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Production of Large Amounts of Pure Water

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DISTILLED WATER of high purity is required for investigating the chemistry of the nutrients and trace elements in sea water. It is needed in large quantity where much experimental culture work using artificial sea water is in progress. To meet this demand, the Gulf Fishery Investigations laboratory has constructed a pair of all-glass stills. Operating in tandem, these will produce in excess of 50 gallons a day of double-distilled water having a specific conductivity of 0.7×10^{-6} mho.

This water is used in preparing culture and nutrient solutions, running chemical analyses, and, equally important, in cleaning laboratory glassware.

A diagram of the two stills is shown in Figure 1. Borosilicate glass construction is used throughout. The boilers, *P*, consist of 72,000-ml. flasks with 102/75 socket neck joints, *C*. Adapters, *D*, connect the 7-foot columns, *G*, to the boilers. The adapters and columns are made of 3-inch glass pipe, held

together with glass pipe connecting clamps, *E*. The columns are packed with borosilicate Raschig rings, held in place with retaining plates, *F*, constructed of block tin or high temperature polyethylene ($\frac{1}{4}$ inch thick). These are profusely perforated with $\frac{1}{8}$ -inch holes. The top of the columns connect to the heat exchangers, *K*, by connecting arms, *I*. These are made of 1-inch glass pipe with 35/25 socket joints on each end as shown (*H* and *J*) and are wrapped with 700-watt Briskeat heating tapes. The heat exchangers are high speed condensers similar to H. S. Martin's Catalog No. M-7032 but are twice as long and have 35/25 socket joints as shown.

Each still contains a siphon tube, *B*, made of block tin or high temperature polyethylene tubing, which enters the system through one of the six entrance holes in adapter *D*. Electrical conductors *T*, conductor braces *U*, and water inlet *O* also pass through this adapter. The first still contains two $2\frac{3}{4} \times 6$ inch carbon electrodes, *A*, and the second, a heating coil, *R*, made by winding 17

feet of 0.051-gage Alloy K (C. O. Jelliff Mfg. Corp., Southport, Conn.) on a $\frac{1}{2}$ -inch mandrel. The condensate from each condenser is conducted to storage tanks, *M* (53.5-gallon polyethylene drums, obtained from A. Daigger and Co., Chicago 10, Ill.), by means of polyethylene pipes, *L*, each of which contains a steam vent, *S*.

The operation of the first still depends upon direct conduction of electricity through the water in the boiling pot. Initially, the pot water must be fortified with enough sodium chloride to permit passage of a desired amount of current. Enough salt solution is added through *B*, so that at a water temperature equal to room temperature, or perhaps slightly higher, the conductivity will be increased sufficiently to permit passage of 25 to 30 amperes under a potential pressure of 220 volts. As the temperature increases to boiling, the conductivity also increases. The final current can be controlled by adjusting the level of the siphon overflow, *N*. The water

