ART. VI.—*On a simple Apparatus for the Production of Ozone with Electricity of high tension;* by Prof. ARTHUR W. WRIGHT.

EXPERIMENT has shown that in the production of ozone by electricity the maximum amount of oxygen is ozonized by the silent or glow discharge, and most of the forms of apparatus by which this is effected are contrivances by which oxygen is made to flow slowly through a space traversed by such a discharge. In v. Babo's apparatus, as well as in those of Siemens and Houzeau, the metallic conductors are separated by glass and a stratum of air. By inductive action of the charged metallic surfaces the intervening air becomes charged with electricity oppositely upon its two sides, and simultaneously with the discharge of the metallic terminals, through the wire of the coil, a discharge takes place through the air, not in the form of sparks, but diffusely, producing a glow of purplish light, visible only in the dark.

These apparatus succeed best with electricity of comparatively low tension. In using the Holtz's electro-machine with them the discharge is apt to occur chiefly in the form of sparks through the air, or it may even traverse and perforate the glass, and the form of the apparatus must be varied to give the best results.

When the poles of the machine itself are separated to a sufficient distance the electricity passes between them either in the form of a diffuse brush, spanning the whole interval, or with a very minute brush upon the negative pole, and a glow upon the positive, the intermediate space not being visibly luminous. This is the so-called dark or silent discharge, exhibiting the phenomena of the electric shadow when suitable objects are interposed, as described in a former paper.* When this occurs the strong odor shows that a considerable amount of the atmospheric oxygen is converted into ozone.

* This Journal, II, xlix, p. 381, and III, i, p. 437.

If this discharge is made to take place in an enclosed space through which air or oxygen can be driven, the ozonizing effect of the electricity is heightened and can be utilized. The apparatus which I have employed, and which has afforded very satisfactory results, consists of a straight glass tube about 20 centimeters long and having an internal diameter of 2·5 centimeters, the two ends being stopped with corks covered on the inner side with a thin coating of cement to protect them from the action of the ozone. Through the axis of each cork is inserted a glass tube of about 5 millimeters caliber, and 7 centimeters in length, having a branch tube inserted perpendicularly at the middle and long enough to permit a rubber tube to be slipped upon it. The outer ends of the tubes themselves are closely stopped with corks, through which are passed straight, thick copper wires carrying suitable terminals at their inner ends, and bent into a ring at the others. They are fitted so as to make tight joints, but to allow of motion in order to vary the distance between their inner ends. One of these wires carries a small ball; the other terminates in a disk with rounded edge, set perpendicularly to the axis of the tube, and so large as to leave an annular space of some two or three millimeters breadth around it. The gas is admitted through one of the branch tubes and escapes from the other, after having passed through the whole length of the tube.

In using the apparatus the wires must be connected with the poles of the machine in such a manner that the disk becomes the negative terminal, as this arrangement gives the greatest degree of expansion and diffuseness to the current. On turning the machine, and adjusting the ball and disk to a proper distance, a nebulous aigrette surrounds the latter, quite filling the interval between it and the wall of the tube, while the part of the tube between the disk and ball is crowded with innumerable hazy streams converging upon the positive pole, or simply causing the latter to be covered with a faint glow. A current of air or oxygen sent into the tube must pass through this, and ozone is very rapidly produced, and in great quantity. The condensers are of course not used with the machine, when this apparatus is employed.

There appears to be an advantage in causing the oxygen to pass from the negative toward the positive within the tube, for the gas through which the discharge passes is transported in the contrary direction, as may be readily seen on bringing a candle flame between the poles of the machine, or causing a thin column of smoke to rise through the polar interval. The flame and the smoke are deflected, and stream off toward the negative pole. If the gas should be admitted in the direction mentioned, there would be a tendency to obstruct its flow some-

what, and thus keep it longer under the influence of the electricity.

Some experiments which were made with the apparatus will give an idea of its efficiency. One hundred cubic centimeters of water were placed in an upright tube or test-glass, and into it were put 20 drops of strong indigo solution, causing it to assume a deep blue tint. Air was driven through the ozonizing tube, under a pressure of about three inches of water, and on issuing from it conveyed by a tube into the solution. When the electro-machine was put in operation, being turned with sufficient speed to give nearly its maximum effect, the solution completely lost its blue color in less than four minutes. Blue litmus solution under similar circumstances became pale pink, but required a considerably longer time for the change.

When Schönbein's test solution is employed the deep blue color is immediately produced, but the solution is too thick to work well if the starch has been heated considerably, or for a long time, in making it. A better proportion is to take one part of potassic iodide by weight, ten parts of starch, and five thousand parts of water. This forms a milky solution, sufficiently mobile to mix well when the ozonized air bubbles through it. When 100 cubic centimeters of this solution were used, and air passed through the apparatus as before, the blue color appeared at once on application of electricity, and in 30 seconds it was deeply colored.

With dry oxygen the effects were much more rapid and remarkable. 100 cubic centimeters of the solution were used, as before. The instant the machine was put in action the liquid about the end of the delivery tube became deep blue, and in from ten to fifteen seconds the whole had acquired a uniform and intense blue color.

The summer moisture having interfered somewhat with the effective working of the electro-machine, there has been no opportunity to determine the percentage of ozone produced in this manner, but it appears to be very large. When dry oxygen is passed through the tube very slowly, the issuing gas when inhaled produces a painful burning sensation in the lungs, and causes violent coughing, which persists for a considerable time.

When oxygen is used it is found that the electrodes must be separated to a much greater distance than is necessary for air, otherwise sparks pass and destroy a large proportion of the ozone already formed. With air the direct spark in the apparatus could not be made to pass over an interval of more than 7 centimeters, but in oxygen they did not cease until the poles were separated about 11·5 centimeters. When the tube was filled with air and the poles were 7 or 8 centimeters apart the

discharge was of the silent kind, but on admitting oxygen it immediately took the form of direct sparks.

The quantity of the solution used in these experiments was much greater than would be needed in order to exhibit the characteristic reactions of ozone to an audience of moderate size. One-half or one-third of the amount would be quite sufficient, and the time required for the reaction would be proportionally shorter. The great quantity of the ozone, as well as the ease and rapidity with which it is produced, render the apparatus especially serviceable for use in the lecture-room.