of metals with non-oxidizing acids. The pores and intergranular spaces of the metal may be enlarged, the action proceeding deep within the interior of apparently sound metals. Capillaries probably play their part, also, in the ordinary corrosion of unsound metals. Even when metals are apparently sound, pores too small to be detected with the microscope may be the obscure cause of deep penetration and pitting. This type of corrosion may be looked for in the case of metals submerged in the absence of oxygen. Wherever bubbles can be retained there may be more rapid action.[3]

It is believed that this type of corrosion is quite important and worthy of further study.

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A Simple Differential Air Thermometer for Use at Low Temperatures.—Having occasion recently to separate mixtures of nitric oxide, nitrous oxide, hydrogen chloride and nitrosyl chloride and to examine the mixtures for other possible gases boiling at intermediate temperatures, I have devised a simple air thermometer for the approximate determination of temperatures between the boiling point of liquid air and zero.

A bulb with a capacity of 2.5 to 5 cc. is blown at the end of a capillary tube 50 cm. in length and with an internal diameter of about 0.8 mm. A small globule of mercury, enough to occupy a length of about 5 mm. of the capillary, was introduced and, by cooling the bulb slightly, this was brought to a position about 100 mm. from the end, and the end was sealed. It is evident that if the temperature of the air in the capillary above the globule remains constant, and we disregard the small change in the volume of the air below the mercury and the transfer of air from the capillary to the bulb, the pressure in the bulb will vary directly as the absolute temperature. Taking the length of the column of air above the mercury as 1 at $0°$, the length at any other temperature may be calculated, approximately, by the formula $273 \times 1/T$, in which T is the absolute temperature. The calculation gives the following values.

Temp., °C.	0	−10	−20	−30	−40	−50	−60	−70	−78.5	−80	−90
$273 \times 1/T$	1	1.039	1.079	1.123	1.172	1.224	1.282	1.345	1.404	1.414	1.492

Temp., °C.	−100	−110	−120	−130	−140	−150	−160	−170	−180	−190	−191.6
$273 \times 1/T$	1.578	1.674	1.784	1.908	2.052	2.219	2.415	2.649	2.936	3.286	3.351

With the temperature of the room at $25°$, three points are fixed on the stem for the top of the mercury when the bulb is immersed in melting ice,

[3] Shipley, McHaffie and Clare, *Ind. Eng. Chem.*, **17**, 381 (1925).

in a mixture of carbon dioxide snow with ordinary alcohol, and in fresh liquid air. The carbon dioxide snow in alcohol is quite accurately —78.5° at 760mm. pressure, with a change of 0.1° for 10 mm. That of liquid air is —191.62°.[1]

By measuring the length of the column of air from the zero point to the end and multiplying this by the numbers given in the table, the approximate locations on the stem of the several temperatures given in the table have been calculated. The differences between these observed and calculated values for —78.5° and for —191.6° are then plotted as ordinates with temperatures as abscissas. If the portion of the curve from 0° to —78.5° is practically a continuation in a straight line of that from —78.5° to —191.6°, the differences for each 10° may be read from the graph and used to correct the calculated values to true values. If the line is not straight,

Temperature, °C.
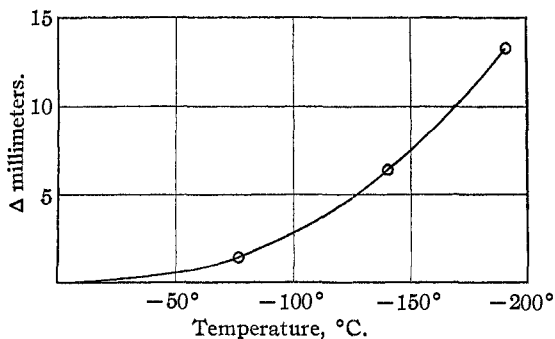
the coefficients a and b may be calculated for the empirical equation, $at° + bt°^2 = \Delta$, using for Δ the differences at —78.5° and —191.6°. With these coefficients Δ may be calculated at —140° and a more accurate graph may be drawn. The accompanying figure illustrates a graph prepared as described.

After fixing points at 10° intervals by means of the graph, single degrees may be marked at equal intervals between these points with a maximum error of about 0.3° in the lower part of the scale and less above that.

It can be seen from the table that the thermometer is most sensitive at low temperatures, the interval for 1° being about eight times as great at —190° as at —40°. Also, a difference of 1° from the standard temperature of 25° for the air above the mercury will cause an error of only 0.3° at —190°, while the error is 0.93° at 0° and 0.67° at —80°.

By using hydrogen in the bulb and careful calibration, a thermometer of this type could be made quite accurate even down to the temperature of liquid hydrogen.

[1] These values are given me by Professor Rodebush, who has checked them rather accurately.

After using for some weeks a thermometer constructed as described, the points at $0°$ and at $-78.5°$ were found to be unchanged, indicating that there had been no leakage of air past the mercury.

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Possible Limits for the Heat of Dissociation of Oxygen.—The ionization of oxygen to form singly charged oxygen molecules has been found to occur at about 16 v. by Lockrow and Duffendack[1] and by Smyth.[2] In their study of the low-voltage arc in oxygen, Lockrow and Duffendack find a marked strengthening of lines and the appearance of new lines at 19.5 v.,[3] and they ascribe this to dissociation and simultaneous ionization of one atom.[1] Smyth, working at low pressures and using his method of positive-ray analysis, did not find oxygen atom ions below 23.0 v.

For the similar process in hydrogen Smyth showed that the appearance of atom ions depended on a secondary process involving collisions, since by changing the pressure in the impact region, the voltage at which atom ions appeared could be greatly altered, this voltage decreasing as the pressure increased, until atom ions appeared at the same point as molecule ions.

Returning to the case of oxygen, in view of the fact that at very low pressure, oxygen atom ions do not appear until a considerably higher voltage is reached than that at which they appear at the relatively large pressures used in the low-voltage arc, it would seem probable that excited oxygen molecule ion can dissociate into oxygen atom and oxygen atom ion upon collision with some neutral particle, provided that its energy is greater than, or equal to, the energy change represented in such a process of dissociation. Now, atom ions are not found to occur at 16 v. and, therefore, unless the state of the molecule ion corresponding to 16 v. is metastable, for some special reason not being able to dissociate upon collision, the 16 v. molecule ion does not possess the energy necessary for the dissociation. The molecule must possess more energy than that represented by 16 v. to be able to dissociate upon collision. It appears that at 19.5 v. the excited molecule ion has sufficient energy to undergo this change upon collision. It may well be, however, that the energy increase represented in the dissociation is less than that corresponding to 19.5 v., but that under 19.5 v.

[1] Lockrow and Duffendack, *Phys. Rev.*, **25**, 110 (1925).

[2] Smyth, *Proc. Roy. Soc.* (London) **105A**, 116 (1924).

[3] Communicated by Dr. Duffendack in a letter to the author.