

#### References and Notes

1. The assistance of Eusebio Davalos, Ignacio Bernal, and Roman Piña Chán of the Instituto and Carmen Leonard of the Centro de Investigaciones Antropológicas de México is gratefully acknowledged.
2. The National Geographic Society provided funds to support the recent investigations. Their recent interest may be considered a continuation of their earlier interest in the site, which dates from 1922-25, when Byron Cummings investigated the Cuicuilco Pyramid under the society's auspices. The University of California, through the Committee on Research and Associates in Tropical Biogeography, provided further assistance.
3. A. L. Kroeber, *Univ. Calif. Publ. Am. Archaeol. and Ethnol.* 17, 401 (1925).
4. B. Cummings, *Natl. Geographic Mag.* 44, 212, 220 (1923); *Univ. Arizona Soc. Sci. Bull.* 4, 50 (1933).
5. G. Vaillant, *Am. Museum Nat. Hist. Anthropol. Papers* 32, plate LXIX (1931).
6. G. Vaillant, *ibid.* 32, plate LXXV (1931).
7. G. Vaillant, *ibid.* 35, Fig. 26 (1934).
8. E. Noguera, *Am. Antiquity* 9, Fig. 2, Nos. 12, 13 (1943).
9. R. P. Chán, *Las Culturas Preclásicas de la Cuenca de Mexico* (Fondo de Cultura Económica, Mexico City, 1955).
10. E. Noguera, *El Mexico Antiguo* 3 (1935).
11. R. Millon, *Boletín del Centro de Investigaciones Antropológicas de Mexico*, No. 4 (1957); *Am. Antiquity* 23, No. 2 (1957).

30 September 1957

### Electrolytically Controlled Device for Dispensing Liquids

Commercially available equipment for dispensing small volumes of liquids continuously for 24 to 72 hours was considered inadequate, or too expensive or cumbersome for certain applications. An instrument was therefore designed to utilize the production of gas by electrolysis of water for dispensing solutions aseptically and at any desired rate, by regulation of the electric current (*I*).

The unit, shown in Fig. 1, has two chambers, a generator (*A*) holding the platinum electrodes and a reservoir (*B*). The two chambers are separated by a rubber balloon (*C*). Gases generated by electrolytic decomposition of water in the generator apply pressure within the balloon which in turn forces the liquid through the delivery tube (*D*). The 9-mm inner tubing (*E*) eliminates the chance of explosion by separating the oxygen and hydrogen generated by electrolysis. Tube *E* also acts as an automatic cut-off switch by interrupting the circuit when sufficient gas accumulates in tube *E* to fill it below the tip of the movable electrode (*F*).

The electrode section (*A*), including tube *E*, is filled with an electrolyte. After chamber *A* is completely filled, suction is applied at *G* to collapse the rubber balloon (*C*), after which the stopcock is closed. The liquid to be dispensed is placed in chamber *B*, and the air is displaced by allowing balloon *C* to expand into the lower chamber. As soon as all of the air is displaced, *A* and *B* are tightly fitted together, the stopcock is

closed again, and the delivery tube (*D*) is opened.

The delivery rate was found to be equal to that calculated by using the electrochemical equivalents of hydrogen and oxygen, with appropriate corrections for temperature and pressure of the gas phase. A current of 1 ma produced 0.0104 ml of gas per minute at 760 mm-Hg and 0°C. A small transformer and selenium rectifier with a potentiometer and milliammeter have been used, but the transformer and rectifier can be replaced by a 6-v battery.

This device has been used for delivering liquids for continuous-flow paper electrophoresis, and for compensation in a Tiselius type electrophoresis apparatus. A modified apparatus, in which the generator was connected to a reservoir by Tygon tubing, was used for controlling flow rates in ion-exchange or chromatographic separations. Either device can be used for continuous adjustment of *pH* or for addition of nutrient solutions to bacterial cultures during growth, as in a chemostat.

Electrolytic production of gas from water to dispense liquids has the following advantages. (i) The rate of flow is almost infinitely variable. (ii) The flow rate can be adjusted easily at any time without disturbing the apparatus assembly. (iii) The liquid is dispensed uniformly. (iv) The cost per unit is much less than the cost of equipment in which a syringe is used to perform analogous operations. (v) Controls may be remote from the actual device, and power requirements are minimal. (vi) The appa-

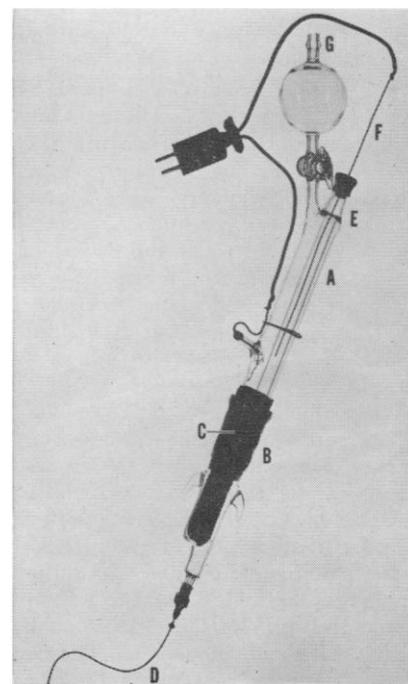


Fig. 1. Electrolytically controlled device for dispensing small volumes of liquid.

