potassium dichromate, and then from a barium hydroxide solution. The salts used were of Baker's Special Analyzed Chemicals, and in the case of the potassium iodide, the measurements were checked against a recrystallized sample. In every case several readings were taken on the bridge, and in the case of the potassium iodide, four different samples of salt, and three different cells were used, all giving check results.

The above results were obtained where Λ = equivalent conductivity and $\phi/_{1000}$ = dilution.

In plotting the curves, the logarithms of the dilutions were used.

The results obtained for the concentrated solutions of potassium iodide are decidedly different from those given by Jones and Douglas,[1] but the type of curve agrees very closely with that of Kahlenberg,[2] the molecular conductivity being a little higher than Kahlenburg's.

In plotting the conductivities of potassium iodide and potassium bromide at 18°, on the same basis, the values as given by Kohlrausch and associates, show the same tendency, but not so marked, but the concentrations are not so great.

The values at 0° for potassium iodide resemble in some respects, the conductivities of certain salts in methylamine and liquid ammonia, as given by Franklin and Gibbs[3] and Franklin.[4]

A satisfactory explanation of the results obtained does not seem possible at present. It is hoped that further measurements may produce some clue.

This work was carried out at the suggestion and under the direction of Prof. E. C. Franklin.

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[FROM THE INSTITUTE OF ANIMAL NUTRITION LABORATORY, STATE COLLEGE, PA.]

ELECTRIC COMBUSTION FURNACE FOR METHANE DETERMINATION.

BY J. A. FRIES.

Received June 13, 1910.

In connection with the respiration calorimeter experiments upon cattle which are being carried on here, it is necessary to determine the amounts of combustible gases (consisting chiefly or wholly of methane) excreted. For this purpose an electric combustion furnace has been in use in this laboratory during several periods of 50 consecutive hours each, and is giving perfect satisfaction.

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[1] *Am. Chem. J.*, 26, 445. Calculated to reciprocal ohms, Tower's "Conductivity of Liquids."

[2] *J. Phys. Chem.*, 5, 348.

[3] THIS JOURNAL, 29, 1389.

[4] *Z. physik. Chem.*, 69, 272.

The work to be done and the size and construction of the furnace are so different from those of ordinary combustion furnaces that a description of the furnace may not be without interest and value.

Work Required of the Furnace.—From the continuous current of air passing through the respiration calorimeter chamber when an experiment is in progress, samples for analysis are taken at frequent and regular intervals, the quantity of these samples being equal to a continuous air current of 3.5 liters per minute. This amount of air passes through the combustion tube, where the combustible gases are oxidized, platinized kaolin serving as a catalyzer.

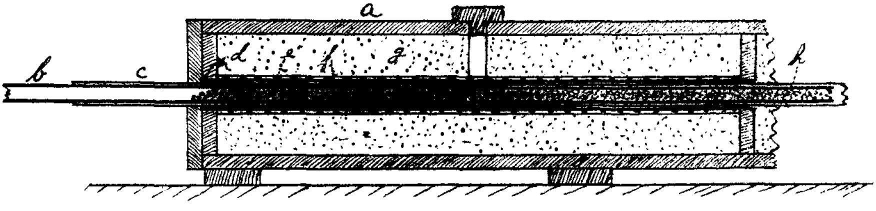
Combustion Tube.—The combustion tube, which is similar to that used previously with a gas furnace for the same purpose during a number of years, is a seamless copper tube 3.35 meters long, $^3/_4$ inch iron pipe size, inside diameter about 20 mm., and with walls about 3 mm. thick. The heated section of this copper tube is protected by a nickel-plated brass tube 8 feet long which fits loosely over it.

Electric Current.—The electric current at our disposal is a three-phase alternating current of about 110 volts pressure during the day, but in the evening and night when the most lighting is required, the voltage is increased to between 120 and 125.

Material for Furnace.—The outside box and supports for the tubes were $^3/_4$ inch thick asbestos lumber. Three quartz tubes, 37 mm. inside diameter, each about 70 cm. long, were used for cores upon which were wound the resistance coils, consisting of 6 mm. Nichrome ribbon. A 3 mm. asbestos cord and an 18 mm. asbestos tape were used to keep the resistance coil in position and prevent short circuiting.

Construction of the Furnace.—The accompanying sketch of a section of the furnace shows the construction of the same.

The outside dimensions of the asbestos box are: 215 cm. long, 17.5 cm. wide, and 19 cm. high. The asbestos was worked and screwed together like ordinary wood. Cross partitions supporting the ends of the quartz tubes were securely fastened to the sides of the box. Each quartz tube was wound separately with about 4 meters of Nichrome ribbon 6



Cross-section showing one-third of the furnace: *a*, asbestos lumber; *b*, copper tube; *c*, brass tube; *d*, quartz tube; *e*, Nichrome ribbon; *f*, asbestos tape; *g*, quartz sand; *h*, platinized kaolin.

mm. wide and 0.3 mm. thick, having a resistance of 173 ohms per 1000 feet. This length made a coil of 29 turns equally spaced over the exposed length of the tube. The ribbon was wound directly on the quartz tube, wired fast with resistance wire at each end, and between each turn was wound a 3 mm. asbestos cord. Between the turns of the cord an 18 mm. asbestos tape was wound directly over the Nichrome ribbon. This method of winding made it all very firm and practically impossible for the ribbon coils ever to work loose and the loops to come in contact with each other. The wound quartz tubes were put in position so that they formed a straight opening. The ends of the coils leading out to the binding posts on the outside of the asbestos box were doubled back upon themselves twice and wired together, in order to reduce the resistance and the heating of them by the current. Very thin asbestos was laid over joints and any crack in the asbestos tape winding so as to keep the sand away from the tubes, and then the box was filled with fine quartz sand. About the middle of each tube and coil there was left a round hole, 1 inch in diameter, extending from the outside of the lid to the asbestos covering on the ribbon, and by means of this opening the condition of the tubes as to heat can be observed at any time. The binding posts were screwed on the side of the box and the doubled up ends of the ribbon project between the lid and upper edge of the side of the box. Three of these binding posts connect the three main wires and the three ends of the resistance coils. The coils themselves were connected in star fashion, that is, the three free ends were united.

