ART. XXIV.—*The Formation of Salt Crystals from a Hot Saturated Solution;* by E. TATUM LONG.

IN 1909 Professor G. D. Harris propounded the theory that the "Domes" of Louisiana and Texas are due to the force exerted by growing crystals at some great depth where a saturated hot solution from below became cooled and thus caused a precipitation of the salt.

In the June number of this Journal of last year Mr. Stephen Taber published an article on "The Growth of Crystals Under External Pressure." While the latter's experiments were in progress other investigations were started with the object of demonstrating from the viewpoint of geology and physical-chemistry that a saturated hot solution of sodium chloride when cooled, would deposit salt, and that this released salt would form crystals which in growing would exert an appreciable force and which would continue to grow in spite of resistance.

Mr. Taber's object was "determining whether it is possible for growing crystals to exert a linear pressure and if so, the conditions under which the pressure is developed." Though the purpose of the two investigations was thus somewhat different, one fact at least seems to have been demonstrated in common.

In Mr. Taber's article, "The Growth of Crystals Under External Pressure," he constantly lays stress upon the necessity that the surface where growth is to take place be in contact with a supersaturated solution. In the experiment here described, another salt was used from those employed by Mr. Taber, but the same fact was again demonstrated. The crystals ceased to grow as soon as the supersaturated solution was withdrawn from their surface. Furthermore the rate of growth was largely governed by the amount of flow and hence the quantity of salt released for crystallization.

An apparatus (fig. 1) was set up with a reservoir A placed considerably above the point where crystallization was to take place, C. This reservoir contained cold water and a good deal more common table salt than the water could take into solution. A was connected with B, a second reservoir, also with salt in excess, by a long glass tube with rubber connections to short glass tubes, placed in the rubber stoppers in the side necks of the two receivers. On the lower connection a stopcock was placed so as to regulate the flow of the cold brine into B. A Bunsen burner was placed under B and a thermometer, T, was run through the top stopper well down into the

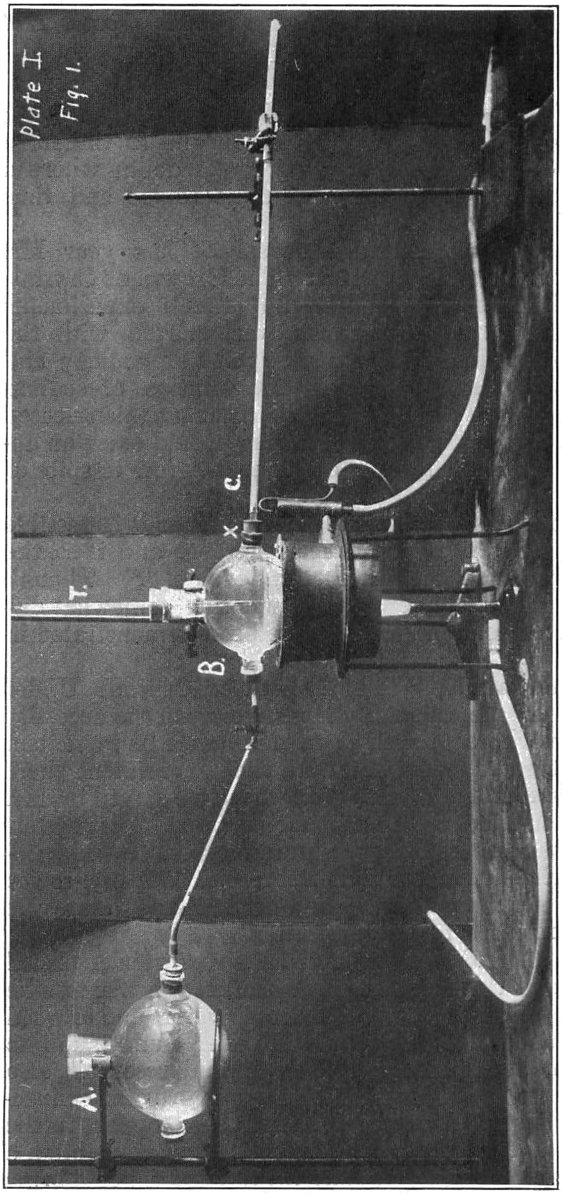

FIG. 1.

