CCLXXXVI.—*The Routine Preparation of Low-conductivity Water.*

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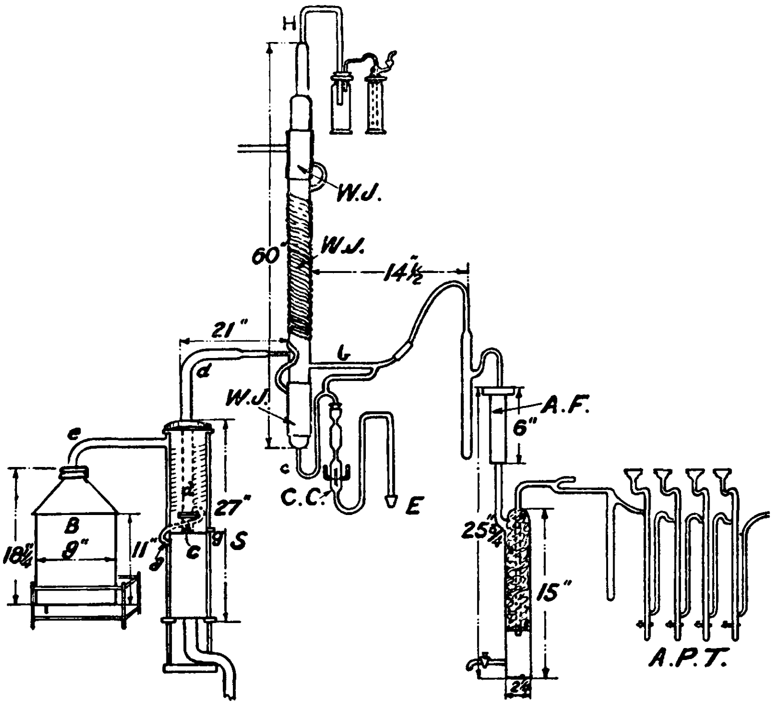
THE present communication gives details of improvements in the construction of Bourdillon's still for conductivity water (J., 1913, **103**, 791), by which it has been found possible to produce a large daily supply of such water of high quality.

Bourdillon's still delivered 7—8 litres of 0·2 gemmho conductivity in a single distillation from Oxford tap-water, and, although even the best water obtained showed conductivities as high as 0·11 gemmho from tap-water and 0·09 from distilled water at 18°, the authors constructed a precisely similar still with a view to effect improvements.

The water from this still sometimes had conductivities similar to those obtained by Bourdillon, but a regular daily supply did not maintain this degree of purity for any considerable period, even with frequent attention to small adjustments. The causes of the rises in conductivity appeared to be (*a*) minute air-leaks in some parts of the apparatus, *e.g.*, round the rubber stoppers, (*b*) inadequate trapping of spray, or (c) "creeping" of water from the trap to the condenser. Air-leaks generally occurred between the spray-trap and the rest of the apparatus even when the rubber stoppers used by Bourdillon were replaced by pipe-unions, and "creeping" of water took place to a surprising extent, especially when there were considerable fluctuations of pressure in the still.

FIG. 1.

