nitric acid, which quickly attacks and loosens it so that it may be washed out by water.

No lubricant is fit for use unless it renders the stop-cock nearly or quite translucent, so as to show whether or not the plug is coated over its entire length.

A thick rubber and wax mixture is especially suited for well-ground glass stop-cocks upon gas vessels which are to be exhausted and which have therefore to sustain the full pressure of the atmosphere. Such mixtures have been in use for stop-cocks of ordinary burettes in volumetric work during about two years and have given satisfactory results in every way.

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ABSTRACT OF A DESCRIPTION OF A RESPIRATION CALORIMETER FURNISHED BY PROFESSORS ATWATER AND ROSA.[1]

BY C. F. LANGWORTHY.

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IN 1892 Professors Atwater and Rosa undertook the development of an apparatus for measuring the income and outgo of matter in the animal body. It was proposed, among other things, to study the application of the law of conservation of energy in the animal organism, and plans were made for experiments with man. These required a respiration calorimeter large enough to accomodate a man in comparative comfort for several days at a time and capable of measuring accurately the total income and outgo of matter and energy. The work has been carried out at Wesleyan University, Middletown, Conn., where the facilities of the chemical and physical departments and the mechanical laboratory were made available. The work has been conducted with funds and appliances supplied by the U. S. Department of Agriculture, the Storrs Connecticut Experiment Station, and Wesleyan University.

Considerable time was spent in elaborating the apparatus until it was sufficiently perfected for use in experiments with man. That part which has to do with measuring the income and outgo of matter is similar in principle to the respiration apparatus of

[1] Read at the Sixteenth General Meeting of the American Chemical Society at Washington, D. C., December, 1897.

Pettenkofer and Voit. Many improvements and additions have, however, been made. The appliances for measurement of heat are entirely original. Advantage has been taken of recent progress in electrical science and other branches of physics, and the result is an instrument of remarkable accuracy, notwithstanding its large size.

The portion of the apparatus which has to do especially with respiration experiments has been described in detail in Bulletin No. 44 of the Office of Experiment Stations of the U. S. Department of Agriculture, and the results of four experiments, which include the balance of income and outgo of nitrogen and carbon, are reported in detail. In one of these experiments the subject remained in the respiration chamber for twelve days.

At the meeting of the British Association for the Advancement of Science at Toronto, in 1897, Professor Rosa read a paper describing at some length the special devices used in the measurement of heat and energy produced by the subject in the calorimeter. Brief reference will be made here only to the principal points.

The respiration calorimeter is situated in the basement of the Orange Judd Hall of Natural Science at Wesleyan University.

The respiration chamber is a room or box in which a man may live comfortably during the period of an experiment. The inside dimensions are: Length, 2.15 meters; width, 1.22 meters; height, 1.92 meters. It is provided with conveniences for sitting, sleeping, eating, and working, as well as arrangements for ventilation and for the study of the respiratory products. The chamber consists, in fact, of three concentric boxes, the inner one of metal and the two outer ones of wood. The inner box, of which the inside dimensions have just been given, is double-walled, the inner wall being of sheet copper, the outer of sheet zinc. The two walls are eight cm. apart. This double-walled box is held in shape by a wooden framework between the two metal walls. The inside volume is approximately four and eight-tenths cubic meters.

The limits of this abstract prevent any extended description of the devices used for measuring the incoming and outgoing currents of air or those for measuring the heat produced inside the respiration chamber. A number of improvements suggested by observation and experiment have been made. For instance, the air as it enters and leaves the chamber is practically freed from moisture by freezing. This greatly facilitates its analysis. The amount of water removed can be accurately determined by weighing.

Since the experiments reported in Bulletin No. 44 were made, meter pumps have been built by the University mechanician, Mr. Blakesley, which render the measurement of the air more simple and accurate. The length of stroke and the volume of air per stroke can be determined, and thus the volume of air drawn through the apparatus may be measured. The pumps are also arranged to deliver an aliquot part of the air for analysis.

In the experiments with man the food, urine, and feces were analyzed by the official methods and the heats of combustion were determined by the bomb calorimeter. No balance of income and outgo of energy was reported in Bulletin No. 44. A considerable number of experiments with man have been made since the publication of that bulletin in which the balance of income and outgo of heat was determined.

