checked against our alphabetical card catalogue, the missing cards put in it and duplicates made and distributed in the index-catalogue.

In the second place bibliographies in recent books and in extensive papers dealing with particular subjects or structures will be checked, since in such sources are found many valuable references old and new which do not get into the annual bibliographies. In this way we expect to get some 25 or 30 per cent. more titles than are to be found in the annual issues of the "Zoological Record."

In the third place we receive here a considerable number of separates, which are checked, carded, indexed and the cards distributed as soon as they come in, and thus our catalogue is about two years ahead of the "Zoological Record" and the other annual bibliographies. The greater the number of such separates which come in, the more nearly up to date our card catalogue will be, and this is the point in this appeal for the early sending in of such separates. These references once carded become available for all who may call at the museum.

Now readers of this article are already asking, "What about publication of this card catalogue?" This is not a question that I can answer. It will be years before material will be accumulated in sufficient amount for another volume. Whenever that time comes, it will be for the president and trustees of the museum to decide the question of publication.

The results of my work can not be sent out by letter, but to any one calling at the department the recent references in his particular subject will be put before him on five minutes notice. And such use, it may be remarked parenthetically, is being made of our catalogue at intervals nowadays.

*Readers of* SCIENCE *who are students of fishes, will you send me your separates promptly that they may promptly be made available for others? I want everything wherein fishes touch the life of man.*

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## SPECIAL ARTICLES

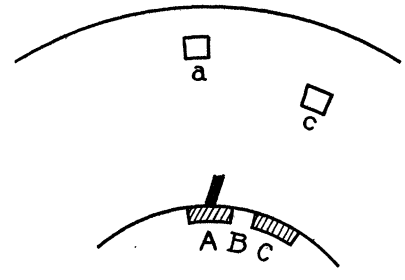
### THE LIFE OF METASTABLE HELIUM AND MERCURY

KANNENSTINE (*The Astrophysical Journal,* 55, 345 (1922); 59, 108 (1923)) and Marshall (*Astrophysical Journal,* 60, 243 (1924)) have reported that in mercury and helium which has just been excited by a discharge, it is temporarily possible to cause an arc to strike at a very low voltage. This voltage is said to be critical and equal to the difference between the ionizing potential of the gas and its resonance potential; *i.e.,* 24.6 − 19.8 = 3.8 volts for helium, and 10.4 − 4.7 = 5.4 volts for mercury. Their interpretation of these results is that a large supply of excited atoms is formed during the primary arc, whose reversion to normal is impossible except by collisions of the second kind *with impurities* or with the walls and electrodes. The length of time during which it is possible to maintain these post-arc currents with low voltages is taken as a measure of the life of the metastable excited atoms.

These results were predicted by Franck and Reiche (*Zeitschrift für Physik,* 1, 154 (1920)) from considerations which are rendered doubtful by recent work on collisions of the second kind.

The author has therefore repeated the work of Kannenstine and Marshall, using more sensitive methods. A commutator was used which applied a high voltage (30–40 v.) to an arc tube for a short time (Period A). This voltage was then disconnected for an interval (Period B) which was long enough to allow all transient phenomena due to inductance and capacitance to die out. During a third interval (Period C) a second known voltage, V, was applied through a microammeter. This meter thus read the time average of a current which was zero except during Period C. It was then found that when V was very low (+1 volt) or negative, the current during Period C was negative and small (10–20 microamperes). As V increased from 1–6 volts, the current increased continuously and reached a definite saturation value of 4–5 milliamperes at 8 volts. No further increase was detected until V = 20 volts. The negative currents, together with the *complete absence of any critical potential,* led to the hypothesis that these post-arc currents are due, not to ionization of excited atoms, but to the persistence of actual ions in the arc space.

To test this hypothesis, a perforated disc was mounted on the same shaft as the commutator. The arrangement is shown schematically in the figure. During a portion of Period A, the arc is visible




through the opening *a*. Similarly, during part of Period C, it is visible through *c*. Experimental conditions were then adjusted so that the current flowing during Period C was 1/4 to 1/3 that flowing during Period A. It was then found that though intense

spectral emission was observable during Period A (*i.e.*, through opening *a*), there was no detectable emission during Period C. Since it is known from various lines of evidence that spectral emission is not appreciably the result of recombination of ions and electrons, but is the result of excitation, this proves conclusively that the post-arc currents are due to the neutralization of negative space charge by the persisting positive ions, and not to the ionization of excited atoms.