either a transition from the ceramic tradition of Ticoman to that of Teotihuacan or the influence at Cuicuilco of developing Teotihuacan from some other part of the Valley of Mexico. The most distinctive and abundant ware bears negative painting (black on yellow or black and red on yellow) with more complex, less curvilinear designs than are typical of Teotihuacan I negative. One type of vessel support has a Teotihuacan I form (8) but the surface lacks the characteristic high polish. Several other wares, including red, red on yellow, white on red, and blackish brown, display decorative designs, forms, or high polish which are related in some manner as yet incompletely understood to standard Teotihuacan I types.

Definite Teotihuacan I sherds are rare and occur in the uppermost levels. These include a scattered assortment of red, negative, polychrome, and fine-line incised types.

A small sample of very thin polished red and polished black sherds from the base of Cummings' shaft near the pyramid and from the deepest levels of mounds 2 and 4 may represent an earlier ceramic period. These are possibly related to El Arbolillo, but no firm conclusion on this is possible until the material has been analyzed further.

A variety of clay figurines support the conclusion on a terminal Preclassic date. Three radiocarbon dates are available for Cuicuilco. De Terra collected a subpedregal carbon sample (No. C-200) from the vicinity of the pyramid which yielded a date of  $2422 \pm 250$  years. In January 1957, two wood charcoal samples (Nos. M-663 and M-664) from below the pedregal were collected from occupation deposits near mound 2 at Cuicuilco-B, and these have been dated by the University of Michigan Laboratory as  $2040 \pm 200$  and  $1430 \pm 200$  years old, respectively. Since samples M-663 and M-664 should be the same age, it seems probable that a laboratory error was made in treating one or both samples. Of the two, the oldest (M-663) is more likely to be closer to the actual age. Piña Chán's date for the termination of the Preclassic (Formative) in the Valley of Mexico is 200 B.C. (9). Since the Cuicuilco-B material seems to be primarily Late Preclassic but is associated with ceramics which are related to Teotihuacan I as known from the sites of El Tepelcate (8), the inner hearting of the Pyramid of the Sun at Teotihuacan (10), and to the newly discovered Teotihuacan I complex at Teotihuacan (11), the date of sample M-663 seems to be more nearly correct than that of M-664.

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ratus can be made small and compact for mounting on individual flasks in an incubator or on a shaker for adding acid, alkali, or other reagents during incubation of bacterial cultures. Only light leads are needed to service the units and, if several units are to be used, as for replicate flasks, addition will be identical in all flasks if the electrodes are wired in series. (vii) There are no moving parts which need lubrication.

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#### Reference

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### Radiation-Induced Reactions of Potassium Bromide with Air

Pressed discs of potassium bromide (1) showed selective absorption in the 4000 to 650-K (2) infrared region after irradiation with 1.5-Mev electrons in the presence of air, oxygen, nitrogen, helium, or carbon dioxide. The samples received about  $10^{21}$  ev/g at a dose-rate of about  $10^{19}$  ev/min. In all experiments the potassium bromide "windows" became less transparent as devitrification, with consequent scattering, proceeded. In addition, there was decreased absorbance of the only bands initially present—those centered at 3430 and 1630 K, which were due to adsorbed water or to occluded water retained by the potassium bromide despite careful desiccation, or to both. These results were produced also by heating the discs several hundred degrees. The rate of devitrification decreased as the rate of heating was decreased. The "windows" were restored to the glass-clear condition by repressing. While loss of water and devitrification were the only effects noted for experiments conducted in the three gases last named, in oxygen and in air, radiation-induced chemical reactions occurred.

When a potassium bromide "window" was irradiated in ordinary laboratory air, new bands appeared in the infrared absorption spectrum, with maxima at 1360, 1260, 830, 1440, 1765, and 2340 K, in order of decreasing magnitude. Part of the pattern was unstable and shifted rapidly: peaks at 1385 and 825 K appeared and grew at the expense of the original 1360 and 830 maxima. The rate of shift was greater in humid air. Since the new peaks were characteristic of potassium nitrate dispersed in potassium

bromide and in Nujol (3), it was interesting to speculate on the precursor. The immediate possibilities were: (i) that scattered "isolated" nitrate ions on the surface of the disc migrated to form potassium nitrate crystals; (ii) that a metastable crystalline phase of potassium nitrate was initially formed on the surface under the influence of the crystalline surface forces of the potassium bromide lattice and subsequently recrystallized. The latter possibility appeared to be the more likely since it was found (4) that isotropic, triangular microcrystals of high melting point, which spontaneously changed to the normal anisotropic form of potassium nitrate, were produced on the surface of potassium bromide crystals irradiated in air with polonium alpha rays.

