ed use of the washer has been made, and after practical trial of some time it is stated that it has been found by the engineers to be the best and cheapest washer invented for holding nuts tight that they have had practical experience with. This, we think, speaks very highly for the capacity of the device and consider that the test is a crucial one, and may be taken by intending users as excellent evidence of what may be expected of the device.

ELECTROCHEMICAL CALCULATIONS.

By Joseph W. Richards, A.C., Ph.D.

(*Continued from last month.*)

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Example: How much oxygen and hydrogen should be produced per day by 300 amperes passing through twenty cells in series?

Solution: The ampere hours performing electrolysis are

$$300 \times 20 \times 24 = 144{,}000$$

The Faradays' passing are

$$144{,}000 \div 26.82 = 5{,}370$$

The volumes of gas produced will, therefore, be:

$5{,}370 \times 11.11 = 59{,}670$ litres of hydrogen.
$5{,}370 \times 5.55 = 29{,}835$ litres of oxygen.

If the gas evolved is a compound gas or acid radical, which is formed at the electrodes, the valence of the acid of basic constituent in a molecule of the gas, is the basis of calculation. For instance, CO, CO^2, CH^4, H^2S all represent molecules of the said gases, of a volume of 22.22 litres, and contain respectively:—

CO	contains	2	gram-equivalents	of	oxygen.
CO^2	"	4	"	"	"
CH^4	"	4	"	"	" hydrogen.
H^2S	"	2	"	"	"

One Faraday (26.82 ampere hours), which would produce one gram-equivalent of oxygen or hydrogen, would, therefore, produce ½ a molecule (11.11 litres) of CO or H^2S or ¼ molecule of CO^2 or CH^4 (5.55 litres).

Another means of calculating the volume of these gases is to note that CO^2 and H^2S are equal in volume to the oxygen or hydrogen contained in them, CO is double the volume of the oxygen contained in it, and CH^4 is double the volume of the hydrogen going into its composition; so that the volumes of the compound gases can be calculated from the volumes of the simple gases going into their formation. The relations alluded to are shown by the Roman numerals indicating molecules or volumes in the following equations:—

$$\overset{\mathrm{I}}{O^2} + 2C = \overset{\mathrm{II}}{2CO}$$

$$\overset{\mathrm{I}}{O^2} + C = \overset{\mathrm{I}}{CO^2}$$

$$\overset{\mathrm{II}}{2H^2} + C = \overset{\mathrm{I}}{CH^4}$$

$$\overset{\mathrm{I}}{H^2} + S = \overset{\mathrm{I}}{H^2S}$$

Ohm's Laws.

The resistance which the electric current encounters to its flow through the body of a substance is determined by the specific resistivity of the body per unit cube of substance, multiplied by its length and divided by its cross-sectional area. The specific resistivity is given in tables per centimeter cubed, in ohms, and the simple arithmetic described gives us the resistance of any bar or wire of said material. The resistance of the body being known, Ohm's laws furnish us with the relation between the applied voltage and current flow through the body, as follows:—

$$\text{Current} = \frac{\text{potential drop}}{\text{resistance}}$$

or,

$$\text{Amperes} = \frac{\text{volts drop}}{\text{ohms resistance}}$$

These relations apply to the current **in the body** of an electrolyte just as strictly as to a metallic wire (and tables of specific resistivity of electrolytes are given in almost all books on electrochemistry),* but they do not apply at all to the resistance or drop of potential at the surface of an electrode; that is, at the contact surface where current enters or leaves an electrolyte. That latter potential drop is due to chemical work being performed, and has no connection whatever with ordinary ohmic resistance and Ohm's laws.

Resistance Capacity of Vessels.

In making electrochemical experiments, as in tubes or in vessels between fixed electrodes, it is often convenient to calculate, as a constant of the apparatus, the "resistance capacity" of the vessel. This is simply its ohmic resistance, between the two fixed electrodes, supposing it to be filled with a liquid whose specific resistance is unity. If the cross section is uniform, and the electrodes of similar area, this resistance capacity would be, in ohms, supposing the measurements made in centimeters:

$$\text{resistance capacity} = \frac{\text{length between electrodes}}{\text{cross sectional area of electrolyte}}$$

Thenceforth, if said vessel is filled between the electrodes with a liquid whose specific resistance is known, the ohmic resistance of the electrolyte will be simply the product of the resistance capacity by the specific resistance of the given liquid used: that is Ohmic resistance of electrolyte = resistance capacity of the vessel $\times$ specific resistance of electrolyte.

Determination of Ohmic Resistance.

If the conductor is not electrolyzed by the current, its resistance is measured by sending a known current through it and measuring the drop of potential at its terminals.

$$\text{resistance (in ohms)} = \frac{\text{potential drop (in volts)}}{\text{current flowing (in amperes)}}$$

The current used may be either direct or alternating; the former is preferable because of the more accurate measurements possible. Another method, not so often used, but applicable under many circumstances, is to put a delicate thermometer or thermo-couple in contact with the conductor and measure the rate at which its temperature **begins** to rise. Knowing its specific gravity (weight of one cubic centimeter in grams) and its specific heat (per unit of weight), the heat generated per second in one cubic centimeter is known:

Heat generated (gram calories) = specific gravity $\times$ specific heat $\times$ rise of temperature per second.

But this quantity is also equal to the heat value of the current used, which is 0.2385 times the watts used, or 0.2385 times the square of the current used into the resistance. We, therefore, have:—

$$\text{resistance (in ohms)} = \frac{\text{heat found calorimetrically}}{0.2385 \times (\text{current used})^2}$$

* Kohlrausch and Holborn's "Leitungsfähigkeit der Elektrolyte" is the mos complete collection of such data.