The calorimeter is so arranged that the inner and outer metal walls may be kept at the same temperature. When this is done no heat will pass from the inside out or the outside in. The temperature of the inner and outer walls is measured by special devices and the air spaces adjoining the metal walls may be heated or cooled as is shown to be necessary. Since no heat can be lost by passing through the walls of the chamber it only remains to measure the heat generated in it. The means employed are the reverse of those used in heating buildings with hot water. That is, the heat is absorbed by a current of cold water passing through radiators or absorbers. The temperature of the incoming and outgoing currents of water is very carefully determined, and knowing this and the volume of water passing through the absorbers in a given time, the amount of heat produced can be calculated. The current of air necessary for ventilation is kept at the same temperature as it enters and leaves the chamber, hence no heat escapes except by the stream of water and by the latent heat of water vapor passing out with the ventilating current of air.

A number of electrical tests were made of the accuracy of the calorimeter as regards measurement of heat. For this purpose a wire resistance coil was placed inside the chamber. This was connected with wires passing through the wall to the outside and connected with a voltmeter and an ammeter and, in some instances, a Thompson balance. The amount of heat given off inside the apparatus was calculated from the current and was also determined in the water passing through the absorbers. The details of the arrangements and observations are reserved for future publication by the investigator. The results are given in Table I:

TABLE I.

SUMMARY OF ELECTRICAL TEST EXPERIMENTS.

Date.	Duration. Hours and minutes.	Heat as measured.	Capacity correction.	Corrected heat.	Theoretical heat.	Per cent. measured.
	H. M.	Cal.	Cal.	Cal.	Cal.	
March 20, 1897..	13 20	1001.9	—9.0	992.9	989.5	100.3
March 25, 1897..	6 05	528.8	—6.0	522.8	522.1	100.1
March 26, 1897..	7 17	1252.1	—1.2	1250.9	1253.1	99.8
April 30, 1897. .	6 00	21.4	0.0	21.4	21.5	99.5
	....	....	....	2788.0	2786.2	100.1

One objection to this use of the electrical method as a test of the accuracy of the apparatus is found in the fact that the conditions were not the same as obtained in an experiment with a man. There was no ventilating current of air through the apparatus, and no water or carbonic acid was given off within it. A number of check experiments were therefore made with ethyl alcohol, and a current of air was passed through the apparatus as in experiments with man. The heat of combustion of the ethyl alcohol was determined by burning it in the bomb calorimeter. These check experiments were made before and after each experiment with a man. In every case the alcohol was burned for a time, generally from three to six hours, before the experiment proper began, the object being to get the temperature of the interior of the apparatus, the moisture content of the air, and the moisture adhering to the inner walls and the heat absorbers as nearly as possible in equilibrium. The attempt was made to have the temperature and moisture content of the air during the last three to six hours of the experiment the same as in this preliminary period, on the assumption that under these conditions the amounts of moisture in the apparatus would be the same at both times. The quantities of water and carbon dioxide in the air at the beginning and at the end of the experiment were determined in samples of about ten liters drawn out for the purpose.

The apparatus and the conditions of the experiment were such as to permit reasonable uniformity in the flow of the ventilating current of air through the chamber, the rate of combustion of alcohol, the consequent production of carbon dioxide, water vapor, and heat, and the temperature of the interior of the chamber. From 500 to 1,000 cc. of ethyl alcohol was burned in the respiration chamber and the carbon dioxide, water, and heat produced were measured. The results are briefly summarized in Table II.

Considered as results of analyses and of determinations of the heat of combustion of ethyl alcohol, these figures for experiments 1, 2, and 4 would compare with the theoretical figures as shown in Table III.

Note.—Since the above abstract was prepared, a number of additional check experiments with alcohol have been made with the respiration calorimeter, as well as experiments with man, in which the income and outgo of energy was determined, in addition to the balance of income and outgo of carbon and nitrogen. The check experiments and two experiments with man have been reported by Professors Atwater and Rosa in the Tenth Annual Report of the Storrs Connecticut Experiment Station (pages 212–242). The results of the alcohol check experiments are shown in Table IV.

In one experiment with a man the energy of the material actually oxidized in the body was calculated to be 3,864 calories per day. The heat measured by the calorimeter was 3739 calories. In the other experiment with a man the energy of the total material oxidized in the body was 2354 calories per day. The heat measured by the calorimeter was 2329 calories. In other experiments not yet reported the measurements agreed with the theoretical values within one per cent. or less.