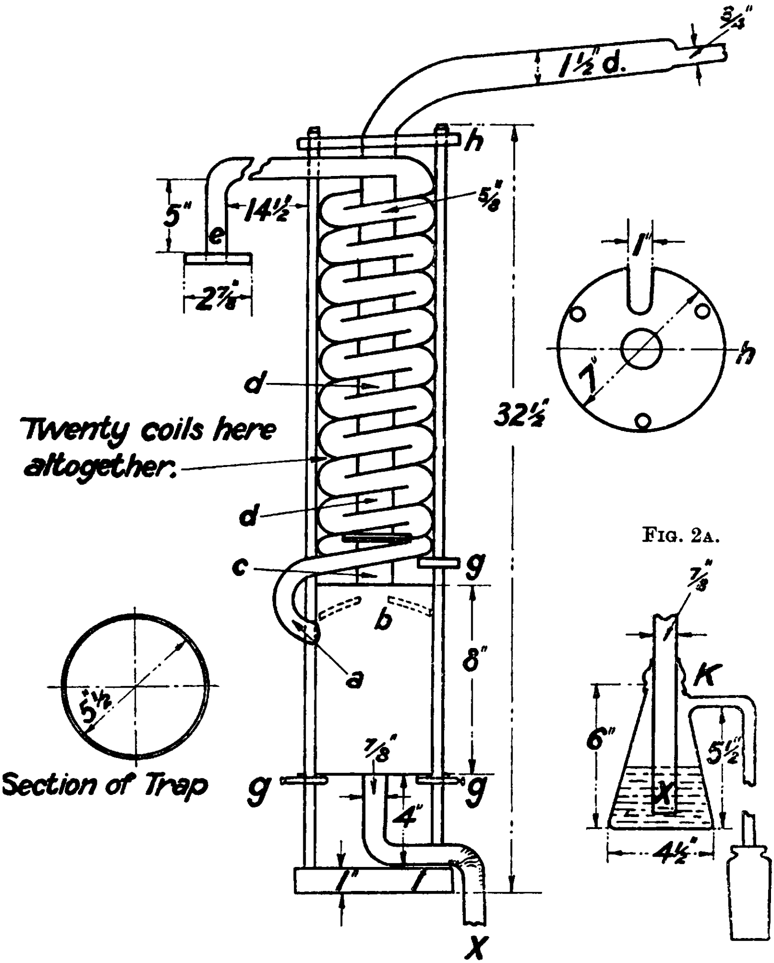


B. Boiler.
S. Spray trap.
W.J. Water jacket and cooling coils.
C.C. Conductivity cell.
A.F. Air filter.
A.P.T. Air purification train.
E. Outlet for purified water.

To eliminate these causes of trouble, the whole of that part of the still between the boiler and the block-tin condenser was re-designed; at the same time, some improvements were made in the air-purification train. The still in its final form is shown in Fig. 1.

The boiler, *B*, is made of 18-gauge (1·2 mm. thick) copper sheet, tinned on the inside. It is connected to the rest of the apparatus by two circular flanges, 7·0 cm. in diameter, soldered both to it and to the copper pipe, *e*. A ring of "hallite" packing is used between the flanges, which are held together by six bolts. (A flange is shown in Fig. 2, *e*.) The boiler holds 10 litres of water, which is introduced, together with the ground potassium bisulphate, by separating the flanges. This is the only joint on the still that

FIG. 2.



Dimensioned sketch (not drawn to scale).

need be broken during several months' running. The available waters were a hard London tap-water, and a supply which contained traces of oil. The former was objectionable owing to the possible formation of heavy boiler-scale, so the latter was used after a preliminary rough distillation with potassium permanganate and caustic potash in a simple form of still.

From the boiler, the steam passes through the copper tube, *e* (Figs. 1 and 2), to the trap, which has been redesigned and very solidly constructed, as shown on an enlarged scale in Fig. 2. The tube, *e*, is of 1·3 cm. internal diameter and is bent into 20 coils each of 12·5 cm. diameter, and its end is brazed into the copper trap tangentially so as to give circular motion to the steam entering the trap at *a*. A circular conical baffle-plate, *b*, is inserted above this. The steam outlet at *c* is provided with a 7 cm. circular flange (not shown in Fig. 2) which is bolted to " hallite " jointing and a similar flange on the block-tin tube, *d*. This tube has an internal diameter of 4 cm. and is soldered to the condenser. The ample width of this tube prevents any trapping of water; in the earlier still, a long, narrow, coiled tube was used and arranged outside the copper coil, but water occasionally accumulated in the bends and caused violent fluctuations of pressure in the still.

The copper coil and trap are lagged with cotton waste and asbestos sheet and are held in place by three adjustable supports, *g*, which can be clamped to three vertical brass rods. These brass rods are rigidly fixed into a heavy cast iron base, *I* (Fig. 2).

A brass plate, *h*, is bolted to the tops of the rods, and, together with a flange, provides support for the central tin tube. At first, the water from the submerged outlet tube, *X* (Fig. 2), was merely allowed to run into an open beaker, but the best water was not obtained until a definite air-trap and non-return valve were used, as shown in Fig. 2A.

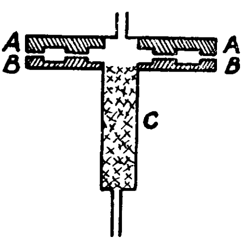
The main block-tin condensing column is similar to that of Bourdillon, but the arrangements at the lower end have been altered as shown in Fig. 1; *d* is the steam inlet leading from the trap and is soldered into the main column, *b* is the inlet for purified air, and *c* the outlet for the conductivity water; *W.J.* consists of two glass water-jackets connected together by a long coil of compo-tubing carrying a stream of water. The conductivity-measuring vessel *C.C.* is fixed on to *c* by a rubber stopper. The advantage of this arrangement is that the water does not become saturated with air in the cold as in Bourdillon's method, and consequently air-bubbles do not form on the electrodes of the conductivity cells.

