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ARTICLES VIII-X.

ART. VIII. THE REACTIONS AND RESISTANCE OF FISHES TO
CARBON DIOXIDE AND CARBON MONOXIDE

BY

MORRIS M. WELLS, PH.D.

ART. IX. EQUIPMENT FOR MAINTAINING A FLOW OF OXYGEN-
FREE WATER, AND FOR CONTROLLING GAS CONTENT

BY

VICTOR E. SHELFORD, PH.D.

ART. X. A COLLECTING BOTTLE ESPECIALLY ADAPTED FOR THE QUAN-
TITATIVE AND QUALITATIVE DETERMINATION OF DISSOLVED
GASES, PARTICULARLY VERY SMALL QUANTITIES OF OXYGEN

BY

EDWIN B. POWERS, M. A.

ERRATA AND ADDENDA.

- Page 50, second column, line 13 from bottom, for *Danais archippus* read *Anosia plexippus*; line 8 from bottom, for *mellifica* read *mellifera*.
- Page 51, line 11 from bottom, for *Danais* read *Anosia*.
- Page 159, at right of diagram, for *Bracon agrilli* read *Bracon agrili*.
- Page 289, second column, last line but one, for *Scalops* read *Scalopus*.
- Page 294, line 3, for *catesbeana* read *catesbiana*.
- Pages 327 and 330, line 12, for *orcus* read *oreas*.
- Page 347, line 4, for *Cecidomyidæ* read *Cecidomyiidae*.
- Page 356, line 7, for *Anthomyidæ* read *Anthomyiidae*.
- Page 368, line 18, dele second word.
- Page 373, after line 10 insert as follows: 53a, *subpruinosa* Casey, 1884, p. 38.
- Page 375, after *submucida* Le Conte, 48, insert *subpruinosa* Casey, 53a.
- Page 377, after line 7, insert as follows:—
1884. Casey, Thomas L.
Contributions to the Descriptive and Systematic Coleopterology of
North America. Part I.
- Page 379, line 11 from bottom, for *sensu lata* read *sensu lato*.
- Page 382, line 12, for VII read VIII.
- Page 408, line 2, for *the next article in* read *Article VIII of*.
- Page 410, line 6 from bottom, for = $\frac{1}{2}$ read '11.
- Page 412, line 7, for 31 read 30.
- Page 421, line 17 from bottom, insert *it* before *grows*.

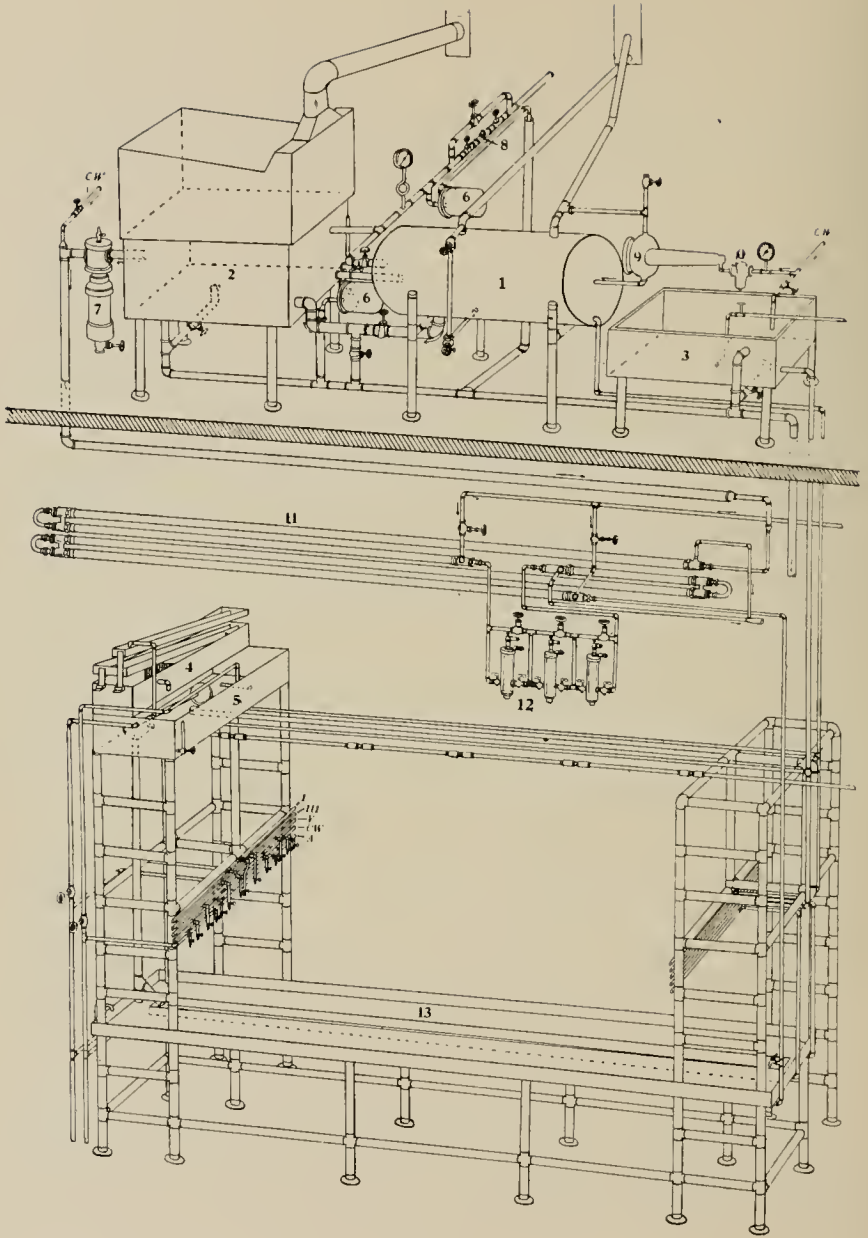
ARTICLE IX.—*Equipment for maintaining a Flow of Oxygen-free Water, and for controlling Gas Content.** BY VICTOR E. SHELFORD.