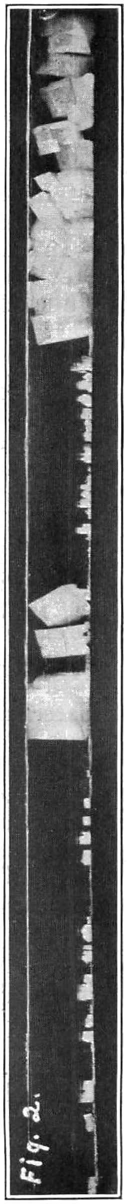

FIG. 2.

hot brine. During the first step of the experiment, a second glass tube was run through the stopper (X) in the right hand side neck of B without rubber tube connection, at the outer end of which, however, there was a connection on which another stopcock was placed. During the second step, instead of the glass tube, a common rubber finger was used. It was punctured at the tip and a small glass tube inserted, while the open end was stretched over the same rubber stopper, X.

The most effective temperature to bring about deposition from the hot brine was found to be between 70° and 75° C. Below that, there was not enough NaCl absorbed for an appreciable deposition, and above 75° recrystallization went on in B. As enough hydrostatic pressure could not be obtained by raising A so that the passage through the stopper at X could be kept open, it had to be frequently cleared by a steel rod with a right-angle turn run through the top neck of B. This stopper was also removed to replenish the supply of salt, but otherwise B was kept air-tight to prevent crystallization by evaporation.

After five or six days the hot brine became sufficiently saturated to begin the formation of crystals at C, the first point where crystallization took place, and therefore the point where it was always farthest advanced. At the end of a few weeks the crystals had grown so that they completely filled the tube and stopped the flow entirely. Figure 2 shows the conditions at this stage of the experiment. The hydrostatic pressure was increased but no seepage could be forced through. This run was repeated several times under slightly different conditions, but the result was always the same even though the time varied somewhat.

The second step was then started: to make the crystals grow against pressure, in this case a rubber finger. This was so successful that after a month, one crystal expanded the rubber wall of its prison so far as to puncture it. The tiny hole was cemented over and effectually closed, but in a few days another crystal went through at a different point, this time making a much larger hole.

On page 550 of Mr. Taber's article he says, "The tendency to form crystals is much stronger in some substances than in others, but it is never so strong as to cause growth on a face which is not in contact with a supersaturated solution, and even if a growing surface is in contact with a supersaturated solution, the relative rate of growth is chiefly controlled by the rapidity with which the material for growth is made available."

The results of the two series of experiments thus independently worked out would therefore seem to establish without question, not only that a hot saturated brine will deposit salt when cooled, but that the developing crystals in growing exert a lateral pressure sufficient to permit continued growth even against opposing external forces.

Some of the stages of growth of the crystals in this experiment are given in figs. 3–6. Fig. 3 shows the collapsed finger with only the liquid running through. Later the crystals began to expand the rubber, and at the end of the first run, the connection with the stopper sprang a leak; fig. 4 shows the condition of the second run, after the first puncture and before the second one, which ended the experiment. Fig. 5 is an enlargement of 3, and 6 an enlargement of 4.

Fig. 3.

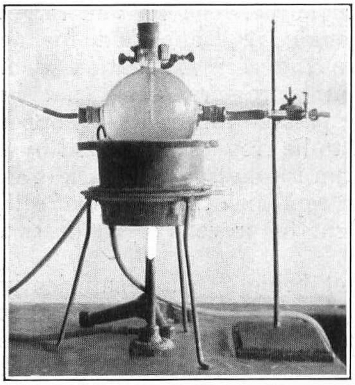

Fig. 4.

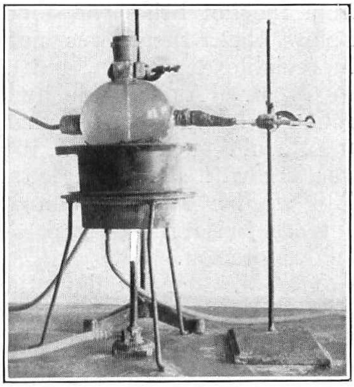

Fig. 5.

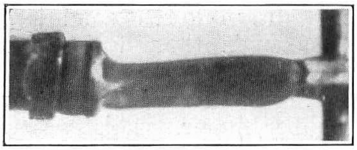

Fig. 6.