On the upper part of the tin condenser is a narrow tin tube, *H*, soldered to the main column and joined by a rubber connexion to a glass tube leading into a bottle. A second bottle is connected so that the escaping air bubbles out through a shallow layer of distilled water. If a sudden diminution of pressure occurred in the still, the water in the second bottle would merely be sucked back into the first and not into the still.

The rate at which bubbles pass through the water serves as a rough indication that the purified air is passing satisfactorily through the still. Before distillation is stopped, the second bottle should be replaced by a soda–lime tube.

The Weiland purification trains, *A.P.T.* in Fig. 1, contain *N*-sulphuric acid, caustic potash solution, and distilled water; two are used in parallel, as it was found advisable to use a much faster stream of air than that used by Bourdillon. Recently Weiland's design has been modified : the columns containing the glass beads are now 2·5 cm. in diameter and are pinched in near the tops to retain the beads; the funnels and taps have been increased in size. The air passes through a dust-filter (*A.F.*, Fig. 1) constructed as shown in Fig. 3. This filter is a modification of one described in the Meteorological Office Report of the Advisory Committee on Atmospheric Pollution, 1916—17. It is constructed of brass, and the air first passes through the tube *C*, which is filled with special jewellers' wool, and then through a disc of special blotting paper (Ford 428 Mill) inserted between brass discs *A* and *B*, which have circular and radial grooves cut in them as shown. *A* and *B* are bolted together and the joint is waxed over externally.

FIG. 3.



The course of an actual distillation was as follows : Ten litres of laboratory distilled water were placed in the boiler with 20 g. of powdered potassium bisulphate, and heated to boiling; the "hallite" joint softened in the steam, and the boiler was then connected with the still.

The heating was adjusted so that the conductivity cell was filled and emptied every 9 or 10 minutes. This rate of delivery corresponds to the production of about 0·75 litre of water per hour and should not be greatly exceeded; if the still is run too rapidly, a trace of spray seems to get into the condenser during distillation.

The conductivity of the water was determined by the standard bridge method, a galvanometer being used to detect the zero position. This was possible because the conductivity was so low that only very small currents passed, and polarisation effects were negligible. The cells in which measurements were made were standardised with *N*/50-solutions of potassium chloride. The possible errors in the values for conductivities given in Table I are within $\pm$ 5%. The table gives the values (in gemmhos) of the specific conductivity, κ, of each batch of water reaching the conductivity cell in a typical run of the still, the purified air being supplied at a rate of about 22·5 litres per hour, and the temperature of the water being about 15°.

TABLE I.

Batch No.	κ.	Batch No.	κ.	Batch No.	κ.	Batch No.	κ.
1	0·17	10	0·057	19	0·055	28	0·054
2	0·13	11	0·055	20	0·055	29	0·055
3	0·078	12	0·062	21	0·055	30	0·059
4	0·077	13	0·057	22	0·055	31	0·063
5	0·062	14	0·052	23	0·054	32	0·067
6	0·059	15	0·050	24	0·054	33	0·071
7	0·055	16	0·052	25	0·054	34	0·084
8	0·072	17	0·054	26	0·065		
9	0·059	18	0·055	27	0·054		

Batches 3—33 inclusive, amounted to 4040 c.c. The volume of waste water collected at the "run off" from the steam trap was 2485 c.c.

In other runs, conductivities as low as 0·045 gemmho at 18° have been obtained. This figure is not much inferior to the best values of Kohlrausch and Heydweiller (0·040 at 18°) (*Pogg. Ann.*, 1894, **53**, 223) who distilled in a vacuum in an apparatus which was only adapted to give a small quantity of the purified water. The authors' still has been in constant use for more than 2 years and requires very little attention other than the periodic renewal of the solutions in the air-purification train. It will regularly produce about four litres a day of water with a conductivity of about 0·065 gemmho.

The authors wish to express their grateful thanks to Mr. H. R. Raikes, who placed his great experience at their disposal when constructing both the still and the apparatus for measuring conductivities.

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