Furthermore, Kannenstine's results using a Braun tube were reproduced in all essential details, in very pure helium, in helium of ordinary purity (no impurity visible spectroscopically) and also in helium containing large amounts of mercury vapor. No quantitative difference greater than the limit of reproductibility under the same conditions was found.

Many of the peculiarities of the Braun tube figures were found to be produced by the resistance of the potentiometer and other elements of the circuit.

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## THE SUCCESSIVE STIMULATION OF THE ARC LINES OF HELIUM BELOW THE IONIZATION POTENTIAL

RECENT experiments made in the research section of this laboratory have demonstrated photographically the successive stimulation of the arc lines of helium under increasing potential of electron bombardment between the resonance and ionization points.

The potentials necessary for the stimulation of the lines of the visible spectrum were calculated from the established term values of these lines and from a term value for the normal atom based on the assumption that the correct ionization point is 24.5 volts. The photographs show a concordance of observation with calculation to better than one tenth of a volt. The voltmeter corrections were made from ionization point curves taken under the same conditions in the same apparatus assuming the correct point to be at 24.5 volts. This correction amounted to 1.1 volts, a value also calculable by the usual methods by application of contact difference of potential and other corrections. A large Hilger quartz spectrograph was used with a plate setting to cover from about 5000A to 3000A. With this setting the spectrum at 22.9 volts consists of a single line, 3889A. This is the second line of the coplanar principal series, m = 2. The calculated voltage necessary to stimulate this line is 22.9 volts. At 23.5 volts three lines are found 5016 (calculated 23.00 volts), 4713 (23.51) and 3889. At 23.9 volts nine lines occur, 5048 (23.56), 5016, 4922 (23.65), 4713, 4472 (23.65), 4121 (23.88), 3965 (23.65), 3889 and 3188 (23.62). At 25 volts the full spectrum is obtained.

When viewed visually the lines appear and extinguish sharply in order. The disappearance of the line 5048 leaving 5016 adjacent to it furnishes a convenient method for establishing instrumental corrections if the calculated value for the appearance of the line is accepted as correct.

The experiments are an extension of work reported to the American Physical Society at its Washington meeting in April, 1924. The apparatus described at that time has been altered by the introduction of an equipotential lime cathode of a type similar to that suggested by G. Hertz (*Zeit. für Phys.*, 22, 24, 1924), but of a different shape, sharply peaked at its narrowed center to permit closer approach to the grid. The distance of electron acceleration did not exceed one half of a millimeter. Under these conditions both voltage and current were remarkably steady. No "kicks" or "hysteresis loops" were found in the current-voltage curves nor were there any evidences of oscillatory disturbances.

These results are a confirmation of the early observations of Rau (*Sitz. Ber. d. Phys. Med. Ges.*, Wurzburg, 1914) and of Richardson and Bazzoni (*Nature*, 98, 5, 1916) and of the recent publications of G. Hertz (*l. c.*).

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RANDAL MORGAN LABORATORY,
UNIVERSITY OF PENNSYLVANIA,
APRIL 15, 1925

## THE NATIONAL ACADEMY OF SCIENCES

### ABSTRACTS OF PAPERS PRESENTED AT THE WASHINGTON MEETING, APRIL 25 AND 26

*Measurement of the circulation in man:* DR. YANDELL HENDERSON and HOWARD W. HAGGARD, Sheffield Scientific School, Yale University. Ever since Harvey showed that the blood circulates, the determination of the volume of flow per minute has remained the outstanding, unsolved problem of the circulation. It is not merely general knowledge that is needed, but rather the means of determining the functional efficiency of the circulation in individuals in all conditions; in other words, a simple and fairly accurate method for measuring the circulation in man. The method based on absorption of nitrous oxide from the lungs is inaccurate and of limited applicability.

Investigations in this laboratory have led to the formulation of the principles controlling the absorption of any gas whatever by mere solution from the lung air into the blood. These principles show that the rate of absorption of a very soluble gas, such as ether or alcohol vapor, is dependent mainly on the volume of air breathed, that is, the respiration; while the rate