Although nitrogen dioxide alone (the other nitrogen oxides were inert) reacted with potassium bromide in a manner similar to that of irradiated air, the 100-fold greater rate of reaction at room temperature (20-fold greater at 70°C) in the latter case indicated that energy-rich surface dislocations or excited gaseous intermediates were involved in the reaction. At constant dose-rate, it was found that the production of infrared-absorbing species decreased as the contact time of the irradiated air with the salt diminished. Coupled with the fact that discs irradiated in helium at room temperature did not undergo appreciable postirradiation reaction with air, the view that excited gaseous intermediates were involved gained plausibility.

Of the absorption bands listed above, those centered at 1385, 825, and 1765 K could be identified as belonging to potassium nitrate; that centered at 2340 K, which appeared only in windows prepared from chemically pure potassium bromide and not in windows made from Harshaw optical grade potassium bromide, was undoubtedly produced by carbon dioxide arising from the radiolysis of organic impurities; that centered at 1260 K, on the basis of other work (5) could be tentatively identified as belonging to potassium nitrite produced by radiolysis of potassium nitrate. Although potassium carbonate has been reported (3) to have a very strong absorption band at 1450 K, the 1440 peak here noted did not appear when potassium bromide was irradiated in an atmosphere of carbon dioxide; it did appear when the irradiations were conducted in atmospheres of oxygen or air. Possibly KNO, which has been reported (6) to absorb at 1445 K, or KOBBr was the absorbing species.

The irradiation of a disc in an atmosphere of dry oxygen produced, in addition to the aforementioned peak at 1440 K, an infrared absorption band with a maximum at 790 K, which was found to be the principal absorption region of

potassium bromate when it was dispersed in potassium bromide or Nujol (3). This absorption did not appear when the irradiations were conducted in dry or moist air.

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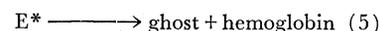
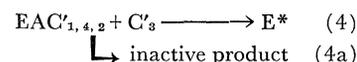
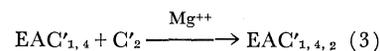
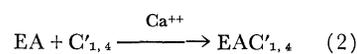
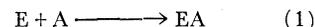
#### References and Notes

1. M. M. Stimson and M. I. O'Donell, *J. Am. Chem. Soc.* 74, 1805 (1952); U. Schiedt and H. Reinwein, *Z. Naturforsch.* 7b, 270 (1952).
2. The convention "kayser" (symbol K) as a name for the reciprocal centimeter unit of wave number has been used: Report of the Joint Commission for Spectroscopy, Rome, Sept. 1952, *J. Opt. Soc. Am.* 43, 410 (1953).
3. F. A. Miller and C. H. Wilkins, *Anal. Chem.* 24, 1253 (1952).
4. R. Blösch, *Österr. Akad. Wiss. Math.-naturw. Kl. Sitzber. Abt. IIa*, 162, 99 (1953); L. Wieninger and N. Adler, *Acta Phys. Austriaca* 4, 81 (1950).
5. A description of this work is in preparation.
6. D. J. Millen, C. Polydoropoulos, D. Watson, *Proc. Chem. Soc.* 1957, 18 (1957).

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### Mechanism of Immune Hemolysis: Recognition of Two Steps in the Conversion of $EAC'_{1,4,2}$ to $E^*$

In recent publications from this laboratory (1) it has been established that the lysis of sheep erythrocytes (E) by Forssman antibody (A) and guinea pig complement ( $C'$ ) is the result of a series of successive reaction steps, as follows:



In this scheme  $C'_1$ ,  $C'_2$ ,  $C'_3$ , and  $C'_4$  represent the four recognized components of complement (2).  $Ca^{++}$  and  $Mg^{++}$  have been found to function in steps 2 and 3, respectively.  $E^*$  refers to an activated or damaged cell which eventually hemolyzes without further interaction with complement from the fluid phase. The conversion of  $EAC'_{1,4,2}$  to  $E^*$  by  $C'_3$  has been found to proceed without requirement of a divalent cation such as  $Ca^{++}$  or  $Mg^{++}$ , and hence can take place in the presence of 0.01M ethylenediamine tetraacetate (EDTA). As a source of  $C'_3$ , either  $C'_y$  (guinea pig serum lacking  $C'_1$  and  $C'_4$ ) or whole guinea pig serum in the presence of 0.01M EDTA has been used. The identification of  $C'_3$  as the component which interacts with  $EAC'_{1,4,2}$  to form  $E^*$  (3) is based on the observation that  $EAC'_{1,4,2}$  can be hemolyzed by  $R_1$ ,  $R_2$ , or  $R_4$ , but not by  $R_3$  (4).