The results obtained in the check experiments and in experiments with man are extremely accurate. It would appear that

TABLE II.—SUMMARY OF RESULTS OF ALCOHOL CHECK EXPERIMENTS.

No. of experiment.	Date, 1897.	Duration. Hours and minutes.	Alcohol burned.	Carbon dioxide.		Water.		Heat.	
				Required.	Found.	Required.	Found.	Required.	Found.
		H. M.	Grams.	Grams.	Grams.	Grams.	Grams.	Calories.	Calories.
1	April 27–29	52 30	955.4	1,659.0	1,657.7	1,106.4	1,109.6	5,449.9	5,380.1
2	May 10–11	29 56	798.8	1,387.5	1,385.5	924.8	925.6	4,556.6	4,558.8
3	May 26–27	33 50	505.4	877.6	882.9	585.3	649.7[1]	2,882.9[1]	2,808.5
4	November 2–3	35 9	788.2	1,366.6	1,374.6	912.4	920.9	4,488.1	4,478.8

TABLE III.

DETERMINATIONS OF RESPIRATION CALORIMETER COMPARED WITH THEORETICAL FIGURES FOR CARBON AND HYDROGEN AND HEAT OF COMBUSTION OF ALCOHOL.

	Experiment 1.	Experiment 2.	Experiment 4.	Average.	Theoretical.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Carbon	52.12	52.12	52.54	52.26	52.17
Hydrogen	13.08	13.05	13.16	13.10	13.04
Heat of combustion	98.70	100.00	99.80	99.50	100.00

TABLE IV.—RESULTS OF ALCOHOL CHECK EXPERIMENTS.

Date.	Duration. Hours and minutes.	Alcohol burned.	Carbon dioxide.			Water.			Heat.		
			Theoretical.	Found.		Theoretical.	Found.		Calculated.	Found.	
1898.	H. M.	Grams.	Grams.	Grams.	Per cent.	Grams.	Grams.	Per cent.	Calories.	Calories.	Per cent.
January 6	5 50	112·2	193·7	193·3	99·8	129·8	131·3	101·2	635·6	647·3	101·8
January 24–27	83 44	1607·8	2787·0	2771·0	99·4	1861·3	1884·5	101·2	9153·2	9127·7	99·7
May 9–10	24 00	503·9	867·9	863·7	99·5	586·6	584·8	99·7	2874·3	2862·0	99·6
Total	113 34	2223·9	3848·6	3828·0	99·5	2577·7	2600·6	100·9	12663·1	12637·0	99·8

[1] The excess of water and deficiency of heat are assumed to be due to evaporation of water inside the chamber.

the discrepancies are well within the limits of experimental error. In other words, the respiration calorimeter, although complicated and of such size and construction that a man may remain in it with comfort for a number of days or weeks, will measure carbon dioxide, water, and heat given off in the respiration chamber as accurately as these factors are measured by the usual laboratory methods. The accuracy obtained is much greater than with any similar apparatus with which we are familiar.

Improvements in details are constantly being made. In general, it may be fairly said that the object sought has been accomplished; that is, that the balance of income and outgo of matter and energy of the human subject may be accurately measured during comparatively long periods of time.

[CONTRIBUTION FROM THE LABORATORY OF ANALYTICAL CHEMISTRY, UNIVERSITY OF MICHIGAN.]

ELECTROLYTIC DETERMINATION OF TIN IN TIN ORES.

BY E. D. CAMPBELL AND E. C. CHAMPION.

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IN the methods at present in use for the determination of tin in tin ores, the decomposition is effected by fusion with sodium carbonate and sulphur, in order to form sodium sulphostannate, from which the tin is obtained either by precipitation as sulphide with subsequent ignition to the oxide or by electrolytic deposition from the ammonium sulphide or oxalate solution. Some of the objections to the Rose method of precipitation as stannic sulphide and subsequent weighing as stannic oxide are the difficulties of washing the sulphide free from sodium salts, the ignition to stannic oxide without loss of stannic sulphide, and the contamination of stannic oxide with silica.

Electrolytic deposition of tin from the ammonium sulphide solution does not seem to give entirely satisfactory results, for although the tin may be completely precipitated, it is very difficult to obtain complete deposition without at the same time precipitating some sulphur. On the other hand, under proper conditions tin may be very satisfactorily deposited electrolytically from the double oxalate solution; and in the method herewith proposed the principal modification is in the method of convert-