This method of wiring reduces the voltage in the coils and hence less ribbon is required per coil for a given amount of heat than by the mesh method of wiring. The maximum heat possible under this system of wiring would be

$$\text{main voltage}/\sqrt{3} \times \text{amperes}.$$

By actual test the voltage across these resistance coils varied from 60.5 to 62.5, and the ammeter measured about 23.5 amperes, while at the same time the voltage between the three mains was 107.5 to 108.5. The load on the main was not perfectly balanced nor was the current very steady, but from the average of the readings, the heat generated in each coil would be 1434 watts, or computed to the surface of the tube, equal to 1.7 watts per square centimeter.

This amount of heat proved to be entirely too much and the temperature of the furnace rose to nearly 1200°. The greater efficiency noticed in this furnace, when compared with the results of laboratory tests made with quartz tubes wound with wire and insulated with magnesia covering, must be ascribed to the better insulating quality of the sand, and to the fact that a broad ribbon was used for resistance coils instead of a small wire.

In order to reduce the heat in the furnace, a coil consisting of 5 feet of the same ribbon was put in as outside resistance in each of the three main wires and in order to meet the fluctuations and increase in voltage on the main, two sets of coils, 1 foot ribbon per coil, were so arranged on the top of the box that one or both sets could be thrown in by means of two switches. Each of these sets of coils equals about 1 ampere difference in the current.

By this arrangement of the resistance, the current can be held at 15 to 15.5 amperes, which maintains a temperature of 700° or a little less in the furnace. This is equivalent to about 0.79 watt per square centimeter tube surface. With the copper combustion tube in position, the temperature of the furnace is reduced somewhat near the ends of the furnace, but under these conditions the heat has been found to be sufficient for the work required.

The ends of the copper combustion tube were threaded and reduced to $^1/_4$ inch iron pipe size by means of brass fittings, the joints of which were also soldered. The return pipe from the furnace to the train of absorption tubes is iron connected with good rubber tubing.

Test of the Furnace and Combustion Tube.—When all connections had been made ready for use the whole system was put under 5 inches mercury pressure and suction and showed no leak. Next, the oxidation capacity of the furnace was tested by allowing alcohol vapor to be carried through with the air current, the carbon dioxide formed being absorbed and the air again allowed to pass through a similar combustion tube heated by gas. It was found that the combustion was perfect in the electric furnace, not a trace of carbon dioxide being found after the second furnace.

After this test a weighed quantity of alcohol was oxidized with the following results:

		CO_2.	H_2O.
5.4127 grams alcohol, sp. gr. 0.82478:	Theoretical,	9.2271 g.	6.2542 g.
	Found	9.2210 g.	6.1920 g.

The carbon dioxide found agrees as well as can be expected with the theoretical, but the water is a little low. This was caused by stopping the experiment a little too soon, some of the water still remaining condensed in the connections. The time used for the determination was $3^1/_2$ hours. This test was considered entirely satisfactory and the furnace has proven so ever since.

Expansion of Copper Tube.—The copper combustion tube expands about 1 inch in length when heated, besides a very small amount in diameter, hence it should not fit too tightly in the furnace, nor have very sharp edges nor rough surfaces over which to move. Because of this expansion it is advisable to use rubber connections at the cool ends or some flexible tin or lead pipe where such material can be used. The small unevenness commonly found in the quartz tubes does not seem to interfere with the expansion.

Durability of Copper Combustion Tube.—Copper tubes such as have been described have been in use with the gas furnace for as many as 1100 hours before being renewed. With the electric furnace, where the heat is much more uniform, the tube, which in this case is nickel-plated on the outside, may last even longer.

Advantage of Electric Furnace over the Gas Furnace.—By the electric furnace a source of probable error—that of combustible gases under certain atmospheric conditions contaminating the air supply of the respiration calorimeter—has been removed. It supplies more uniform heat. It is more economical than gasoline gas since even with much outside resistance the amount of heat lost is only a very small fraction of that wasted by a large gas furnace. There is no trouble in regulating the heat as there is with a varying gas supply.

THE PRECIPITATION OF THE IRON GROUP AND THE COMPOSITION OF CERTAIN FERRIC FORMATES.

By O. F. Tower.

Received June 7, 1910.

The difficulties of precipitating the metals of the iron group, *viz.*, iron, aluminium and chromium are well known. Many prefer to attempt no independent separation, but to precipitate them along with the zinc group by using both ammonium hydroxide and ammonium sulphide. This, however, entails a complex and rather tedious method of analysis, unless chromium is known to be absent. In case manganese is absent the metals of the iron group may be separated rather sharply by repeating the process of precipitation. After the first precipitation with ammonium hydroxide, the precipitate is dissolved in hydrochloric acid and the metals reprecipitated with ammonium hydroxide as before. In this way any zinc or nickel dragged down in the precipitation are fairly completely removed. The most complete method of separation, however, no matter what other common metals may be present, is to precipitate them as basic acetates. Furthermore, the presence of PO_4''' causes no complications when the basic acetate process is employed, provided sufficient $\overset{\cdots}{Fe}$ is present. In addition to causing the removal of the PO_4''', $\overset{\cdots}{Fe}$ is required to insure the precipitation of chromium. The great objection to the use of the method, however, is the great difficulty experienced in filtering and washing the precipitate of basic acetates.