In Article VI of this volume a piece of apparatus for controlling gas content and adding gases and fluids to water is described by the present writer. His earlier work, as well as that reported by Dr. Wells in Article VIII, was done with that apparatus on a water table of temporary construction, but the table and the apparatus have both been replaced by the permanent structures herein described. The new equipment consists of a large drain-table (13), shown in the lower part of the accompanying figure, with the boilers on the floor above. The drain table is provided with double-decked towers nine feet high, for supporting bottles, tanks, etc. in the manner indicated in articles VI and VIII of this volume. Aside from possessing many advantages in the control of conditions where fluids and gases are added, the new apparatus has great advantages in the control of oxygen content, as continuous flow is insured, and with aerating troughs of various lengths almost any amount of oxygen can be obtained in running water. The other apparatus† used gas heat for boiling and could deliver not more than 100 c.c. of oxygen-free water per minute, and this amount was not certain to be free from oxygen continuously. The new piece of apparatus delivers a liter of water per minute and could probably deliver a maximum of four or five liters per minute.

It uses high pressure steam for boiling the water and delivers it with the temperature brought down to that of the water supply. We may accordingly follow the course of the water supply from the supply pipe to the exit from the cooling coil. Water is introduced into the first boiler, No. 1, from the supply pipe at the right of the upper group of apparatus. It is passed through a Schutte & Koerting 1½" strainer to an inclosed float cock, No. 9. This float cock, a stock article on the market, maintains water at a definite level in both tank

*The apparatus described in this article was developed in connection with the work on stream pollution done by the author and described in Article 6 of this volume; the new apparatus was provided by the University of Illinois in the new Vivarium Building to supersede the piece described in that article. The drawing was provided by the Department of Zoology.

†See Shelford and Allee, *Journal of Experimental Zoology*, Vol. 14, pp. 207-266. 1913.



No. 1 and tank No. 2. Tank No. 1 is a water-heater containing a steam coil and vented by two large pipes connected with the flue. A large amount of steam and gas is given off from the water escape from this tank. Tank No. 1 is connected with tank No. 2 by a two-inch pipe containing a valve which makes possible the draining of one tank without draining the other. The water being withdrawn from tank No. 2, flows from No. 1 to No. 2 and is boiled for a long time in the latter, which measures $2 \times 2 \times 4$ ft. and is supplied with a six-inch vent in a large cover. The water leaves tank No. 2 at the left through a dirt trap, No. 7, and passes through the floor to the room below. The discharge line can be flushed with university water from CW. The steam used is high pressure—usually 90 pounds—but may be reduced to 25 or 30 pounds by a pressure-reducing valve, No. 8; the steam traps, No. 6, remove the condensation.

After passing through the floor the water goes through a cooler, No. 11, made from block-tin pipe (black iron return bends at the ends) placed inside $1\frac{1}{2}$ " pipes connected with each other by cooler tees, the cooling water flowing into the cooler at the point where the boiled water leaves it. In the middle of the coil are three gas introducers (12), which are modified beer air-purifiers made by Bishop, Babcock, and Becker, the gas being introduced into the chambers, through which the water flows, through blocks of basswood, thus dividing it into very small bubbles. Oxygen, carbon dioxide, and nitrogen have been introduced.

The water is delivered at the ends of a drain table. Tank No. 3 is used for securing water which is saturated with oxygen under atmospheric conditions in quantity sufficient to run through a number of bottles containing animals. Tank No. 4 is for aerating the university water-supply by running it down crimped inclines and through two chambers where the iron which is precipitated is removed. This water is stored in tank No. 5. Two tanks like Nos. 4 and 5 are provided above tank No. 3, with the controlling float-cock in No. 3, so that water may be partially aerated and delivered to No. 3, where compressed air forced into it renders it very alkaline and saturated with oxygen. The drain table is supplied with water from tanks Nos. 3 and 5 and from the university supply marked CW, and also with air (A).