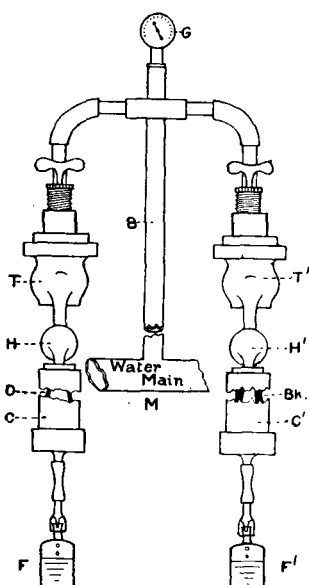


Fig. 1.

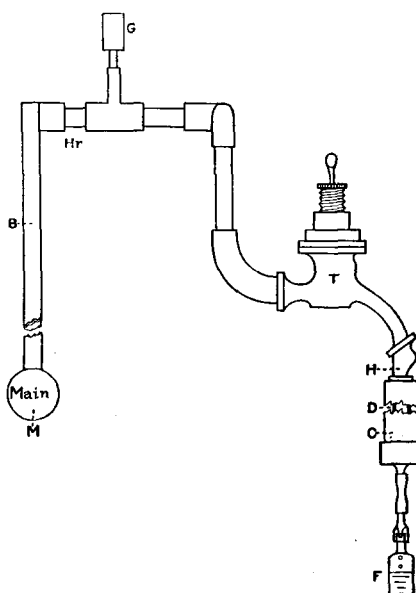


Fig. 2.

Hooded glass nozzles were connected by rubber to the exits of the filters in order that the samples of filtrate taken in the flasks, *F, F'*, should escape contamination by air organisms. The filters, together with the glass nozzles, were sterilised by heating to 120° C. for one hour in the metal cases supplied by the makers. After attaching to the sockets or hoods, *H, H'*, the water was screwed full on and allowed to run continuously. Samples of the filtrates from the two filters to be compared were collected simultaneously every few hours in bottles containing a solution of 10% peptone and 5% salt, so as to give in the test sample about 1% peptone. These samples were incubated at 37° C. for over seven days, and the day noted on which the first trace of growth appeared. In many cases the clear and the cloudy

fluids were also examined microscopically and the clear fluids were uniformly found to be germ free, whereas the cloudy samples were rich in micro-organisms. The tap water taken directly from the main was found to contain an average of 50 to 100 germs per c.c., as indicated by cultivation on agar plates, the examinations being made as soon as the samples had been taken.

*Examination for Transmission of Bacteria from Tap Water.*

Tables I, II, and III clearly indicate the relative efficiencies of the Doulton, the Berkefeld and the Slack and Brownlow filters. Tests of the Doulton filter, ten in number, ten of the Berkefeld and five of the Slack and Brownlow were made under identical conditions.

TABLE I. *Tests of ten Doulton Filters for transmission of micro-organisms under variable pressure.*

Maximum pressure 32.5 lbs. per sq. inch.  
Dimensions of filters—diameter, base 3.2 cm., apex 2.3 cm., length 18 cm.

No.	Day of filtration—	1	2	3	4	5	6	7
1	Growth	0	0	0	+	+	-	-
	Day of incubation	7	7	7	7*	7	-	-
2	Growth	0	0	0	+	+	+	+
	Day of incubation	7	7	7	7*	7	7	7
3	Growth	0	+	+	+	+	-	-
	Day of incubation	7	7*	7	7	7	-	-
4	Growth	0	0	0	-	+	+	-
	Day of incubation	7	7	7	-	2	1	-
5	Growth	0	0	0	-	0	+	-
	Day of incubation	7	7	7	-	7	2	-
6	Growth	0	0	0	+	-	-	-
	Day of incubation	7	7	7	2	-	-	-
7	Growth	0	0	+	+	+	-	-
	Day of incubation	7	7	2	1	1	-	-
8	Growth	0	+	-	-	-	-	-
	Day of incubation	7	2	-	-	-	-	-
9	Growth	0	0	0	0	+	-	-
	Day of incubation	7	7	7	7	3	-	-
10	Growth	0	0	0	+	-	-	-
	Day of incubation	82	81	80	1	-	-	-

\* Growth may have appeared before the 7th day of incubation.