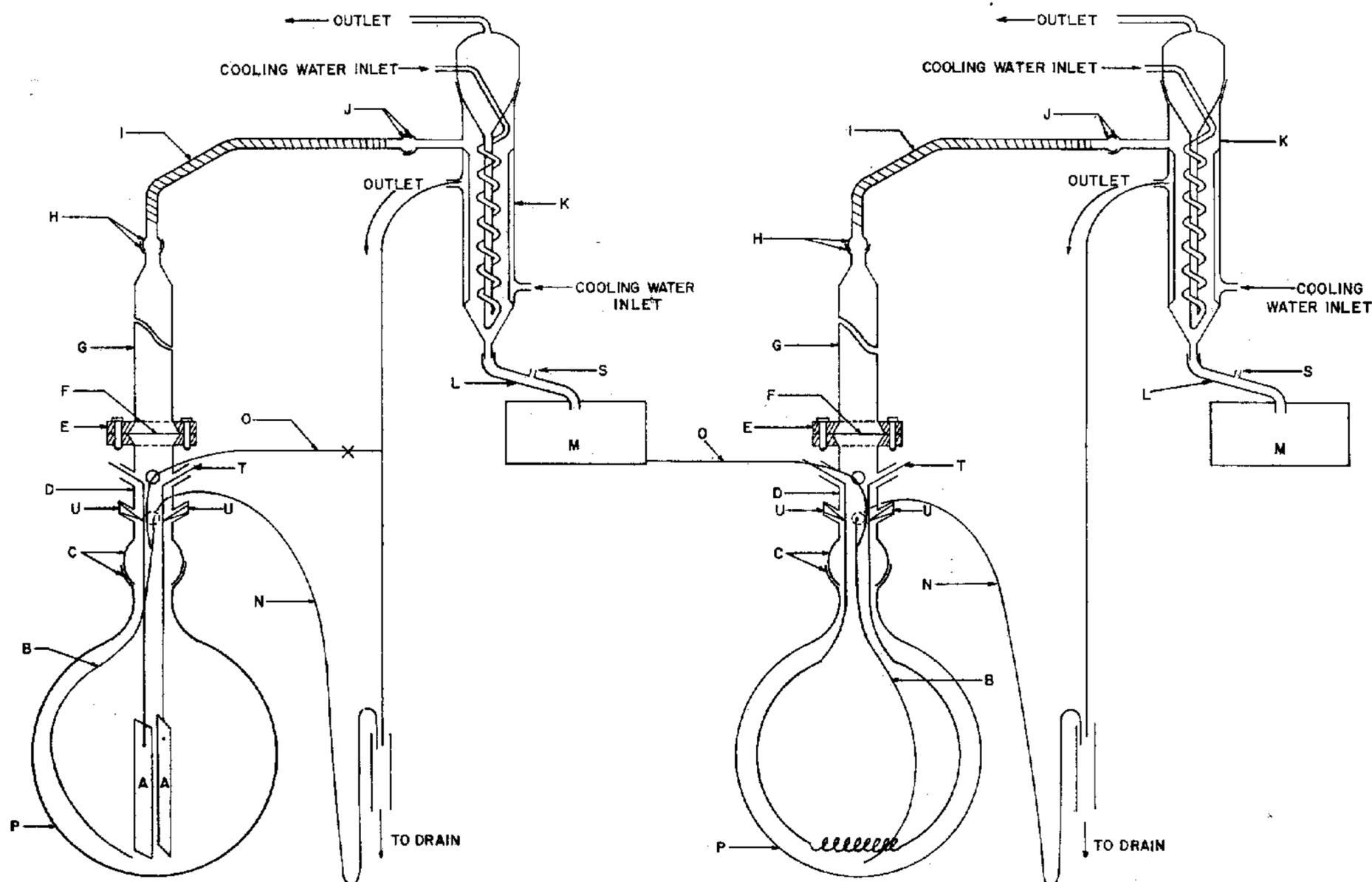


Figure 1. Diagram of two stills

input through *O* should be slightly greater than the production of distilled water. This will prevent excessive accumulation of solids in the boiling pot and permit the siphon regulator to maintain suitable equilibrium conditions for long periods of time without attention.

Electrolytic action of the raw water in the first still necessitates the use of carbon electrodes. These simplify the maintenance of a constant water level. As the level tends to increase, the resulting increase in current consumption builds up the internal steam pressure in the system. This, in turn, increases the flow of water through the siphon until equilibrium conditions are attained. Similarly, the reverse of these conditions tends to prevent the level from dropping.

As recommended by Ballentine [ANAL. CHEM. 26, 549 (1954)], the two connecting arms, *I*, are wrapped with flexible heating tapes to prevent formation of water films that might carry impurities into the condensers.

The rate of flow of cooling water

through the condensers is regulated so that the condensate emerges with a fair amount of vapor, which escapes through *S*, carrying with it much of the volatile impurities. The outlet water from the condenser is tapped just before entering the drain to provide a warm water feed source for the boiling pot. The feed water, on entering the boiling pot, must be allowed to run down the siphon tube. This prevents vapor locking within the tube, which would prevent siphon regulation.

The storage tank, *M*, supplies water to the second still. This is identical to the first, with the exception of the heating element, *R*. This consists of a coil of resistance wire which limits current consumption to about 40 amperes at 220 volts. As current through this coil is in no way dependent upon the liquid level in the boiling pot, the regulation of the siphon is not so precise as in the first still. However, if the flow rate through *O* is adjusted so that it is about 1 or 2% greater than that of the output, a fairly constant level can be maintained. The pot is cleaned whenever

the distillate conductivity rises above about 0.8×10^{-6} mho. Every 24 hours potassium permanganate is added to oxidize any organic impurities. No special provision has been made for the removal of carbon dioxide.

The rate of production of the first still at a current consumption of 70 amperes at 220 volts is about 5 gallons per hour of distillate having a conductivity of approximately 1.3×10^{-6} mho, and that of the second, at a current consumption of 40 amperes at the same voltage, is just under 2.5 gallons per hour of distillate having a conductivity of about 0.7×10^{-6} mho. The excess water from the first still is used wherever high purity distillate is not required.

If an attempt is made to increase current consumption in the first still, the column may flood and seriously impair the purity of the product. Operating at the suggested amperages, the product of the second still compares favorably with that of smaller all-glass laboratory stills having outputs of 1 to 2 liters per hour and no special provision for elimination of carbon dioxide.