ing the laws governing gas pressure. It is the impact of these molecules against the walls of the semipermeable membrane. On the other hand, Kahlenberg shows it to be the force of chemical affinity, while Professor Traube proves it is an "interfacial pressure obtained by subtracting the surface tension of one fluid from the tension of the fluid into which it diffuses." Since surface tension is a cohesive force, osmosis may depend upon electromotive force because, according to both Sir Oliver Lodge[5] and Fernando Sanford,[6] the forces of chemical affinity and cohesion are electrical. This is a much mooted question for, by assuming Dr. Lupke's[7] "Osmotic Theory of the Current of Galvanic Cells," the starting point is again reached. Fortunately the question as to the motive power of osmosis has no bearing on the result of the selective action in flotation caused by osmosis. As shown, this selective action in all three methods of flotation depends primarily upon gas occlusion by the mineral to be floated. Mickle showed that no mineral will float on the surface of hot acid solution, even if dilute. Thus an electrolyte creates a greater selective action in surface tension flotation.

This selective tendency exists in neutral solutions due to the fact that metallic particles occlude more gas than others. In bulk oil flotation, the metallic particles have occluded more air and, hence, are more easily wetted with oil than with water. The osmotic force set up by the electrolyte in froth flotation expels occluded gas from the mineral particles. There is still left with the metallic particles sufficient gas for them to act as nuclei so that the nascent gas of the liquid may form bubbles to float them.

Just as vapor must have a nucleus upon which to form a rain drop, so the nascent gas in flotation pulp must have a nucleus upon which to form a bubble. Duhem[8] shows that a bubble will never form where the liquid is continuous, due to the fact that its infinitely small radius would be less than the limiting radius of collapsibility. Note how the vapor bubbles of boiling water form on the bottom or sides of the vessel.

Not only are bubbles necessary for froth, but they must be more or less persistent. The surface film that encloses the bubble as it is formed in the interior of the liquid becomes a part of that bubble and, due to surface tension, remains with it throughout its passage to the surface of the liquid, in the same way that the surface film of a soap bubble remains with it throughout its passage in the air. This is easily proved by slowly blowing a colored bubble at the bottom of a large beaker of which the upper portion at least is filled with clear liquid. Due to this fact, the bubbles may have their films strengthened or toughened so they will endure for a longer time. Therefore, if the bubble be coated with some such substance as oil, the total force of surface tension is increased, due to the surface tension of the water film plus that of the oil film. Surface tension tends to decrease the size of the bubble as is well illustrated by Boys,[9] while the expansive force of the gas enclosed tends to enlarge it. The hydrostatic head aids surface tension in maintaining the bubble in the interior of the liquid.

Arriving at the surface, the bubble may burst due to: (1) interior gas expansion; (2) adhesive force of the contained gas for the atmosphere; (3) evaporation of the enclosing film. Therefore an immiscible substance aids in two ways in making the bubble more persistent: (1) adding to the force of surface tension; (2) forming a film less easily evaporated. Since molecular forces are dealt with, these films approach one molecule in thickness and hence little oil is required. The colors of the bubbles also show this.

In addition to the oil film, the bubbles may be still further strengthened by an armor of metallic particles. These metallic particles containing occluded gas are, as shown above, more easily oil-coated than gangue particles. Due to cohesion, an electrical force, these particles are firmly held together and to the bubble film, which is then enclosed in a network of them just as a balloon is enclosed in a netting of rope. Bubbles thus made will endure for days and have been spoken of as "oil froth."

Oils that are good "collectors" are practically insoluble in water and form a film not easily evaporated, so make persistent bubbles. Good "frothers" are oils more or less soluble and, while they make quantities of bubbles and much froth, evaporate quickly, so that the bubbles burst more readily. Mineral particles are very easily coated with volatile oils and the bubbles are readily armored, but they burst readily, sometimes with violence. Being soluble, these oils decrease the surface tension since their surface tension is less than that of water.

Most oils aid flotation in three ways: by (1) increasing surface tension of the oil film with the additional force of surface tension of the water film; (2) decreasing adhesive force of the water for metallic particles by forming films around them; and (3) increasing cohesive force of metallic particles for each other by means of the oil film. Thus it is seen that although oil is a great aid, there can be no universal theory for flotation which considers oil necessary. By this method of elimination, it is shown that all processes and kinds of flotation can be satisfactorily explained by gas occlusion and that the bubbles for froth formation are from nascent gas.

BETHLEHEM STEEL CO.

Bethlehem Steel Corporation has issued its full pamphlet report for the year 1915. It shows that on December 31, 1915, cash on hand totaled $15,380,350, against $5,220,910 on December 31, 1914. Miscellaneous investments aggregate $27,617,495, against $437,664 on corresponding date of preceding year. Cash on hand and investments totaled $42,997,845. A large percentage of these investments consist of Anglo-French bonds which Bethlehem Steel subscribed for last year.

The statement shows total provision for repairs and depreciation of $9,106,671 last year, compared with $4,716,273 in preceding year. Bonded debt of Bethlehem Steel Corporation on December 31, 1915, stood at $31,099,000, a reduction of $5,108,700 from December 31, 1914. There was appropriated for and invested in additions to property and working capital $12,500,000. Actual amount of bonds purchased for sinking fund or cancelled was $6,193,300.

[5] Electrons by Sir Oliver Lodge, Principal the University of Birmingham; Chap. 16, Nature of Cohesion, Page 153, July, 1906.
[6] A Physical Theory of Electrofication (1911), by Fernando Sanford, Prof. of Physics, Stanford University. Page 43.
[7] Elements of Electro Chemistry, by Dr. Robert Lupke. Part 3.
[8] Thermodynamics and Chemistry, by P. Duhem, 1903. Page 366
[9] Soap Bubbles, by C. V. Boys.