0 represents no growth. + represents growth. - observation not made.

*Doulton.* From Table I it will be seen that only two out of ten Doulton filters transmitted germs on the second day of continuous

filtration, and the incubation periods, viz. two and seven days, indicate that the number of germs must have been very small. In no case did the filtrates from the Doulton filters show the slightest sign of contamination during the first 24 hours, which shows that no direct transmission of organisms took place.

Of the ten filters, one gave slightly contaminated filtrates on the third day.

Four filters transmitted germs on the fourth day, one gave a filtrate on the fifth day which only showed contamination after two days' incubation, and another only after three days at 37° C. Lastly, one filter gave sterile filtrates for five days, and on the sixth day the samples only showed growth after two days' incubation.

TABLE II. *Tests of ten Berkefeld Filters for transmission of micro-organisms under variable pressure.*

Maximum pressure 32.5 lbs. per sq. inch.  
Dimensions of filters—diameter 5 cm., length 12 cm.

No.	Day of filtration—	1	2	3	4
1	Growth	+	+	+	+
	Day of incubation	1	1	1	1
2	Growth	+	+	+	-
	Day of incubation	1	1	1	-
3	Growth	+	+	+	+
	Day of incubation	1	1	1	1
4	Growth	+	+	+	+
	Day of incubation	1	1	1	1
5	Growth	+	+	+	-
	Day of incubation	1	1	1	-
6	Growth	+	+	-	-
	Day of incubation	1	1	-	-
7	Growth	+	+	-	-
	Day of incubation	1	1	-	-
8	Growth	+	+	-	-
	Day of incubation	1	1	-	-
9	Growth	0	+	-	-
	Day of incubation	7	1	-	-
10	Growth	+	+	-	-
	Day of incubation	1	1	-	-

*Berkefeld*<sup>1</sup>. Of ten Berkefeld filters only one gave a sterile filtrate on the first day. The remaining nine gave contaminated filtrates within 15 minutes, that is to say, as soon as the filters were started.

<sup>1</sup> Cf. Table II.

Further, the number of germs passing these nine filters immediately must have been relatively great as growth took place after incubating for one day. These results agree with tests made by Pfuhl (1903).

*Slack and Brownlow*<sup>1</sup>. Five of these filters gave uniformly highly contaminated filtrates during the first 15 minutes' filtration, abundant growth taking place after 12 to 24 hours' incubation. Another filter did not allow water to pass owing to the outlet of the candle being blocked by cementing metal.

*Note.* In order to make sure that the absence of growth on the seventh day of incubation in the case of the Doulton filtrates implied absolute sterility, many of these samples were incubated for 14 days, and in the case of No. 10 filter for over 80 days—at the end of these periods no trace of growth could be detected.

TABLE III. *Tests of five Slack and Brownlow Filters for transmission of micro-organisms under variable pressure.*

Maximum pressure 32.5 lbs. per sq. inch.  
Dimensions of filters—diameter 3 cm., length 18.5 cm.

No.		Day of filtration—1	2	3
1	Growth	+	+	+
	Day of incubation	1	1	1
2	Growth	+	—	—
	Day of incubation	1	—	—
3	Growth	+	—	—
	Day of incubation	1	—	—
4	Growth	+	—	—
	Day of incubation	1	—	—
5	Growth	+	—	—
	Day of incubation	1	—	—

#### *Conclusions.*

Of the filters tested the Doulton filters alone uniformly prevented the direct transmission of micro-organisms; the Berkefeld filters all permitted of direct transmission, with one exception, and all the Slack and Brownlow filters gave contaminated filtrates immediately. In the cases of the Berkefeld filters and the Slack and Brownlow filters the germs passed through within 15 minutes from the commencement of filtration, whereas seven out of ten Doulton filters withheld the organisms and gave sterile filtrates for four days, and in three cases for longer periods. As these tests were made with a water pressure

<sup>1</sup> Cf. Table III.

varying from zero to 32·5 lbs. per square inch often in a few seconds. the above examination appears to us to be not only severe but also conclusive.

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